# ENCYCLOPÆDIA BRITANNICA

किं। इस के ही बर्गान हैंगत हैंस

A New Survey of Universal Knowledge

Volume 21
SORDELLO to TEXTILE PRINTING

ENCYCLOPÆDIA BRITANNICA, LTD

CHICAGO · LONDON · TORONTO

All rights reserved
PRINTED IN GREAT BRITAIN



## ENCYCLOPÆDIA BRITANNICA

### Volume 21

## SORDELLO to TEXTILE PRINTING

ORDELLO, a 13th-century Italian troubadour, born at Goito (c. 1200), who is praised by Dante in the De vulgari eloquentia, and in the Purgatorio is made the type of patriotic pride. He is the hero of a well-known poem by Robert Browning. The real Sordello was the most famous of the Italian troubadours. About 1220 he appeared at Florence in a tavern brawl; and in 1226, while at the court of Richard of Bonifazio at Verona, he abducted his master's wife, Cunizza, at the instigation of her brother, Ezzelino da Romano. The scandal resulted in his flight (1229) to Provence,

where he seems to have been for some time. He entered the service of Charles of Anjou, and probably accompanied him (1265) on his Naples expedition; in 1266 he was a prisoner in Naples. The last documentary mention of him is in 1269, and he is supposed to have died in Provence. His didactic poem, L'Ensenhamen d'onor, and his love songs and satirical pieces have little in common with Dante's presentation, but the invective against negligent princes which Dante puts into his mouth in the 7th canto of the Purgatorio is more adequately paralleled in his Serventese (1237) on the death of his patron Blacatz, where he invites all Christian princes to feed on the heart of the hero.

BIBLIOGRAPHY .- G. Bertoni, I trovatori BIBLIOGRAPY.—U. Bettom, I would a d'Italia, Modena, 1915; A. Jeanroy, La pôésie lyrique des troubadours (Paris, 1934) II, 167. For Sordello's life and works see the edition of Cesare de Lollis (Halle, 1896),

SORDINO, SORDONI, SORDUN, musical terms somewhat promiscuously applied (1) to contrivances for damping or muting wind, string and percussion instruments (Sordini); (2) to a family of obsolete wind instruments blown family of obsolete wind instruments blown by courtest of Messes. Hooper by means of a double reed (Sordoni or AND JACKSON Sordun); (3) to a stringed instrument. SORDING, AN OBSOLETE To these must also be added the Surdel- STRING INSTRUMENT



ling or Sordelling, a kind of musette invented (see BAG-PIPE) in Naples in the 17th century.

SOREL, AGNES (c. 1422-1450), mistress of King Charles VII of France, was born of a family of the lesser nobility at Fromenteau in Touraine. She was attached to the service of Isabel of Lorraine, queen of Sicily, wife of René of Anjou, the brother-in-law of Charles VII. After 1444 until her death in 1450 she was the acknowledged mistress of the king, the first woman to hold that semiofficial position which was to be of such great importance in the subsequent history of the old regime. Her ascendancy dated from the festivals at Nancy in 1444, the first brilliant court of Charles VII. Her sudden death from dysentery, shortly after the birth of her fourth child in 1450, was

attributed, apparently without foundation, to poison.

SOREL, ALBERT (1842-1906), French historian, was born at Honfleur on Aug. 13, 1842. He was of a characteristically Norman type, and remained all his life a lover of his native province. He studied law in Paris, and entered the foreign office (1866). In 1870 he was chosen as secretary by M. de Chaudordy, who had been sent to Tours as a delegate in charge of the diplomatic side of the problem of national defense; in these affairs he proved himself a most valuable collaborator. After the war of 1870-71, when Boutmy founded the École libre des sciences politiques, Sorel was appointed to teach diplomatic history (1872), a post in which he achieved great success

Some of Sorel's courses have formed books: Le Traité de Paris du 20 novembre 1815 (1873); Histoire diplomatique de la guerre franco-allemande (1875); also the Précis du droit des gens which he published (1877) in collaboration with his colleague Théodore Funck-Brentano. In 1875 Sorel left the foreign office and became general secretary of the Présidence du sénat.

His duties left him sufficient leisure for the great work of his life, L'Europe et la révolution française (8 vols., 1885-1604). His object was to do over again the work already done by Stbel, but from a less restricted point of view and with a clearer and more calm understanding of the chessboard of Europe. He spent almost 30 years in the preparation of this history; the analysis of the documents, mostly unpublished, on French diplomacy during the first years of the Revolution, which he published in the Revue historique (vol. v-vii, xi-xiii), shows with what scrupulous care he read the innumerable despatches which passed under his notice.

Sorel was elected a member of the Académie française (1894). He died in Paris on June 29, 1906.

Sorel's other works include: La Question d'Orient au XVIIIe stècle,
Sorel's other works include: La Question d'Orient au XVIIIe stècle,
e les origines de la triple alliance (1878); Montesquieu (1887) and
Mme. de Stalet (1801) in the Grands écrivans series; Bonaparte et
Hoche en 1797 (1896) and Recueil des instructions données aux
ambassadeurs, vol. i only (1884). Most of his essays and articles
contributed to various reviews and to the Temps have been collected.

SOREL, CHARLES, SIEUR DE SOUVIGNY (1597-1674). French novelist, was born in Paris about 1597. In 1635 he was historiographer of France. He wrote Histoire comique de Francion (1622), Le Berger extravagant (1627) and Polyandre (1648). He died on March 8, 1674.

SOREL, a city of Quebec, Can., at the confluence of the Richelieu and St. Lawrence rivers, 45 mi. N.E. of Montreal; on the Canadian National railways. Pop. (1951) 14,961. It occupies the site of a fort built in 1665 by A. de Tracy to guard the route by way of the Richelieu to Lake Champlain and the Hudson. There are major shipbuilding and armament works.

SORGHUM, a cereal, forage and syrup crop plant grown largely in warm countries and known botanically as S. vulgare (Andropogon Sorghum or Holcus Sorghum), Sorghum probably

originated in Africa. It is one of the most important tropical grains. The types grown for grain (grain sorghum) are called by various names, including durra, Egyptian corn, great millet or Indian millet. In India it is known as jawari (Hindustani), jowari (Bengali), cholum (Tamil) and jonna (Telugu), and in the West Indies as petit mil or Guinez-corn. In China and Manchuria it is called kaoliang. It is a strong grass, growing to a height of from 2 to 8 or even 16 ft. The stalks and leaves are coated with a white waxy bloom. The pith in the stalks of different varieties may be juicy or rather dry. The juice may be sweet or non-sweet. The leaves are sheathing, solitary and about 2 in. broad and 21 ft. in length; the panicles are loose, contracted or dense. Self-pollination of the flowers is common but considerable cross-pollination occurs. The grains may be either free or retained in the hulls after thresh- MILLET OR GUINEA CORN (SORing. Many varieties are awned. The seeds are ellipsoid, rounded or flattened and of varied sizes somewhat smaller than wheat



GHUM VULGARE)

(A) Shoot, (B) Flowering stem (inflorescence), (C) Pistil, (D) Fruit, (E) Single flower, (C & E) Enlarged grains. The seeds may be white, yellow, red or brown. The hulls are mostly straw-coloured, red, brown or black.

Sorghum is the leading cereal grain in Africa and is important also in India, north China, Manchuria and the United States. It is grown to some extent in Russia, Persia, Arabia, Argentina, Australia and southern Europe, as well as in other regions. It is best adapted to warm conditions and is very resistant to drought and heat. Hundreds of varieties are grown in various parts of the world. The grain is similar in composition to that of maize except in being higher in protein and lower in fat. For food it usually is ground it to a meal and made into porridge, bread or cakes. Natives of south Africa refer to the product as "mealies." Whole grains sometimes are popped or puffed. The grain also is used in making alcoholic beverages. The sweet sorghums (sorgos) are grown chiefly in the United States and south Africa for forage or for syrup manufacture. The sweet stalks are chewed by natives in various countries. The broomcorn plant, belonging also to the species S. vulgare, is similar to other sorghums in adaptation and many r int characteristics.

For a full account of the cultivation and use of the species in India see Sir G. Watt's Dictionary of the Economic Products of India (1893).

See also W. W. Robbins, Botany of Crop Plants (1931). (J. H. Mn.)

SORIA, a province of Spain, formed in 1833 out of Old Castile. Pop. (1950 census) 161,182; area, 3,977 sq.mi. Soria is a bleak region, bounded on three sides by mountains. A range of sierras culminating in the peaks of Urbion (7,392 ft.) and Cebollera (7,024 ft.) on the north and the great Sierra del Moncavo (7,595 ft.) on the east separate the valley of the Duero from the Ebro. Almost the whole of the province belongs to the region watered by the Duero and its affluents. There are forests of pine, oak and beech and large tracts of pasture land. The climate is cold and dry, and the scenery austere.

SORIA, the capital of the Spanish province of Soria; on the river Duero (Douro). Pop. (1950) 16,878. The churches of Santa Domingo and San Nicolas, the collegiate church of San Pedro, the cloisters of the convent of San Juan, and several other ecclesiastical buildings are fine specimens of Romanesque work of the 12th and 13th centuries. Near the Duero are the ruins of the old citadel, and the 13th century walls remain.

SORITES, in logic, means a series of connected syllogisms, in which the conclusion of one syllogism is used as a premise in another. See Logic and the bibliography given there.

SORMOVO, a town of the Russian S.F.S.R., in the Nizhegorod region, on the Volga. It was a village of about 6,000 inhabitants in 1897, but grew after the provision of electric power to a population of 40,071. It manufactures machinery and refines crude Baku naphtha brought up the Volga river.

SOROCA, a town of Bessarabia, on the right bank of the Dniester, 81 mi. N.N.W. of Kishinev. Pop. (1930) 14,661, including many Jews. Corn, wool, fruit, wine and cattle are exported. Soroca was the old Genoese colony of Olchiona and still has the ruins of a 13th century Genoese castle. The Moldavians erected a fortress in the 15th century. Soroca changed hands many times between Poland, Russia and Turkey; in 1940 Rumania ceded it to the U.S.S.R. but regained it the next year.

SOROLLA Y BASTIDA, JOAQUIN (1863-1923), Spanish painter, was born at Valencia on Feb. 27, and studied at the academy there, in Italy and in Paris, where he especially interested himself in the works of J. Bastien-Lepage and A. von Menzel (qq.v.); he was also influenced by the north European realists, particularly A. Zorn (q.v.). His early paintings were of history and social realism (one of the latter kind, "Oltra Margarita," 1892, now at St. Louis, being his earliest success), but he later became well known for brightly lit scenes with Valencian peasants and fisherfolk and children playing in the surf, his style after about 1903-04 becoming impressionistic and summary, with heavily impasted pigments. Between 1910 and 1920 he painted portraits of Spanish writers and a "Panorama of the Forty-nine Provinces of Spain" for the Hispanic Society of America. He died in Madrid on Aug. 10, 1923.

BIBLIOGRAPHY.—A. de Beruete y Moret et al., Eight Essays on Joaquin Sorolla y Bastida, 2 vol. (New York, 1999); R. Doménech, Sorolla y (Madrid, 1919); A. de Beruete y Moret, Sorolla y Bastida (Madrid, 1920); Sorolla in the Collection of the Hispanic Society of America (New York, 1926).

SORORATE. This term was introduced by Sir James Frazer to designate all marriages with a wife's sister, whether in the lifetime of the first wife or after her death. In his view, generally accepted today, it is complementary to the custom of the levirate. (Folklore of the Old Testament, vol. ii, p. 317.) The concept already appears in E. B. Tylor's "On a Method of Investigating the Development of Institutions" (Journal of the Anthropological Institute of Great Britain and Ireland, vol. xviii, pp. 245-269, 1889), where levirate and sororate correctly figure as correlates of the postulate that matrimony is a bond between families rather than individuals. A. R. Radcliffe-Brown subsumes both institutions under the principle of the social equivalence of brothers and sisters, respectively. These relationship terms are to be understood in a classificatory sense, i.e., a more remote relative of the same sex may serve as secondary mate instead of a blood sibling. Though related in principle, levirate and sororate

are not invariably associated, but they usually are, and appear to be the commonest of preferential secondary marriages. Either may be permissive rather than obligatory. The Maricopa (Arizona) insist on a widow's marrying a husband's relative, whereas the replacement of a deceased wife by a kinswoman of hers is customary, but not compulsory.

Though successive and simultaneous marriage of two or more sisters falls under the same principle, some tribes, e.g., the Kazak, favour one, while tabooing the other practice. Hence it has become necessary to distinguish between sororal polygyny and sororate. The typical rule for the former is that the husband of the eldest girl in a family marries her juniors as they come of age; L. H. Morgan found this usage in at least 40 North American tribes; and even recently Navaho men often were simultaneously married to two sisters, occasionally to three. Australian aborigines recognized the same pre-emptive claim, but in many tribes the husband contented himself with the two oldest girls, conveying his claims on their younger sisters to his junior brother. With remarkable unanimity aborigines explain sororal polygyny on the ground that sisters are unlikely to quarrel as co-wives. The effect of both the sororate and sororal polygyny is to have children extend the term "mother" to the maternal aunt, but this terminological trait is more probably directly correlated with unilinear descent (George P. Murdock).

BIBLIOGRAPHY.—A. R Radcliffe Brown, The Social Organisation of Australian Tribes (Melbourne, 1931); R. H. Lowie, Social Organisation (New York, 1948); George P. Murdock, Social Structure (New York, 1949).

SORORITIES, national Greek letter organizations of women in colleges and universities in the United States and Canada. Sororities are self-perpetuating, each having a characteristic badge and symbolic insignia. In the 1950s there were more than 1,700 college chapters in about 250 colleges in the United States and Canada; about 3,900 alumnae groups and a total membership of about 800,000. The governments of all are similar—a council of five to nine members to carry out legislation enacted at national or district conventions. Many sororities have accumulated endowment funds, offer scholarships, maintain loan funds for members and support national philanthropic projects. Practically all sororities maintain a central office, publish quarterly magazines, song books. manuals and bulletins.

The National Panhellenic conference was formed in 1902 as an organization of national sororities. (R. L. F.; M. C. H.)

SORREL (Rumex acetosa) (family Polygonaceae), a hardy perennial, native to Great Britain, Europe and Asia, and found throughout the north temperate zone. The leaves are used in soups, salads and sauces and as a pot herb. Sorrel grows freely in any good garden soil, and is propagated either by seeds or by dividing the roots during the early part of spring. They should be planted in rows 15 to 18 in. apart. The leaves, when fully grown, are gathered singly. The common garden sorrel is much superior to the wild plant called dock in the United States; French sorrel (Rumex scutatus) is a hardy perennial, distributed through Europe but not native in Great Britain.

SORRENTO, a city of Campania, Italy (ancient Surrentum). Pop. (1951) 10,837. Sorrento stands on cliffs about 160 ft. high, between the Bay of Naples and the Bay of Salerno. It is a summer and winter resort, its northerly aspect rendering it comparatively cool. At Sorrento Bernardo Tasso wrote his Amadigi; Torquato Tasso was born there. The most important temples of the ancient city were those of Athena and of the Sirens, the latter the only one in the Greek world in historic times. The place was famous for its wine, its fish and its red Campanian vases. It was protected by deep gorges, except for a distance of 300 yd. on the southwest, defended by walls, the line of which is followed by those of the modern town. The arrangement of the modern streets also preserves that of the ancient town. On the east the most important ancient ruin is the reservoir of the subterranean aqueducts. which had 27 chambers. There are also remains of villas, including that of Pollius Felix, the friend of Statius.

SORSOGON, a municipality, capital and port of the province of Sorsogon, Luzon, Philippines, on the Gulf of Sorsogon, 279 mi.

de

from Manila. Pop. (1948) 26,004. Abacá (Manila hemp) is the chief product. Bikol is the vernacular. Of the inhabitants aged 6 to 19 inclusive, 35 6% were reported in 1939 as attending school.

SOSIGENES, Greek astronomer, and mathematician, probably of Alexandria, flourished in the 1st century B.C. According to Pliny (Nat. Hist. xviii, 25), he was employed by Julius Caesar in the reform of the Roman calendar (46 B.C.), and wrote three treatises. From another passage of Pliny (ii, 8) it is inferred that Sosigenes maintained the doctrine of the motion of Mercury round the sun, which is referred to by Cicero, and was also held by the Egyptians. He was the tutor of Alexander of Aphrodisias. He wrote Revolving Spheres, from which important extracts are preserved in Simplicius' commentary on Aristotle's De caelo.

SOSITHEUS (c. 280 s.c.), Greek tragic poet, of Alexandria Troas, a member of the Alexandrian "pleiad." He must have resided at some time in Athens, since Diogenes Laërtius tells us (vii, 5, 4) that he attacked the Stoic Cleanthes on the stage and was hissed off by the audience. Suïdas calls him a Syracusan. According to an epigram of Dioscorides in the Greek anthology (Anth. Pal. vii, 707) he restored the satyric drama in its original form. Part of his pastoral play, Daphnis or Lityerses, is extant.

See O. Crusius s.v. Lityerses in Roscher's Lexikon der griechischen und römischen Mythologie. The fragment in Nauck's Tragicorum graecorum fragmenta apparently contains the beginning of the drama.

SOSNOWIEC, a town of Poland, in Slask province. Pop. (1946) 77,853. It owes its importance to its position in the centre of Dabrowa coal field, near Bedzin, Dabrowa and Katowice. The towns of this region are almost continuous, extending from Kielce into the provinces of Kraków and Slask. Sosnowice is also a railway junction. Situated on the Warsaw-Vienna railway, it is a junction for the Kielce and Radom, Kraków and Lvov and Katowice and Breslau lines. Electric power stations were established. Iron foundries and textile factories, as well as coal mines, employ large numbers of workmen. Sosnowice was seized by Germany in World War II and was returned to Poland in 1945.

SOSTENUTO, musical term signifying that the passage so marked is to be played in a "sustained" manner.

SOTADES, Greek satirist, of Maronea in Thrace (or of Crete), chief representative of the writers of coarse satirical poems, called κίναιδοι, composed in the Ionic dialect and in a metre named after him "sotadic." He lived in Alexandria during the reign of Ptolemy II Philadelphus (285–247 B.C.). Sotades was imprisoned for a satire on Ptolemy, escaped to Caunus, was captured, shut up in a leaden chest and thrown into the sea.

Only a few genuine fragments of Sotades have been preserved (see J. G. Hermann, Elementa doctrinae metricae, 1816).

SOTER, pope from about 167 to 174. He wrote to the Church of Corinth and sent it aid. His letter is mentioned in the reply given by Dionysius, bishop of Corinth, and Harnack thinks it can be identified with the second so-called epistle of Clement.

SOTHERN, EDWARD ASKEW (1826-1881), English actor, was born in Liverpool on April 1, 1826, the son of a merchant. After acting in the English provinces, he went to the United States in 1852. There he made a great success in New York in 1858 as Lord Dundreary in Tom Taylor's Our American Cousin. He created the title role in T. W. Robertson's David Carrick (1864) and also made a hit as Sam Slingsby in John Oxenford's Brother Sam (1865). He died in London Jan. 21, 1881.

SOTHERN, EDWARD HUGH (1859-1933), American actor, was born at New Orleans on Dec. 6, 1859, the son of Edward Askew Sothern, noted English comedian. His first stage appearance was in a small part with his father's company at the Park theatre in New York city in 1879. He toured England in 1882-83, became leading comedian in McCullough's company in 1883, and under Daniel Frohman was leading man at the Lyceum theatre in New York city. He married Virginia Harned in 1896, and in 1899 formed his own company with her as his leading lady.

In 1900 he appeared in the title role of Hamlet, in 1901 in that of Richard Lovelace and in 1902—03 as Villon in If I Were King, three of his greatest roles. In 1904 he entered into combination with Julia Marlowe, the two first appearing together in Romeo and Juliet at Chicago. Except for two years, 1907—09,

appear that the physical basis of the theory of sound involves (s being the force required to produce unit displacement). Thus three fundamental considerations. First a vibrating body is essential to the production of sound; second, an elastic medium in contact with the vibrating body is required to transmit the vibrations to a distant point; and third, some form of receiver is necessary to absorb the energy from the medium and to reconvert it into a form of vibratory motion convenient for observation. We shall follow this order of treatment as far as practicable.

#### SOURCES OF SOUND

Vibrating Systems .- A fundamental advance in the theory of sound was made in 1843 when Georg Ohm proved that the simplest and most fundamental type of sound sensation is that which corresponds to a simple harmonic motion, i.e., to the simplest mathematical form of periodic function.

Such motions may vary in period and amplitude but in no other manner; they are consequently ideal for the production of "simple" or "pure" tones. Another important feature of this form of motion is the possibility of transmission from one medium to another without change of form. Again, it has been proved by J. B. J. Fourier that the most complex form of periodic motion can be analyzed (or synthesized) into a series of simple harmonic motions having frequencies which are multiples of that of the complex motion. The vibrations of a tuning fork may approximate closely to a simple harmonic motion, the resulting sensation being described as a "pure tone."

Simple Harmonic Motion is typified by the oscillations of a particle attracted toward a fixed point O with a force varying as the distance x from O. If s be the force at unit distance from O, then at x it will be -sx, the sign of the force being always opposite to that of the displacement. Thus if m is the mass of the particle

$$m^{\partial 2x}/\partial t^2 = -sx$$
 or, writing  $n^2 = s/m$ ,  $\partial^2 x/\partial t^2 + n^2x = 0$ 

of which the solution is

$$x = a \cos(nt + \epsilon)$$
 (2)

the constants a and  $\epsilon$  are arbitrary. The motion is therefore periodic, the values of the displacement x, and the velocity  $\partial x/\partial t$  of the particle recurring whenever nt increases by  $2\pi$ . The periodic time of the oscillation is therefore

$$T = 2\pi/n = 2\pi\sqrt{(m/s)} \tag{3}$$

a quantity independent of a. The type of vibration indicated by equation (2) is of fundamental importance. The equation shows that the particle oscillates between two points at a distance a on opposite sides of O. This distance a is called the amplitude of the vibration. The quantity e represents the initial phase of the vibration when t=0. By simple differentiation of equation (2) coordinate the velocity of the particle  $\partial x/\partial t = -an \sin(nt+\epsilon)$  and the acceleration  $\partial^2 x/\partial t^2 = -n^2 x$  as postulated in equation (1). The meaning of equation (2) for S.H.M. is often expressed graphically as the projection on a diameter of the motion of a point moving uniformly, with constant angular velocity n on a circular path of radius a, the periodic time (for one revolution) being  $T = 2\pi/n$ . The reciprocal of the period T, viz.,  $n/2\pi$ , is termed the frequency. The quantity n is sometimes called the pulsatance.

Practical demonstration of the relation between a simple harmonic motion and the corresponding circular motion may be seen in any type of reciprocating engine; the motion of the piston in the cylinder is approximately simple harmonic while that of the flywheel is circular with uniform velocity. A simple pendulum, a weight suspended on a spring, a rapidly vibrating wire, tuning fork or diaphragm all illustrate, approximately, simple differences in frequency and amplitude only.

The relationship (3) for the periodic time of vibration is of very de application in the theory of sound. It indicates the general

Order of Treatment. - From what has already been said it will factor m and decreases with the "stiffness" or "elastic factor" s in the case of a simple pendulum of length l, s = mg/l, from which the periodic time of an oscillation is  $T = 2\pi\sqrt{(l/g)}$ . The period of vibration of a mass m on a helical spring of strength s is expressed directly by (3), viz.  $T = 2\pi\sqrt{(m/s)}$ . We also obtain from (2), for the energy of the vibrating particle

Mean kinetic energy = Mean potential energy = ma?n2/4

Maximum energy =  $ma^2n^2/2$ .

The energy is a maximum at the mid-point and at the two turning points of the vibration. In the former case it is all kinetic and in the latter all potential energy.

When a single particle is acted on by a number of distinct forces, each of which would cause it to perform S.H M., the question arises as to the resultant motion A number of important cases require consideration: - I. Vibrations of the same frequency and in the same straight line It may be shown that such a system of vibrations is reduced to a single resultant by means of a vector polygon, the angles representing relative phases, in exactly the same manner as a system of forces acting at a point. II. Two vibrations of nearly the same frequency and acting in the same straight line: beats. This case has very important applications in sound and is of frequent occurrence. If two vibrations of the same amplitude and nearly equal frequency act together the resultant amplitude will at first be double the single amplitude. As the higher frequency vibration gains on the lower, however, thereby changing the relative phase, a point will be reached when they are in opposition and will neutralize each other (amplitude zero). This cyclic process goes on so long as both vibrations are maintained. If the two frequencies are N and  $N+\partial N$ , the resultant amplitude will vary between 2a and o, the time interval between two successive maxima being  $2\pi/\partial N$ , i.e., the frequency of the beats will be  $\partial N$ , the difference between the two, nearly equal, frequencies. The phenomenon of beats is observed when two notes nearly in tune are heard together - a periodic rise and fall of intensity being noticed. As the beats between two notes increase in frequency a sensation of roughness or discord (dissonance) sets in, and ultimately two independent notes of the diatonic scale are recognized. The beat effect has direct application in the comparison of one sound frequency (e.g., that of a vibrating string) with a standard of frequency such as a tuning fork. The well-known heterodyne of radiotelegraphy or telephony is a heat effect between two sets of radio-frequency (e.g., 106 cycles per second) oscillations, slightly mistuned. The beat-note is adjusted to have any frequency, say 500 periods per second, which falls within the audible range. III. Vibrations at rightangles. In this case we are dealing with the motion of a particle on a plane surface. When the imposed vibrations have the same frequency, it is readily shown that the particle traces an elliptical path, which may vary from a straight line, when the phases differ by 180°, to a circle when the phases differ by 90° and the amplitudes are equal. (a). Frequencies nearly equal. In this case the particle follows a path which slowly changes through the various forms, straight line, ellipse, circle, etc., due to the slowly changing phase difference. The frequency of performance of a complete cycle of figures will, of course, be  $\partial N$ , the difference between the two nearly equal frequencies. (b). Frequencies commensurate. 2:1, 3:1, 4:1, etc. Here again the particle traces out a curve having a certain number of Loops—this number being equal to the ratio of frequencies. For nearly commensurate frequencies the curve slowly changes as the phase difference varies. Numerous mechanical devices have been designed for drawing automatically the various "harmonic" curves obtained by compounding two or more harmonic vibrations. These generally consist of two compound pendulums controlling a common writing point, and each capable of performing simple harmonic motion; any differences in their motion arising from harmonic motion in one or possibly two directions simultaneously. Beautiful and fascinating designs may be traced in this

An optical method of exhibiting a small difference of frequency ale that the period T increases with the "inertia" or mass between two tuning forks was devised by J. A. Lissajous (18221880). A small mirror is attached to one prong of each fork, one of which vibrates in a vertical plane and the other horizontally. A narrow pencil of light is reflected successively from the two mirrors and falls on a screen. When the forks vibrate together the spot of light on the screen traces out the "resultant" curve of the two vibrations. If the two forks have the same frequency the figure is a stationary ellipse; if they differ slightly in frequency, the ellipse assumes successively the various forms including a straight line and a circle. These figures are known as Lissajous figures. The same principle may, of course, be applied to any two systems vibrating at right angles with approximately equal, or commensurate, frequencies. Recently Dye has employed the cathode-ray oscillograph for the harmonic comparison of very high electrical frequencies (of the order role p.p.s.).

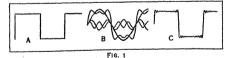
Fourier's Theorem.—Summation of any number of simple harmonic-vibrations of commensurate frequencies. Synthesis and analysis of complex wave-forms of vibration. This very important theorem due to J. B. J. Fourier (Theorie de la Chaleur. Paris, 1822) asserts that any single-valued periodic function whatever can be expressed as a summation of simple harmonic terms having frequencies which are multiples of that of the given function. (See Harmonic Analysis.) The theorem not only deals with the synthesis of a complex form of vibration, but also indicates a method of analysis of such a vibration into its component simple vibrations or harmonics. Thus if x is the resultant displacement at a time t, in a complex vibration of frequency n/2\pi,

$$x = f(nt) = A_0 + A_1 \cos nt + A_2 \cos 2nt + \dots + A_r \cos(rnt) + B_1 \sin nt + B_2 \sin 2nt + \dots + B_r \sin(rnt).$$
(6)

By suitable choice of the amplitude-values  $A_0$ ,  $A_1$ , etc.,  $B_1$ ,  $B_2$ , etc., it is possible to analyse or synthesise any form of single-valued periodic vibration. Thus the displacement curve represented by fig. 1 (a), may be obtained by adding a sufficient number of odd terms of a sine series. In fig. 1 (b) the first, third and fifth terms are added, in fig. 1 (c) the first fifteen odd sine terms are added. It will be seen that (c) approximates closely to (a), the more terms taken the more nearly does the synthesised curve approach the ideal. The mathematical analysis or synthesis of complex wave-forms may become very laborious. In order to simplify the process various mechanical "harmonic analyses" have been constructed (see Millar's "Science of Musical Sounds") which perform the necessary mathematical integrations, by a direct mechanical process. Fourier's theorem and harmonic analysis have a wide field of application not only in the study of sound-vibrations, but in astronomy, meteorology,

tide prediction, mechanical and electrical engineering.
Loudness, Pitch and Quality. Intensity, Frequency and
Wave-form.—Sounds differ from one another in three respects.

(i) Londness and Intensity.—These two terms refer to the subjective and physical aspects respectively. The intensity of a sound refers to a definite physical quantity which determines the rate of supply of vibrational energy (proportional to [amplitude]). Londness corresponds to the degree of sensation, being



dependent both on the intensity of the sound and the sensitiveness of the ear under the particular conditions. Near the limits of audibility loudness may be very feeble although the intensity be very great. The sensation of loudness varies over a relatively small range for enormous variations of intensity. An ear which can detect a feeble watch tick remains undamaged by a neighbouring explosion—although the range of intensity involved in these examples may be greater than rol<sup>22</sup> to r. The relation between sensation (loudness) and stimulus (intensity or amplitude) is generally expressed by Weber's law—"The increase of stimulus

necessary to produce a just perceptible increase of sensation is proportional to the pre-existing stimulus." This law indicates a rapid diminution of sensitiveness of the ear with increase of total intensity of the sound.

(ii) Pitch and Frequency. - The frequency of a regular or periodic vibration is the number of vibrations performed per second. Musical sounds arrange themselves in a natural order according to pitch. The latter depends solely on the predominant frequency of the vibrations-the greater this frequency the higher the pitch-and on the number of these vibrations reaching the ear per second. The latter stipulation is made to include sounds received from sources of sound in motion. This relation between pitch and frequency is simply verified by means of a revolving toothed wheel striking the edge of a card which produces a sound whose predominant frequency is proportional to the product of speed (revolutions per second) and the number of teeth on the wheel. For a given note the predominant frequency is the same whatever the source of the note, and the ratio of the frequencies of two notes forming a given musical interval is the same in whatever part of the musical range the two notes are situated. The more important consonant intervals with their frequency ratios are Unison 1:1, Major Third 5:4, Fifth 3:2, Major Sixth 8:5, Minor Third 6:5, Fourth 4:3, Minor Sixth 5:3, Octave 2:1. Notes whose frequencies are multiples of that of a given one the fundamental, are called harmonics. The frequency ratios defining each note of the diatonic musical scale are

The same series of ratios applies to any octave which may be chosen.

(iii) Quality and Wave-Form.—Sounds of the same pitch and loudness, but produced by different means, are distinguished by their quality. Thus the same note produced by a voice, a piano, or a violin, would have distinct characteristics which are at once recognisable by the ear. Very few sounds can be regarded as "pure," that is, free from overtones. The presence or absence of these overtones decides the quality of the sound. A tuning fork emits almost a pure tone whereas a violin note is rich in overtones characteristic of the instrument. Quality depends therefore on wave-form. Fourier's analysis of the wave-form of the sound emitted by a particular instrument tells us which harmonics are present and their relative importance.—On account of

Forced Vibrations, Damping, Resonance.—On account of the dissipation of energy by forces of a frictional nature, a vibrating body if left to itself, is gradually brought to rest. Its vibrations may be maintained, however, by the application of a suitable periodic force, which supplies the energy dissipated by friction and sound radiation. It is important to consider the relation between the frequency of such a force and the frequency of the free or natural vibration of the body. It is generally assumed that for small oscillations the frictional forces are proportional to the velocity of the particle. Consequently the equation of forces becomes

$$m\frac{\partial^2 x}{\partial t^2} + r\frac{\partial x}{\partial t} + sx = F\cos pt \tag{7}$$

where F cos pt represents the external periodic force of maximum value F and frequency  $p/2\pi$ , r is the resistance per unit velocity and s the restoring force per unit displacement. Writing  $s/m=n^2$ , F/m=f and r/2m=k it can be shown that the displacement x' is given by

$$x = \frac{f \sin \epsilon}{2kp} \cos(pt - \epsilon) \quad \text{where} \quad \tan \epsilon = \frac{2kp}{(n^2 - p^2)} \tag{8}$$

representing the forced vibration of period  $p/2\pi$  and amplitude  $f\sin e/kp$ . In the case where there is no friction, the damping constant k=0,  $\sin e=\tan e=0$ , e=0 or  $\pi$ , and



Amplitude of Forced Vibrations. —In the steady state of maintained oscillations, equations (8) and (9) represent the resultant forced motion. The amplitude A of the motion, is given by

$$A = \frac{f \sin \epsilon}{2kp} = \frac{f}{\{(n^2 - p^2)^2 + 4k^2\hat{p}^2\}^{\frac{1}{2}}} \left( \text{Since } \sin \epsilon = \frac{2kp}{\{(n^2 - p^2)^2 + 4k^2\hat{p}^2\}^{\frac{1}{2}}} \right)$$

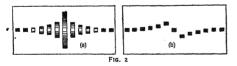
This expression is of fundamental importance. The amplitude A is a maximum when the denominator of the expression is a minimum, i.e., when  $p^2 = n^2 - 2k^2$  (provided  $n^2 > 2k^2$ ); the maximum value being then

$$A_{\max} = f/2kn. \tag{11}$$

In the case where there is no damping (k=0), and the free frequency n is the same as the forced frequency p, it will be seen that the amplitude A becomes infinite. Such a case of course never occurs in practice, for the damping k is never zero. For moderate values of damping  $(n^2 > 2k^2)$ , the forced amplitude  $A_{\max}$ . (equation [11]) is greatest when the forced frequency coincides with that of the free vibration, and may become very large when k is small. This condition is known as resonance. When dealing with sources of sound, we shall have occasion to refer frequently to resonant vibrations.

Phase of Forced Vibrations .- The force and the resultant forced vibrations are not necessarily in phase. From equation (8) we see that tane is always positive when p is less than n, that is  $\epsilon$  lies between o and  $\pi/2$  when the forced frequency is less than the free frequency, and tane is always negative when p is greater than n, that is,  $\epsilon$  lies between  $\pi/2$  and  $\pi$  when the forced frequency is greater than the free frequency. At resonance, when n=p,  $\tan\epsilon=\infty$  and  $\epsilon=\pi/2$ , i.e., the force and the displacement are "in quadrature" whilst the force and velocity are "in phase." Away from resonance, if the damping is small, the phase difference e will, in general, be nearly equal to o or to π, that is, the displacement will be in phase or out of phase with the force according as the frequency of the force is less or greater than the frequency of the free vibrations. These phase effects are beautifully demonstrated by means of a frequency meter of the vibrating reed type, viewed intermittently at, or very near, the frequency of excitation. The graduated series of reeds appear as in fig. 2 (a) when viewed in the ordinary way, but as in fig. 2 (b) when viewed intermittently. In accordance with the theory, the reeds on opposite sides of the resonant one are seen to be in opposite phase, with the resonant reed intermediate.

Power Dissipation.—In order to maintain vibrations against damping forces, a certain rate of energy supply is necessary. This is measured by the product of the force  $f \cos pt$  and the



particle velocity  $\partial x/\partial t$  (obtained by differentiating equation [2] with respect to t). The mean power required to maintain vibrations is thus found to be

$$W = \frac{f^2}{4k} \cdot \sin^2 \epsilon \tag{12}$$

This reduces to zero when  $\epsilon=0$  or  $\pi$  i.e. when k=0 (see equation [10]). In the case of damped vibrations at resonance the power dissipation is a maximum for

$$\epsilon = \pi/2$$
, whence  $W_{\text{max}} = f^2/4k$  (13)

Sharpness of Resonance.—The effect of damping becomes relatively more and more important as resonance is approached. At resonance the amplitude and power dissipation reach a maximum. The ratio of power dissipation W under specified conditions to that at resonance is given by

$$\frac{W}{W_{\text{max.}}} = \sin^2 \epsilon = \frac{4k^2}{\left(\frac{n^2 - p^2}{4}\right)^2 + 4k^2} \quad \text{[from (4)]}$$
 (14)

a relation indicating how the power required to maintain vibrations against frictional and radiation losses varies near resonance. It will be seen from (14) that the energy dissipated at a frequency  $p/2\pi$ , near resonance, is half the resonance value when

$$\left(\frac{n^2-p^2}{p}\right)^2 = 4k^2$$

that is when

$$(n-p)=\pm k$$
 (approx.) or  $\frac{p}{n}=1\pm \frac{k}{n}$ , (15)

i.e., when the frequency of the force differs from that of the resonator by the fraction k/n. This ratio k/n therefore constitutes a measure of the sharpness of resonance. The reciprocal of the ratio, i.e., n/k is sometimes referred to as the "persistence" of the vibrations. The smaller the damping k and the higher the natural frequency n, the sharper will be the tuning, and the greater the persistence of the vibrations. This principle has many striking and important applications. Thus in frequency standardisation, e.g., of tuning forks or quartz resonators, very great accuracy of tuning is essential, and the damping must be extremely small. In other cases, e.g., the faithful reception or reproduction of sound vibrations over a range of frequencies, resonance is distinctly undesirable, and the system must have a natural frequency  $(n/2\pi)$  removed as far as convenient from any possible values of the forced frequency  $(p/2\pi)$ , or, alternatively, the system must be heavily damped (k | k rge).

The damping constant k of a vibrating system is determined by direct measurement of the rate of decay of its free oscillations (from  $A_2=A_1e^{-k\tau}$ , or  $\log A_1/A_2=k\tau$  where  $A_1$  and  $A_2$  are successive amplitudes on the same side and  $\tau$  is the periodic time  $-k\tau$  is known as the logarithmic decrement of the oscillations). The damping coefficient k may be determined alternatively from observations of the sharpness of resonance.

Electrical Oscillations .- Alternating electrical and magnetic effects provide a very convenient means of exciting the corresponding mechanical vibrations. The advent of the thermionic three-electrode valve, as a simple means of producing electrical oscillations over a wide range of frequency and power, has greatly assisted in the rapid development in the design of electrical sound sources, and in electrical methods of receiving and recording sound waves. There is a close analogy between electrical and mechanical oscillations. If we replace inertia (mass) m in the mechanical system by inductance L in the electrical system, mechanical resistance r by electrical resistance R, spring factor (or stiffness) s by r/capacity (1/C), displacement x by quantity Q, velocity  $\partial x/\partial t$  by current  $i=\partial Q/\partial t$ , acceleration  $\partial^2 x/\partial t^2$  by rate of change of current  $\partial^2 Q/\partial t^2$ —the electrical equations become identical with the corresponding mechanical equations. Thus the electrical equation for the forced oscillations of a circuit containing inductance L, capacity C, and resistance R, is

$$L\frac{\partial^2 Q}{\partial x} + R\frac{\partial Q}{\partial t} + \frac{Q}{C} = E\cos pt \tag{16}$$

which is analogous to equation (7) for a mechanical system. With the substitutions mentioned above (with  $k\!=\!L/2R$  and  $f\!=\!E/L$ ) the solution of this equation is similar to equation (8) and the subsequent remarks relative to resonance and damping apply also to the electrical system. The frequency of free vibra-

tion of a mechanical system is  $N = \frac{1}{2\pi} \sqrt{(m/s)}$  (see equation [3]),

and the corresponding frequency of electrical oscillations is  $N = \frac{1}{2\pi} \sqrt{LC}$ . This is also the frequency at resonance in the case of forced vibrations provided the damping k and resistance

R are not excessive.

For the various methods of generating alternating currents, (e.g., by valve oscillators, interrupters, alternators, etc.) the reader should consult the article on Wireless Telegraphy.

Motional Impedance.—On account of the extensive use of electrical forms of sound generators and receivers it is very important in design to have a knowledge of their characteristics. In any form of machine which converts electrical energy into motion the moving mechanism reacts on the electrical circuit. Thus the revolving armature of an ordinary electric motor generates what is called a back e.m.f. in opposition to the applied voltage. This back e.m.f. may alternatively be regarded as an increased resistance to current flow in the armature, the efficiency of the motor being measured by the ratio of this resistance R relative to the total resistance (R+r) in the circuit; the net power used in the motor being a maximum when R=r, in which case the efficiency is 50%. In a similar manner the mechanical vibrating element of an electrical sound generator or receiver reacts on the electrical circuit, the back e.m.f. due to the vibration appearing as a change of impedance of the circuit. The change of impedance due to this cause is termed motional impedance and, relative to the total impedance, is a measure of the efficiency of the sound generator.

Transverse Vibrations of Strings.—When any point of a thin flexible wire stretched between two fixed clamps or bridges is displaced transversely and released, the wire commences to vibrate. This vibration results from transverse motions travelling in opposite directions along the string and successive reflections of these motions from the fixed ends. In order to visualize such reflection of a transverse motion it is well to make a few simple experiments on waves travelling along a stretched rope, one end of which is held in the hand while the other end is fixed. It will be observed that the movement of each particle of the rope when forming part of the reflected wave is in the opposite direction to its motion in the original wave. The rope assumes the form of a sine wave if the end is moved up and down harmonically. Before we can deduce the modes of vibration of a stretched string it is necessary to know the velocity with which a wave of displacement travels along the string and also the manner in which the direct and reflected waves affect each other to produce what are called stationary waves.

Velocity of a Transverse Wave Along a String.— The following method is due to Tait. The string is supposed to be drawn through an imaginary smooth tube with velocity c. The tube is straight except for an isolated curved portion which represents the wave on the string. If R is the radius of curvature at any point of the tube, the force acting in the direction of the normal to an element  $\delta s$  is  $T\delta s/R$  where T is the tension in the string. Now the centrifugal force of the element  $\delta s$ , of mass m per unit length, and velocity c will be  $m\delta s c^2/R$ , and this must balance the force  $T\delta s/R$  if there is to be no reaction on the tube. Thus if  $T\delta s/R = m\delta s \cdot c^2/R$ , then  $c = \sqrt{(T/m)}$  and there is no reaction on the tube, i.e., the tube may be regarded as absent and the wave travelling along the string with the velocity  $c = \sqrt{(T/m)}$ .

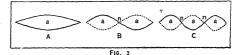
Reflection. Formation of Stationary Waves.—If both ends of the string of length l are fixed, the wave is reflected successively from end to end, and the resultant motion is determined by the superposition of the direct, or incident wave, and the reflected wave. The resultant displacement y at the instant t of a point distant t from one end will be y=f(t-x)-f(t-t), where f indicates "a function of." Since y=0 when x=l we have also f(t-l)=f(t+l), or f(z)=f(z+z) where z=(t-l), which indicates that z is periodic function repeating at intervals of zl. Consequently the c isplacement at any point of the string is periodic, the period T=zl/c being the time taken for a wave to travel along the full length of the string and back again. The frequency of this form of vibration is consequently N=c/zl where  $c=\sqrt{(T/m)}$ , i.e.,

$$V = \frac{1}{2l} \sqrt{\frac{T}{m}}.$$
 (17)

If the displacement y varies sinusoidally with a frequency  $n/2\pi$ ,

we have y=sa cos n(t-x/c)-a cos n(t+x/c) which reduces to y=2a sin  $nt\cdot\sin(nx/c)$ . (18)

At any point x on the string the amplitude is therefore  $2a \sin nt$ , varying sinusoidally with time between zero and 2a. The amplitude of successive particles is also varying with x according



to a sine law. The result is a series of loops on the string of amplitude o to 2a. The condition for the formation of loops on a string of finite length l is clearly that in which l is a whole multiple of the length of a loop, i.e., provided the number of loops is  $1, 2, 3, \ldots$  etc. The fundamental frequency n of the string is given by (17), the various possible overtones are simple multiples of n, i.e., they form a harmonic series. The modes of vibrating with 1, 2, 3 loops is shown in fig. 3. The points marked n, which are permanently at rest during the vibrations, are called nodes, while the points marked n where the amplitude is a maximum are called antinodes or loops. It will be evident that the string could be clamped at the nodes n without affecting the motion of the remainder of the string. Denoting the wave length of the vibration by  $\lambda$  we must have  $N'\lambda = c = \sqrt{(T/m)}$  whence the frequency

$$N' = \frac{s}{2l} \sqrt{\frac{T}{m}} \tag{19}$$

s being the number of loops, *i.e.*, half wave lengths, into which the string of length l is divided.

The string may vibrate with any of the frequencies given by equation (19) at the same time, i.e., a note may be produced which is made up of the fundamental and a number of harmonics. The laws of a vibrating string indicated by equation (19) may easily be verified by means of a monochord or sonometer, which consists essentially of a thin metallic wire (e.g., steel piano wire) stretched over two bridges by means of a weight hanging over a pulley, or by a spring tensioning device. A movable bridge provides a convenient means of varying the vibrating length of the wire. The monochord is a very useful means of comparing frequencies-the frequency of the string being inversely proportional to the vibrating length. Exact tuning is indicated by the "beats" between the monochord note and the note compared with it. The various overtones of a string may also be very simply demonstrated by means of the monochord, the string being lightly damped at any point corresponding to a node and plucked or bowed at a point corresponding to an antinode of the overtone required to be excited. The positions of the antinodes are easily determined by means of little paper riders.

Stiffness of Strings and Yielding of Supports.—When the thickness of the string becomes appreciable in relation to the length of a loop, the stiffness may have a perceptible effect on the frequency of vibration—this effect becoming more and more important the higher the overtone excited (i.e., the greater the number of loops). Where great accuracy is required a modification of equation (10) is necessary, viz.

$$N = \frac{s}{2l} \sqrt{\frac{T}{m} \left\{ 1 + \frac{\pi^3 s^2 r^4 E}{8l^2 T} \right\}}$$

where r is the radius of the circular section of the wire and E Young's modulus of elasticity for the material. Yielding of the bridges supporting the wire may have the effect of increasing or decreasing the frequency according as the supports have (a) very large mass M but small spring factor or (b) very large spring factor  $\mu$  and negligible mass. The effects of (a) and (b) are equivalent to a change of length of the string in the radius  $x:(x-2TI/Ma^2s^2\pi^2)$  and x:(x+2T/MI) respectively.

Methods of Producing Vibration in Strings. Quality.-A stretched string may be set in vibration by numerous methods. Plucking, bowing and striking are the more familiar; exemplified in the harp, the violin, and the piano, respectively. A string may also be set in vibration by forced oscillation of a point of support, e.g., if one end is attached to the prong of a vibrating tuning fork (Melde's experiment). Electromagnetic methods may also be used to excite a metallic string. In one of these methods a light metal wire is attached at right angles to the vibrating wire and arranged to dip in a small cup of mercury at each downward movement. A current passing through this intermittent contact actuates a small electromagnet which maintains the wire in vibration in the same manner as an electric bell is operated. In another method the vibrating wire itself carries an alternating electric current and lies in a permanent magnetic field. When the frequency of the current and position of the magnet are suitably chosen one of the numerous possible overtones of the wire will be readily excited. It will be appreciated that the method of excitation has a very important influence on the form of the wave which travels along the string. The quality of the note is of course dependent on this wave form, i.c., on the relative amplitudes of the various overtones present in the vibration. It is just this addition of overtones to the fundamental which makes it possible for the ear to distinguish between the sounds of a piano, a violin, and a harp, emitting the same fundamental note.

Strings as a Source of Sound: The Sounding Board.—A vibrating wire rigidly supported would radiate extremely little sound energy to the surrounding air on account of the local reciprocating flow of air between opposite sides of the vibrating wire. It is necessary in an efficient stringed sound source that the bridges should yield and communicate the vibrations to a surface of large area, i.e., to a sound board, in contact with the medium. This sound board is therefore a vital part of all stringed musical instruments—it is important, however, in a good instrument, that the sounding board should have no predominant resonance frequencies of its own, otherwise these would reinforce dispropor-

tionately the corresponding frequencies of the strings.

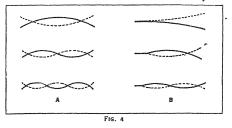
Transverse Vibrations of Elastic Rods.—The vibrations of a stretched wire are controlled by the tension whilst the stiffness of the wire may generally be disregarded. In the case of a relatively thick wire or rod the stiffness may become all-important and tension may ultimately be disregarded. Even when simplified as far as possible the theory of transverse vibrations of elastic rods is very complex in comparison with the theory of strings. In the case of strings, harmonic waves travel with a velocity independent of wave-length but in the case of rods or bars this is not so. It is shown in textbooks of sound (see Bibliography) that the velocity of a transverse elastic wave in a rod is proportional to  $t \cdot \sqrt{(E/\rho)} \cdot / \lambda$  where t is the thickness in the direction of displacement, E elasticity,  $\rho$  density, and  $\lambda$  the wavetength. The velocity is thus dependent on the wavelength, a fact which makes the theory much more complex. It may be shown that the possible frequencies of transverse vibration of a bar are given by

$$N = C \frac{k}{P} \sqrt{\frac{E}{\rho}} \tag{20}$$

where k is the radius of gyration of the section of the bar about the neutral plane, and l is the length of the bar  $(k^* = P/lz)$  for a rectangular bar of thickness l. The value of the constant C depends on the method of supporting or clamping the bar and on the overtone to be excited. The frequency is therefore proportional to the velocity of longitudinal waves  $\{(E/p)\}$  in the material of the bar. It also varies as the thickness (or radius) and inversely as the square of the length of the bar. As in the case of strings, stationary waves are set up in rods by the combined effects of the direct and reflected waves. The possible forms of these stationary waves depend on the method of supporting the rod. Some of the modes of vibration of a free-free rod, i.e., entirely tree or supported at two nodes, are shown in fig. 4a; whilst the self-actionary these bar, i.e., a bar fixed

in direction at one end and free at the other.

In the case of the free-free bar the constant C in equation (20) for the frequency is equal to  $\frac{\pi}{8}(4s\pm 1)^2$  where s may be 1,2,3,3 etc. i.e., the possible frequencies are proportional to the squares of the successive odd numbers commencing at 3. For a clambed-free bar the constant C in equation (20) is approximately equal to  $\frac{\pi}{8}(4s\pm 1)^2$  where s may be 0, 1, 2, 3, etc. More accurate values for  $(4s\pm 1)$  in the case of the fundamental (s=0) and the first overtone (s=1) are 1-1037 and 2-9884 respectively. The

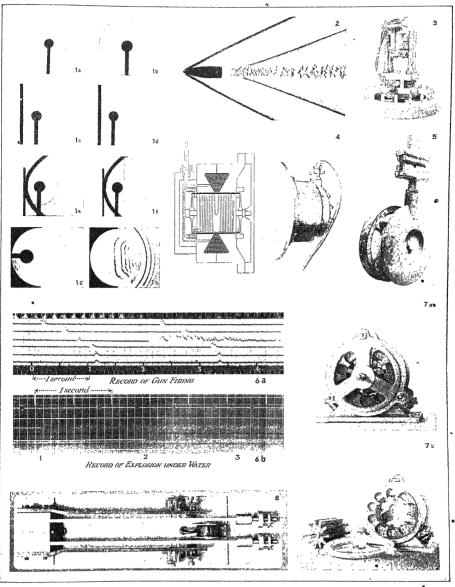


frequencies of the first three tones relative to the fundamental are consequently 1, 6-25 and 17-6 approximately. The relation  $N \subset k \cdot d(E/\rho)/P$  has been experimentally verified by a number of physicists, both in the case of the free-free and the clamped-free

Applications and Methods of Excitation .- As in the case of strings the transverse vibrations of a bar may be excited by striking, plucking, bowing, or by electromagnetic means, the partials present, and consequently the quality of the note being dependent on the method of excitation. The only method of supporting a bar which yields "harmonic partials" is the freefree method, which has application in a musical instrument known as the "harmonicon" or "dulcimer" in which freely supported bars of graded lengths are struck by a hammer, thus producing an agreeable succession of musical tones. Thin rods or reeds, clamped at one end and excited by plucking, are used in the "musical box" so well known. Used in combination with suitable air cavity resonators, clamped-free reeds are fitted in various musical instruments, notably the clarinet group. The combined action of an air blast and a vibrating reed is illustrated in the concertina and the harmonium, whilst in the reed pipes of an organ the reed is combined with a resonant air column. The reed of the telephone earpiece designed by S. G. Brown is operated electromagnetically. It is used in an almost unstable condition, the pull of a permanent magnet being nearly sufficient to overcome the stiffness of the reed. This results in a large increase of sensitiveness to the superposed alternating magnetic field.

sensitiveness to the superposed atternating magnetic item. Frequency Moters form a good example of the electro-magnetic or direct mechanical excitation of reeds. The frequency meter consists essentially of a graded series of clamped steel reeds actuated by a common electro-magnet supplied with alternating current of which the frequency is required. Such instruments have been made covering various ranges from 1 or 2 to 1,500 cycles per second. The frequency of a clamped-free bar may be lowered either by loading the free end or by reducing the cross section near the clamped end. The frequency may be raised either by shortening the bar or reducing the cross section near the free end.

Tuning Forks.—On account of its great purity of tone and constancy of frequency the tuning fork is generally regarded as a standard of frequency and pitch. During recent years it has increased enormously in importance as a frequency standard for controlling electrical circuits, in such a manner as to form an electrical standard of great accuracy and of extensive range.



- Spark-Shadow Photographs illustrating reflection from plane and curved surfaces. (Figs. a to f by A. L. Foley; g & h are comparative spark and ripple photographs by A. H. Davis)
- Fig. 2. Spark Photograph of 8 m.m. bullet in flight. (Cranz)
- Fig. 3. Under-water Sound Transmitter. (Hahnemann)
- Fessenden Oscillator
- Fig. 5. Directional Hydrophone
- Sound-ranging records (a) Army, (b) Navy Phonic Motor (a) assembled, (3) in parts
- Fig. 8. Electrically-maintained Tuning Fork

The tuning fork may be regarded either as a development from a free-free bar bent into the form of a U, or as consisting of a bair of symmetrical clamped-free bars attached to a common block of metal. Numerous patterns are in existence approximating to one or other of these two forms. It will be sufficient here to regard each prong as a clamped-free bar. In consequence of the oscillation of the centre of gravity of the two bars as they vibrate there will be communication of vibration to the block to which they are clamped. To reduce the amplitude of this vibration, which is in the direction of the prongs, the block must be firm and massive. The frequency of a fork of this construction with prongs of rectangular section of thickness t will therefore be

$$N = (1.1937)^{2} \cdot \frac{\pi}{8} \cdot \frac{t}{\sqrt{12.12}} \sqrt{\frac{E}{0}}$$
 (21)

that is,  $N=8\cdot24\times 10^4/l^2$  if the prongs are of steel in which  $\sqrt{(E/\beta)}=51\times10^6$  cms /sec. The frequency of a fork will therefore vary directly as the thickness of the prongs and as the velocity of sound in the material, and inversely as the square of the length of the prongs. The first and second overtones of a fork will have frequencies  $6\cdot25N$  and  $17\cdot6N$  respectively. These overtones may easily be excited in a large fork by bowing at suitable points.

The fundamental tone of a tuning fork may be selectively reinforced by attaching the stem to a resonance box of the same frequency—the overtones of the fork and the air cavity are widely different and do not reinforce each other. Two forks of nearly the same pitch may be compared by the method of beats, which gives in a very simple and direct manner the difference in frequencies. This method is also useful in studying the effect of temperature on the frequency of a fork—the one fork is kept under standard conditions whilst the temperature of another is varied. The temperature coefficient of frequency for a steel fork determined in this way is approximately—10<sup>-4</sup> per degree C rise of temperature. The temperature coefficient of a fork made of elinvar steel is about one tenth of this.

Electrically Maintained Forks .- The vibrations of a lowfrequency fork may readily be maintained by means of electrical contacts controlled by the prongs and an electro-magnet situated between them. The mode of operation is similar to that of an electric bell. Forks of higher frequency (of the order of 1,000 p.p.s.) are maintained by means of electromagnets arranged in a special form of 3-electrode valve circuit devised by Eccles. Electrically maintained forks may be used to drive what are known as phonic motors (see Figures 7 and 8 on Plate), the vibratory motion of the fork being thereby converted into a rotary motion of combined accuracy and constant speed. Electrically maintained forks and phonic motors, with their applications in standard frequency determinations, are described in A. B. Wood's Textbook of Sound. Forks are now in common use as sub-standards of time. The period of a fork is a very constant quantity and serves as a convenient sub-division of a second when time intervals have to be measured with accuracy. As a consequence of the increased application of the tuning fork for this purpose, methods have been devised for increasing the accuracy and perfection of electrically maintained forks. Low-frequency forks of this character giving an accuracy greater than 1 in 10,000 are in common use. If particular care is taken with the choice of material, design, and control of the fork, an accuracy of 1 in 105 or even 1 in a million is possible.

Electrically maintained forks of this nature are used to control electrical "multi-vibrator" circuits which serve as frequency standards for all frequencies which are multiples of that of the fork, e.g., in steps of 1,000 cycles, up to 1.5 million cycles per second. The tuning fork thus functions as a standard of radio-frequencies. It is possible to maintain an electrically driven fork by means of the "seconds" contacts of a standard pendulum clock. Such clock controlled forks are not subject to temperature variations, etc., and remain accurately in step with the standard clock over relatively long periods of time.

Longitudinal Vibrations of Rods.—When a rod is set into longitudinal vibration its axis remains undisplaced whilst cross-

sections vibrate to and fro in the direction of the axis of the rod. The quantities involved are the density of the material and its elastic properties. Consider a rod of cross section A and an elementary slice of it bounded by two planes at x and  $x+\delta x$  at right angles to the axis x of the rod. If the plane at  $x \nmid \delta t$  sisplaced at the time t to  $x+\xi$  the plane at  $x+\delta x$  will be displaced to  $x+\delta x+\xi+d\xi/dx.\delta x$ , that is, the actual elongation of the slice is  $d\xi/dx.\delta x$  and its fractional elongation of  $d\xi/dx$ . This change in thickness of the slice implies a difference in the forces acting on its faces. The total force acting on the face at x will be  $EAd\xi/dx$  where E is Young's Modulus of elasticity. Similarly at the opposite face of the slice the force will be in the opposite sense and equal to  $EA(d\xi/dx-\delta x.d\xi/dx)$ . Consequently the resultant force acting on the slice will be  $EA.\delta x.d\xi/dx$ . Now the mass of the slice is equal to  $\rho A\delta x$ , where  $\rho$  is the density of the material, and the acceleration is  $d\xi^2/dx$ . We have therefore

$$\rho A \delta x \cdot \frac{d^2 \xi}{d l^2} = E A \frac{d^2 \xi}{d x^2} \cdot \delta x \quad \text{or} \quad \frac{d^2 \xi}{d l^2} = \frac{E}{\rho} \cdot \frac{d^2 \xi}{d x^2}$$
 (22)

an equation of the same form as that obtained for the transverse motion of a string, indicating a wave travelling along the rod with velocity  $c = \sqrt{(E/\rho)}$ . The above treatment is approximate only, since it ignores lateral bulging or contracting of the sides of the rod. The result is, however, sufficiently true provided the  $^{\rm flav}$  elength  $\lambda$  is great compared with the width or thickness of the rod. As in the case of vibrating strings the direct and end-reflected waves in a rod of finite length form stationary waves with nodes and antinodes in accordance with the relation

 $c=N\lambda=\sqrt{(E/\rho)}$  or  $N=\frac{1}{\lambda}\cdot\sqrt{(E/\rho)}$ . In the fundamental mode of vibration of a free bar  $\lambda=il$  and the various partials require  $s\lambda=2l$ . Consequently the expression for the frequencies of the partial tones is

$$N = \frac{s}{2l} \sqrt{\frac{E}{\rho}},\tag{23}$$

which is similar to equation (19) for strings, the tension T being now replaced by the elasticity E. When the bar is clamped at the mid point, an important practical case, all partials requiring an antinode at that point are suppressed, consequently only the odd partials are present. It will be seen that the partials given by (23), form a harmonic series—provided N/2 is always large compared with the diameter or thickness of the rod and that lateral bulging and shrinking may be neglected.

The frequency of longitudinal vibrations in bars is usually very high compared with that of the transverse modes, the ratio increasing rapidly as the diameter or thickness diminishes relative to the length. The nodes of a bar vibrating longitudinally are points of maximum stress, whereas the antinodes are points of zero stress. Biot and Tyndall demonstrated this fact to a large audience by means of passing polarised light through the node of a vibrating strip of plate glass. The analyser was set at extinction before the rod was set in vibration so that no light was seen on the screen. On stroking the rod with a resined cloth vigorous vibrations were set up and intermittent light was passed on to the screen. No such effects were observable at the antinodes where there is no stress.

Methods of Excitation.—Rods of metal, wood, or glass, clamped the midpoint or at one end, are readily set in vibration by the steady frictional drag of a resined cloth drawn, with a moderate pressure, along the rod towards an antinode. Another method, more suitable for relatively short stiff rods, is to strike the end a sharp blow with a hammer. This method usually results in a complex sound due to both transverse and longitudinal vibrations—the one or the other may be rapidly damped out by clamping at a suitable point.

Electrical Methods of Excitation.—Powerful longitudinal vibrations may be set up in bars of magnetic material by asting on them with alternating magnetic fields of the resonating frequency. Using a small alternating current magnet (with iron wire core) mounted close to the end of a steel bar, the fundamental and harmonics can readily be excited as almost pure tones. The resonance is extremely sharp (indicating very small internal damping) and careful tuning is required. Vibrations have been obtained in non-magnetic rods by electrostatic methods (J. H. Vincent, Natures. Dec. 31, 1927) the end of the vibrating rod forming one plate of a condenser supplied with high frequency alternating current from a valve oscillator. (See Ellectron Tube.)

Longitudinal Vibrations of High Frequency in Piezo-Electric Crystals.—Certain crystals, notably quartz and rochelle salt, have the property of changing their linear dimensions when subjected to electrostatic stress, and conversely they develop electrical charges on their faces when mechanically strained. The phenomenon is known as piezo-electricity (discovered by P. Curie, 1880). The best effects are obtained when slices or rods of the crystal are cut in certain specified directions relative to the optic axis. Voltage applied to the faces at the ends of the electric axis produces a change of thickness and length of the crystal. If alternating voltage is applied, the thickness and length fluctuate accordingly, the maximum effects being produced when the frequency of the electrical alternations coincides with the natural frequency of longitudinal elastic vibration. W. G. Cady (Phys. Rev., 19, p. 1, 1922) has made use of this property of a quartz crystal in the construction of standards of high frequency, with particular application to radio-frequency standardisation. A special electrical circuit which we need not consider here was employed to detect the resonance in the quartz. Thus Cady found that a quartz resonator 30x4x1.4 m.ms. vibrating longitudinally in the direction of its length had a fundamental frequency of 89,870 cycles per second. The tuning was so sharp that a change of frequency of 1 cycle per second was measurable. The overtones were also excited and found to approximate to harmonics of the fundamental. G W. Pierce (Proc. Amer. Acad., Vol. 59, Oct. 1923 and Vol. 60, Oct. 1925) has succeeded in controlling the frequency of an oscillating valve by means of such a crystal. In this manner a quartz oscillator may be used as a frequency stabiliser for radio purposes.

Quartz plates vibrating longitudinally in the direction of their thickness (the electric axis) have been employed by Langevin, Boyle, and others as a source of suber-sonic vibrations, more particularly for use under water. The same apparatus is used in the converse process of reception, for the alternating pressure of the arriving sound waves produces corresponding electrical effects which, when suitably amplified and heterodyned, can be heard in telephones. Langevin and Boyle have employed this apparatus for the detection by an echo method of submerged objects (wrecks, icebergs, etc.), the sound emitted from a large disc of quartz being sharply directional and therefore suitable for such purposes. (See numerous papers by R. W. Boyle in Proc. Roy. Soc. of Canada 1922—28.) R. W. Wood and A. L. Loomis, using a piezo-electric quartz crystal vibrating at frequencies of the order 5x106 cycles per second have obtained striking effects of a physical and biological nature (Phil. Mag., Sept. 1927). With the crystal vibrating under oil, they estimated the pressure of the sound radiation to be equal to 150 grams weight—the free surface of the oil being raised into a mound 7 cm. high!

The uses of Rochelle salt as a sound generator and receiver have been demonstrated by Nicholson (Amer. Inst. Elect. Eng. Proc., Nov. 1919) who in one application used the crystal to replace a gramophone sound-box, the amplified e.m.f.s produced in the crystal being sufficient to operate loud-speakers or telephones. The elasticity of Rochelle salt is very small,  $E=3\times ro^3$  as compared with  $8\times ro^{11}$  for quartz and  $2\times ro^2$  for steel. (An excellent bibliography on piezo-electricity and its applications is given by W. G. Cady in the Proc. Inst. Radio Engineers, April 1928.)

Torsional Vibrations of Rods.—A solid rod or tube of circular, section may be twisted in such a way that each transverse section remains in its own plane. If the section is not

<sup>1</sup>A. W. Pierce and J. H. Vincent have excited rods of nickel (and alloys of nickel-iron) into resonant vibration by magnetostriction.

circular, a warping is liable to take place and the analysis is very complex. Consider a tube of radius r and thickness  $\delta r$  and let  $\theta$  be the angular displacement of any section distant x from the origin. The "shear" of the material of the tube is  $r \cdot \partial \theta / \partial x$ . The opposing elastic force per unit area is  $\mu r \partial \theta / \partial x$  where  $\mu$  is the coefficient of rigidity of the material  $(\mu = E/x(\sigma + 1)$  in which E is Young's modulus and  $\sigma$  is Poisson's ratio). Since the area of section of the tube is  $2\pi r \delta r$  the moment of this force round the axis is  $2\mu \cdot \pi r^2 \delta r \cdot \partial \theta / \partial x$  and the restoring force acting on the slice of thickness  $\delta x$  has the moment  $2\mu \pi r^2 \delta r \cdot \partial \theta / \partial x^2$ . Now the moment of inertia of the slice is  $2\pi r \delta r \cdot \delta x \cdot \rho r^2$  ( $\rho$  is the density of the material) whence the equation of motion is

$$\rho \frac{\partial^2 \theta}{\partial t^2} = \mu \frac{\partial^2 \theta}{\partial x^2} \quad \text{or} \quad \frac{\partial^2 \theta}{\partial t^2} = c^2 \frac{\partial^2 \theta}{\partial x^2} \quad \text{where} \quad c = \sqrt{\frac{\mu}{\rho}} \quad (24)$$

which is independent of r, and therefore equally applicable to tubes of all radii and to a solid rod. The velocity of tersional vauve transmission is  $c = \sqrt{(\mu/\rho)}$ . The ratio of this velocity to the corresponding longitudinal velocity is  $\sqrt{(\mu/E)} = 1:\sqrt{(2(\sigma+1)]}$ . Taking  $\sigma = 0.25$  for a steel rod the ratio of velocities becomes 1.58. The possible frequencies of torsional vibration of a rod will be

$$N = \frac{s}{2l} \sqrt{\frac{\mu}{\rho}} \tag{25}$$

analogous to the harmonic series for the longitudinal vibrations. Torsional vibrations are readily set up by applying tangential forces of a fricţional character, e.g., by means of a resined cloth, to the free end of a rod clamped at a suitable point.

Vibrations of Membranes.—The transverse vibrations of stretched membranes are related to those of diaphragms and plates in a manner analogous to the transverse vibrations of stretched strings and elastic bars. In the former case the vibrations are conditioned by the applied tension and are independent of elastic forces, whereas in the latter the elastic forces are all-important and tension almost negligible.

By analogy with the case of wave motion in one dimension (a stretched string) it may be shown that the equation

$$m\frac{\partial^2 \xi}{\partial \ell^2} = T\left(\frac{\partial^2 \xi}{\partial x^2} + \frac{\partial^2 \xi}{\partial y^2}\right) \tag{26}$$

represents the motion of a stretched, two-dimensional-membrane where T is the tension m the mass per unit area  $(\rho \times \text{thickness})$  and  $\xi$  the transverse displacement at a point xy. The velocity of wave motion is  $c = \sqrt{(T/m)}$  as in the case of strings. The complete mathematical analysis for stretched membranes of various shapes is given in Rayleigh and Lamb's treatises on Sound. In the case of a circular membrane of radius a the fundamental frequency is shown to be

$$N = \frac{0.765}{2a} \sqrt{\frac{T}{m}}.$$
 (26a)

In the higher partials the diaphragm becomes divided into nodal rings and diameters.

Membranes approximating to the ideal type have been made from soap films, or films of thin collodion, stretched on a metal ring, the vibrations of such thin films being examined by optical methods. Sheets of parchment or of thin metal (steel) are more suitable when it is required to examine the effects of tension. Wente's condenser microphone (see fig. 16a) (see MICROPHONE) has a highly tensioned steel membrane of fundamental frequency about 10,000 cycles per second. The various modes of vibration of a steel membrane are conveniently studied by means of a small electro-magnet (the magnet system of any ordinary telephone receiver will serve the purpose) and a valve oscillator with a suitable range of frequency-control. As a rule, the agreement between theory and observation is only approximate, for the theory generally given takes no account of the serious damping and loading of the diaphragm due to the medium (air) in contact with it. The stiffness of the membrane is not always negligible as assumed in the theory. Examples of membranes as sources of sound are to be found in various forms of drums, tamborines, etc. In the drum, the vibrations of the membrane are reinforced by the vibrations of an air cavity in resonance with it.

Vibration of Diaphragms.—When elastic restoring forces are called into play and tension is of secondary importance we come to the case of the diaphragm. Rayleigh has calculated the periods and motions in vacuo, of a thin circular elastic plate rigidly clamped at the edge. By means of a complex analysis he found that the fundamental frequency of vibration is given by

$$N = \frac{2 \cdot 96}{2\pi} \cdot \frac{h}{a^2} \sqrt{\frac{E}{\rho(1 - \sigma^2)}}$$
 (27)

where h is the thickness and a the radius of the diaphragm, E Young's modulus,  $\rho$  the density and  $\sigma$  Poisson's ratio for the material. More recently, Lamb (Roy, Soc, Proc, A, Vol, 98, 1020) has calculated the frequency and damping of circular diaphragms in air and in water, the value of the frequency in air agreeing closely with Rayleigh's estimate. Thus for a steel diaphragm  $E = 2 \times 10^{18}$ ,  $\rho = 7.8$ ,  $\sigma = 0.28$ , whence  $c = \sqrt{(E/\rho(1-\sigma^2)]} = 5.27 \times 10^5$  cms,/sec., and  $N = 2.5 \times 10^5$  .  $h/a^2$  cycles per second. If h = 0.1 cm, and a = 5 cms, N will be 1,000 cycles per second in air. The addition of a load m to the centre of a diaphragm of mass M has the effect of lowering the frequency given by (27) in the ratio  $1/\sqrt{(1+Sym}/M)$ .

Diaphragm Vibrating in Contact with Water or Other Medium .-The presence of an extensive medium, say water, in contact with the diaphragm has two effects, (1) the frequency is lowered on account of the loading due to the added mass of water vibrating with the diaphragm, and (2) the vibrations are damped owing to the energy radiated as sound waves into the water. Lamb has shown in the case of a diaphragm with one side only in water, that the inertia of the diaphragm is increased in the ratio  $(1+\beta)$  where  $\beta = 0.6689 \rho_1 a/\rho h$  ( $\rho_1$  being the density of the water,  $\rho$  the density of the material of the diaphragm, a the radius and h the thickness). The frequency given by (27) must therefore be divided by  $\sqrt{(1+\beta)}$  in this case. When both sides of the diaphragm are immersed the value of  $\beta$  must be doubled. The persistence of the vibrations is given by  $N/k = 0.385(1+\beta)^{3/2}\rho c_1/\rho_1 c$ , where  $c_1$ is the velocity of sound in the medium and c in the material of the diaphragm. Thus, in the above example where the frequency, is modified by the water, is about 550, the range over which the energy will exceed half the maximum (indicating sharpness of resonance, see page 8) lies between 530 and 570 p.p.s. The persistence is increased, and the resonance is sharpened, the thinner the diaphragm and the greater the load.

Diaphragms form one of the most convenient means of producing and receiving sounds in air or in water. Numerous forms of diaphragm telephone receivers and microphone transmitters are in daily use. Large diaphragms are used as sources of sound-power for signalling over large distances in air or under water. A diaphragm operated at resonance by electro-magnetic methods may become an efficient generator of sound. By suitably choosing its dimensions the frequency of the sound may have any value up to the limits of audibility. A thick diaphragm of small diameter excited by an electro-magnet provides a very convenient source of high frequency sound as an alternative to a bird call, etc., in experimental work.

Directional property of Membranes and Diaphragms.—If a membrane or a diaphragm be mounted on an annular ring it will possess definite directional properties used either as a transmitter or receiver of sound. Regarding it as a transmitter, the sound emitted from opposite sides will be of the same intensity but in exactly opposite phase. Consequently an observer "edge-on" to the diaphragm will hear nothing at all, for the sounds proceeding from opposite sides of the disc will exactly neutralize each other. In the "broadside-on" position, however, the sound from the back of the diaphragm will be partially screened by the annular ring and by the diaphragm itself, whereas the sound from the front will reach the observer unobstructed. As the transmitter is rotated through 36° therefore, the observer will hear two distinct maxima, 18° apart, separated by two corresponding minima, or zero positions. The maxima will, of course, be of

smaller intensity than that observed with one side of the diaphragm completely screened (in which case it is non-directional). The directional properties of an unscreened diaphragm may be simply demonstrated as a receiver of sound by means of a "button" granular microphone attached at the centre. The microphone gives maximum and zero response in the "broadside-on" and "edge-on" positions respectively, relative to a fixed source of sound.

Vibration of Plates .-- We have already referred to the case of a quartz plate vibrating with equal amplitude and phase over its whole surface, this being treated as a special example of longitudinal vibration. We have also dealt with a circular plate clamped at the edge (i.e., a circular diaphragm), the frequency of the fundamental being  $0.47hc/a^2$ , and the overtones  $1.006hc/a^2$  and  $1.827hc/a^2$  for one nodal diameter and one nodal circle respectively. When the plate is free at the edge the mathematical treatment becomes very complex. Near the edge, a peculiar state of strain exists sometimes resulting in abnormally large shearing forces on sections perpendicular to the edge. experimental study of the vibrations of such plates, free at the edge and clamped at the centre of symmetry, begins with Chladni (1787). The method of producing Chladni's figures by bowing and touching certain points on the edge of the plate covered with fine sand, is well known. The nodal figures are very striking in their appearance and wonderful variety-nothing further is needed to testify to the complexity of the problem. Chladni preferred to use glass plates, as their transparency permits of the fingers being used to damp points underneath which are shown to be nodal by the sand above. Simple figures correspond to low frequency tones, and the more complicated figures to the higher tones. Chladni obtained 52 different figures with a square plate and 43 with a circular plate. Metal plates of moderate thickness when struck with a hammer are sometimes used as gongs. The Submarine Signalling Company have used such a gong under the sea, describing it as a "disc-bell" for life-

Curved Plates, Cylinders and Bells.—The complex problem of the flat plate is still further complicated when the plate is curved—for it becomes increasingly difficult to separate the various possible modes of vibration. Rayleigh has calculated the fundamental frequency N of vibration of a thin cylindrical

shell, obtaining  $N \approx \frac{k}{a^2} \left| \frac{e}{\rho} \right|$  where e is an elastic modulus involving bulk modulus and  $\rho$  the density of the cylinder.

A bell may be regarded as a progressive development of a curved plate or, in certain forms, it may be treated as a cylindrical shell with one end closed. The possible variety of forms is far too numerous even to mention here. In practically all cases the bell is supported at the centre of symmetry and is excited by striking near the free edge. Rayleigh made a particular study of the vibrations of church bells, and distinguished five characteristic tones: Lowest tone (4 nodal meridians, no nodal circle), second tone (4 nodal meridians, one nodal circle), third tone (6 nodal meridians, sound best produced when the clapper strikes the bell on the lower thick part termed the "sound bow"), fourth tone (6 nodal meridians, best elicited by striking half way up), fifth and highest tone (8 nodal meridians). Bell founders in England recognise five chief tones in a church bell, reckoning from the highest they are termed the "nominal," "fifth," "tierce," "fundamental," and "hum-note." By suitable distribution of metal in the bell the founder aims at making the hum-note, fundamental and nominal successive octaves-but seldom succeeds. Massive bronze bells are used in charted positions, e.g., lightships and buoys, under the sea as a means of signalling to ships suitably fitted with hydrophones (underwater microphenes) to receive the sound. Sound travels for long distances under water and these bells can be heard many miles away, if the conditions are favourable.

Vibrations of Air Cavities.—Columns of Air: Organ pipes. The simplest case of a vibrating mass of air in a solid enclosure is that of a parallel cylindrical pipe the ends of which may be closed or open. The vibrations of such a column are analogous to the longitudinal vibrations of a solid rod. Provided the diameter of the pipe is not too small, so that viscous drag at the boundary is unimportant, and not too great compared with the length of the pipe and the wave length of the sound, we can assume at any instant, the motion of particles in any particular cross section to be the same. That is, we are dealing with plane waves of sound in the pipe. As in the case of transverse vibrations of strings and longitudinal vibrations of rods, stationary waves are produced in the air column due to the combined effects of the direct and end-reflected waves. Thus the equation of wave motion in the pipe is  $\partial^2 \xi / \partial t^2 = E/\rho \cdot \partial^2 \xi / \partial x^2$ , indicating a wave travelling with a velocity  $\sqrt{(E/\rho)}$  where E and  $\rho$  are the appropriate values of adiabatic elasticity and density of the gas contained in the pipe. Assuming a simple harmonic wave  $\xi = a \cos nt$ the solution becomes  $\xi = [A \cos(nx/c) + B \sin(nx/c)] \cos nt$ . With the appropriate end conditions  $\xi = 0$  at a node (a solid end) and  $\partial \xi/\partial x = 0$  at an antinode (an open end) the various modes of vibration are readily determined.

Remembering that a pulse of compression is reflected as a rarefaction at an open end and as a compression at a closed end, it will be evident that a wave must travel twice the length of a pipe open at both ends, and four times the length of a pipe closed at one end, before the wave repeats itself, i.e., in one period. If  $\lambda$  is the wave length and N the frequency in the stationary wave then  $N = c/\lambda$ . For a pipe open at both ends each open end must be an antinode and the length of the pipe a multiple of  $\lambda/2$ , that is,  $l = s\lambda/2$  where s = r, 2, 3, etc. We have in this case therefore a complete harmonic series of partials whose frequencies are

given by  $N = \frac{sl}{2l}\sqrt{\frac{E}{\rho}}$ , the corresponding wave lengths being proportional to 1, 1/2, 1/3, 1/4, etc.

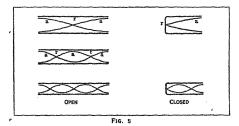
For a pipe closed at one end the closed end must be a node and the length of the pipe an odd mulliple of  $\lambda/4$ , that is  $l=s\lambda/4$  where s=1, 3, 5, etc. The partials therefore form an odd harmonic series the frequencies being  $N=\frac{s}{4t}\sqrt{\frac{E}{\rho}}$  where s is an

odd integer. The corresponding wave lengths are proportional to 1, 1/3, 1/5, etc. A closed pipe resonates to the same fundamental frequency, as an open pipe of twice the length.

frequency as an open pipe of twice the length. The position of the nodes n and antinodes a for a few of the partials of "open" and "closed" pipes are indicated in fig. 5.

partials of "open" and "closed" pipes are indicated in fig. 5.

Correction at Open End.—The approximate theory indicated above (due to Bernouilli) assumes an antinode at the open end.



A true antinode is a point of zero pressure-variation and maximum displacement-amplitude. At the open end of a tube the stationary plane waves inside are changing to spherical progressive waves outside. In other words, the tube radiates sound energy in all directions from the end of the tube. On account of this radiation, the intensity of the reflected waves from the open end is somewhat less than that of the incident waves, which explains the rapid damping of the vibrations when the forcing ceases. The body of air at the open ged has the effect of adding inertia to the air in the tube. Consequently there is a virtual increase

in the length of the air column with a corresponding lowering of pttch. Lord Rayleigh has shown that this effective increase of length approximates to 0.6 times the radius r of the tube if the latter is unlianged. This correction applies at each open end, and is therefore  $1\cdot 2r$  for an open tube, and 0·6r for a closed one It should be observed also, as in the case of rods, that the simple theory only applies when the diameter of the tube is small relative to the length of a loop  $\lambda/2$ 

Resonating Liquids in Metal Tubes.—Columns of liquid enclosed in metal tubes may also be set into resonant vibration. On account of the yielding of the walls of the tube, however, the velocity  $\sqrt{(E/\rho)}$  of the wave is slightly modified since the coefficient of elasticity involved is dependent on the extent of such yielding. The subject has been examined theoretically by Hr Lamb (Sound, p. 174) and by Green (Phil. Mag., 45, May 1923), who has also determined experimentally the change of velocity produced in various liquids by this yielding

Organ P<sub>i</sub>pes.—One of the most important applications of the vibration of air columns is found in the organ pipe. This usually takes the form of a cylindrical metal tube or a wooden pipe of square section. One end of the tube is specially constructed so that a suitable blast of air will set up resonant vibrations in the column of air. In the open "fine" organ pipe the blast of air impinges on a thin lip which forms the upper edge of a narrow slit opening into the tube. When the blast is correctly adjusted the pipe "speaks" and the air column resonates. The fundamental tone is sounded when the blast is moderate, and by increasing the power of the blast the harmonics can successively be produced.

In another form, known as the "reed" pipe, the blast of air impinges on a reed which controls the amount of air entering the pipe. The reed is set in vibration and puffs of air are admitted to the pipe which resonates under the correct conditions. The reed cannot be regarded as a freely vibrating spring for it is affected by the air blast and the resonance in the pipe. "Organ" pipes have been made covering a range of frequencies, from 8 to 16,000 cycles per second, corresponding to lengths of 64 ft. to \frac{1}{2}\$ in respectively. Fifes, flutes, oboes, etc., are other examples of musical instruments employing resonant air columns.

Small Air Cavities:  $\dot{H}$ elmholts Resonators.—The vibrations of air cavities almost completely enclosed were first studied by H. von Helmholtz and have considerable practical importance. A volume of enclosed air having only a small "neck" connecting with the external air radiates very little energy when set into resonant vibration. The damping is therefore very small and the tuning is very exact. The device is therefore very sensitive to a narrow range of frequencies. The motion of the air in the cavity is almost negligible compared with that in the narrow neck. Consequently we may regard the air in the neck as a piston having mass m=plS ( $\rho$  density, l length, and S area of neck), while the air in the cavity functions as a spring of "strength"  $f=ES^2/v$  where E is the elasticity  $(=\gamma p)$  of the gas and v the volume of the cavity. The frequency N of such a mass and spring is  $\sqrt{f/m}/2\pi$ 

activity. The frequency N of such a mass and spring is  $\sqrt[4]{f/m/2\pi}$  i.e.,  $N = \frac{1}{2\pi} \sqrt{\frac{ES^2}{v \cdot \rho l S}}$  or  $\frac{c}{2\pi} \sqrt{\frac{S}{v}}$  since  $c = \sqrt{E/\rho}$ . The ratio S/l is called the "conductivity" of the neck. For a circular aperture in a thin wall, Rayleigh shows that this quantity is equal to the diameter (2a) whence  $2\pi N = c\sqrt{(2a/v)}$ . The frequency is independent of the shape of the cavity provided its linear dimensions are not comparable with a wave length of the sound to which it resonates. A "spherical" Helmholtz resonator is shown in fig. 6. A series of resonators of graduated frequencies (i.e., of varying volume or area of mouth) may be used in the frequency analysis of complex sounds. Resonance may be detected by the ear or by means of a sensitive manometric capsule applied to the small pipe at the base of the resonator, or by means of a Tucker hot-wire microphone (see p. 31) placed in the mouth. Resonators of large volume, and correspondingly low frequency, fitted with hot-wire microphones were employed in the detection and location of gens during World War I. (See Sound-Ranging.) Large resonant microphones are also used in the detection of

Recently, E. G. Richardson (Proc. Phys. Soc., May 1928) by using acoustic impedance methods, has developed a theory of speech about 2,500 ergs/sec. vibration of air cavities which covers the extreme cases of pipes and resonant cavities, and avoids the necessity for a special open-end correction. He obtains the formula  $\tanh L = \kappa/kA$ where  $k = 2\pi N/c$ ,  $\kappa$  is the conductivity of the neck and A is the area of section of the cavity, assumed cylindrical. This formula leads to the recognised values of N for

pipes and resonators. Double Resonators .- In certain circumstances, where an increased sensitivity is desired, double resonators, consisting, for example, of a resonator of the closed pipe variety combined with one of the Helm-

holtz type, are usually employed. By this method, which was first suggested by Boys, a large increase in ampli-

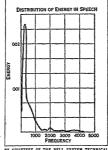


tude may, as a rule, be obtained. The theory of such compound resonators was given by Rayleigh, and has been considerably extended recently by E. T. Paris, who uses them in conjunction with the hot-wire microphone.

Helmholtz Resonator Combined with Tuned Reed -E. E. Fournier d'Albe has employed a sharply tuned reed (clamped free) with a small mirror attached, to indicate resonance in an air cavity. The resonant vibrations in the air cavity agitate the tuned reed, which lies across the mouth, and cause a spot of light, reflected from the mirror, to oscillate. The combination of reed and air cavity responds to one frequency only, for the overtones of the cavity do not correspond to those of the reed.

The Voice and Speech .- The human voice is an excellent example of a combination of vibrating reeds (the vocal cords) and resonant air cavities (the front and back parts of the mouth, separated by the tongue, and the upper or nasal cavity). The analysis and synthesis of speech sounds was commenced by Helmholtz. More recently Paget has shown that "every series of sung or spoken vowels is in fact a trio performed by three instruments, a reed and two resonators-soprano and alto-of which the soprano is in close harmonic relation with the reed." In a series of important papers (Proc. Roy. Soc., 1923, 1924, 1927) Paget has analysed and synthesised the vowel and con-

sonant sounds. Observations on breathed vowel sounds indicated that in every case the oral cavity as a whole, from larynx to lips, actually gives two simultaneous resonances for each vowel sound. In certain cases, more frequent in American "accent" a third resonance due to the upper or nasal cavity may be introduced. By means of plasticine models Paget successfully reproduced the various vowel and more important consonant sounds, as well as combinations of these in well recognised words. Crandall and Mackenzie (Phys. Rev., March 1922) have determined experimentally the energy distribution in speech as a



function of frequency. (See curve fig. 7.) The maximum energy of the male voice occurs at a frequency near 120 p.p.s., the female voice having a maximum about an octave higher. In spite of the fact that the energy of the voice is mostly of low pitch it is the high pitched sounds which are essential to intelligibility of speech. The clearness of speech is unimpaired if all sounds up to 500 frequency are "filtered" out (60% of the sound energy being thereby removed). We shall see later that the ear is most sensitive in the region 1,000 to 4,000 frequency. The rate of emission of sound energy in conversational speech has been estimated by

Sabine (Phys. Rev., 21, 1923) as 125 ergs/sec and for public

Absorption of Sound by Resonators: Sound Filters .-A well tuned resonator absorbs energy of corresponding frequency from the sound-field in which it is placed. This absorption may extend over an area of the order  $\lambda^2/\pi$  where  $\lambda$  is the wave length of the incident sound  $(\lambda = c/N)$ . Quincke (1866) employed resonators to stop tones of definite pitch from reaching the ear (see Rayleigh, Sound, vol. ii., p. 210)—the arrangement acting as a sound-filter. A complex sound passing through a pipe could have any particular tone removed, by fitting a suitable side tube to the pipe. This side tube of length l was closed by a sliding piston which served to "tune" the tube (4l=c/N) to any frequency N it was desired to absorb from the main pipe. Using a succession of such tuned side tubes a corresponding number of tones could be filtered out of the direct sound. G. W. Stewart (Phys. Rev., 1923-26) has greatly extended the possibilities of sound filters by introducing the analogy of electrical filter circuits and the conception of acoustic impedance. On such a basis it is possible to design "acoustic circuits" functioning as "low-pass," "high-pass" and "band-filters" as in the corresponding electrical cases. The "low-pass" filter transmits only those frequencies below a certain limit, the "high-pass" above a certain limit, and the "band-pass" only within a certain range or rafiges. Filters of this nature are used in the laboratory for purifying sounds, e.g., removing harmonics from a complex wave-form to obtain a pure tone; and in connection with speaking devices.

Measurements of Sound Intensity; Using Air Resonators .-The amplitudes at various points in a vibrating air column or cavity may be examined qualitatively by means of small manometric capsules (fitted with tube to a sensitive flame) or by sensitive membranes carrying fine particles or small mirrors. Quantitative results have been obtained by means of a Rayleigh disc which, when inclined at 45° to the axis of a neck of a double resonator, forms a very sensitive detector—the disc tending to set itself at right angles to the vibrating air current in the neck of the resonator (see p. 14.) Alternatively the hot-wire "microphone" (see p. 31) may be used.

Kundt's Dust Figures.-To exhibit the nodes and antinodes in a resonating air column contained in a glass tube, Kundt devised the method of spreading fine powder (lycopodium seed or fine dry cork dust) along the inside of the tube. The dust is immediately thrown into a pattern indicating the positions of nodes and loops along the tube. The experiment is capable of a number of variations yielding valuable data relative to the velocity of sound in gases and solid rods. The wave length  $\lambda_g$  in the gas contained in the tube is at once obtained from twice the nodal separation—the wave length λ<sub>0</sub> in the rod which excites the vibrations in the air column being, for the fundamental longitudinal vibration, equal to twice the length of the rod. These values give at once the relative velocities in the gas and the rod. (See p. 21.)

Sirens.-The sources of sound to which we have hitherto referred are dependent on the principle of resonance for their efficient action. We shall now deal briefly with an entirely different type of sound generator. In the earliest form of siren a revolving disc perforated with a ring of equally spaced holes interrupted a jet of air from the nozzle of a tube mounted opposite the ring of holes. The fundamental frequency of the note produced by the successive puffs of air emerging beyond the disc is clearly equal to the product of the number of holes and the revolutions per second of the disc. This primitive form is known as Seebeck's Siren (1805-1849). In later forms of siren (C. de la Tour's form) the holes were drilled obliquely to the surface of the disc so that the blast of air also produced the necessary rotation of the disc. In this form the intensity of the note increased with frequency—the sound amplitude being roughly proportional to the pressure of the air supply. In recent laboratory forms the siren is motor driven, means being provided for indicating the speed of the revolving disc and consequently the frequency of the sound. A motor driven siren forms a very

convenient means of determining, by a direct method, the pitch of a note. With a circular nozale and equal circular holes the siren note is generally impure—containing a plentiful supply of harmonics in addition to the fundamental. Milne and Fowler [Roy. Soc., 98, 414, 1921) describe a special form of siren which gives comparatively pure tones. The holes in the rotating disc are specially shaped so that the uncovered area of the nozzle varies sinusoidally.

Dove and Helmholtz produced sirens having several rings of hobes provided with corresponding nozzles, so that one or more tones could be produced simultaneously. Sirens driven by compressed air or steam are in common use as sources of sound. Similar devices modified to suit the special conditions have been used for signalling under water—the air supply of the ordinary siren being replaced in this case by a jet of water which causes rotation of the disc and gives the necessary vibratory impulses to the surrounding water.

The Diaphone, a powerful long range signalling device for use in air, is essentially a siren of the same group as those of Seebeck and La Tour since it differs from them only in the fact that the opening and closing of the ports is effected by a reciprocating instead of a rotary motion—this reciprocation being produced directly by means of the compressed air supply.

The Centrifugal Siren.—This device consists of a radially-vaned cylindrical rotor revolving in a stationary casing in which ports are cut. The vanes are connected in pairs at their outer edges by cylindrical segments, so that rotation causes opening and closing of the fixed ports. Air is drawn through an axial aperture where the vanes are cut away. The sound is produced by the expulsion of air through the ports by the centrifugal action of the rotor which may be driven by an electric motor or internal combustion engine. Sirens of this type constitute very powerful and efficient sources of sound for long distance transmission in air, e.g. for use on light-vessels or shore stations as a means of signalling to ships at night or in foggy weather.

Sounds Produced by Rotating Propellers.-The hum of an etectric fan which increases in pitch with increase of speed can be heard only at a short distance. The noise produced by the propeller (airscrew) of an aeroplane may, under favourable conditions, be heard several miles away. The sound emitted in both these cases arises, in the absence of excessive vibration, from the rotation of the "source and sink system" associated with the pressure differences on the rotating blades. A. Fage (Roy. Soc. Proc., 107, 1925) has analysed the sounds emitted from various types of airscrews by means of a resonator, of continuously variable tuning, fitted with a Tucker hot wire microphone. He found that the sound of rotation consists of a large number of harmonics having as fundamental a note of frequency equal to the product of the number of blades and the rotational speed. In addition to these sounds, "tearing sounds" associated with the shedding of eddies from the blades were also observed but the frequencies were not determined. Sounds arising from the flexural vibrations of the airscrew blades and the shaft were found to have frequencies in agreement with calculation.

Propellers Under Water.—Most of the under-water noise from a moving ship comes from the screw propeller. As it revolves, "cavitations" are formed just behind the blades. When these cavitations collapse either on themselves or on the blades, a noise is produced. This noise has no predominant frequency, although it is to some extent characterised by the beat of the engines or the rush of the turbines which drive the propeller. If the latter revolves slowly the cavitations are not formed and there is very little noise. With suitable receivers (hydrophones) the noise of a ship proceeding at a moderate speed, say 10 or 15 knots, can be heard several miles away. (See Bragg, World of Sound.)

Explosive Sounds.—The ejection of a shell from a gun and the subsequent explosion of the shell are both accompanied by a supply tube. The vibrations pressure-wave of large amplitude which can be detected at long ranges. This pressure-wave has, however, a different character in the two cases—the explosion at the gun is due to the ignition of p. 224, should be consulted.

cordite which burns relatively slowly when compared with the rate of detonation of the T N.T. in the shell. Consequently the gun-wave has a wave-front which is much less abrupt than that of the shell detonation. This appears to the ear as the difference between a "boom" and a "crack." An observer of such pressure waves at a distant point receives what appears to be a continuous train of waves, t.e., a reverberation effect, due to the numerous reflected pulses from objects along the track of the primary pulse. Such reverberations may last several seconds. Similar effects are observed under water on the explosion of a mine or a depth charge. The explosion of a few ounces of guncotton under water can be detected and recorded 30 or 40 miles away. A rapid succession of explosions at equal intervals of time may result in a noise of a more or less musical character. This is exemplified in high speed gas or petrol engines, particularly those with several cylinders operating in succession. The note is harsh and the fundamental is accompanied by a long train of harmonics. The musical noise of a high frequency Wehnelt electrolytic interrupter (used in X-ray work) is also due to a regular succession of explosive impulses, arising from the sudden generation of gas under the liquid. The wave-form of such a series of impulses recorded on a cathode-ray oscillograph indicates the extremely abrupt nature of detonations. A single impulse is often sufficient to set a resonator into vibration, thereby producing, indirectly, a musical note.

A single impulse of an explosive nature, produced by a powerful electric spark has been employed in the study of the progress of a sound-wave under controlled conditions—particularly in connection with the complex reflections of sound-waves in auditoriums. (See Acoustics of Buildings.)

Sounds Maintained by Heat.—Most bodies on being heated will expand and in so doing perform a certain amount of mechanical work. If the phases of the forces thus called into play are favourable, a vibration may be set up and maintained.

Trevelyan's rocker is a good example of such a maintained vibration. It consists of a prism of brass or copper almost triangular in section with one edge grooved to form two adjacent parallel ridges. The prism rests with its groove downwards on a block of lead with a rounded top, the end of the prism terminating in a ball which rests on a smooth surface. When the prism is heated and placed on the lead block it begins to vibrate, the weight being carried alternately on one or the other of the two ridges. The cause of these vibrations was ascribed by Leslie to the expansion of the cold block at the point of contact with the hot metal. The effect can be obtained also by a local heating of the points of contact by means of an electric current.

Singing Flames.-Under certain circumstances a small gas flame inserted into a resonant chamber of air or other gas, will emit a musical sound. If heat be given to the air in a vibrating column at the instant of greatest condensation the vibration will be encouraged. If the phase of the heat supply be reversed the vibration will be discouraged. An essential feature of the maintenance of the vibration is the presence of stationary waves in the gas supply tube as well as in the singing tube. The jet must be a node to correspond with a node in the singing tube where the maximum pressure-amplitude occurs. For most satisfactory operation therefore it is necessary (a) that the gas jet should be at or near a node in the singing tube and (b) that the length of the gas supply tube should be an odd multiple of  $\lambda/4$ (where  $\lambda$  is the wave-length, in the gas, of the note sounded). The tube will not sing at all if the length of the supply tube lies between  $\lambda/4$  and  $\lambda/2$ ,  $3\lambda/4$  and  $\lambda$ , and so on. Spherical resonators, large globes, may also be employed, and bulbous chimneys as used for paraffin lamps give satisfactory results. The intermittent character of a singing flame is easily demonstrated by means of a revolving mirror, from which it appears that at one phase the flame may withdraw itself entirely within the gas supply tube. The vibrations sometimes reach sufficient intensity to extinguish the flame completely. For a complete discussion of the phenomena of singing flames Rayleigh's Sound, vol. ii.,

Gauze Tones.—Rijke in 1859 made the discovery that a sound . of considerable power may be produced by a heated piece of fine metal gauze stretched across the lower part of a vertical open tube containing air. In the earlier experiments the gauze was heated by a gas flame and the sound was observed immediately after the removal of the flame. Keeping the gauze hot by means of an electric current the sound may be maintained indefinitely. The maintenance depends on the variable transfer of heat due to the motion of air through the gauze, this motion being a uniform upward convection current with a superposed alternating motion due to the resonant vibration of the air in the tube. In the lower half of the tube the alternating flow assists the direct flow a quarter period before the phase of greatest condensation and opposes it a quarter period after this phase. Bosscha and Reiss (1859) demonstrated the complementary phenomenon. current of hot air fall on a cold gauze, sound is produced-in this case the phase relationship requires the gauze to be in the upper half of the tube, preferably about a quarter the length of the tube from the top.

The Thermophone. Fine Wires or Strips Heated by Alternating Currents. - When an alternating current i sinnt is passed through a fine wire of resistance R the heat developed is proportional to  $Ri^2\sin^2nt = \frac{1}{2}Ri^2(1-\cos 2nt)$ . Consequently the heat developed will vary between 0 and  $\frac{1}{2}Ri^2$  at a frequency  $2n/2\pi$ , that is, at twice the frequency of the current. If a sufficiently large initial direct current io be passed through the wire the double frequency term in  $R(i_0+i\sin nt)^2$  or  $\{R(i_0^2+\frac{1}{2}i^2)+2Ri_0i\sin nt-\frac{1}{2}Ri^2\cos 2nt\}$ may be made negligible—the fluctuations of heating effect then vary with the frequency  $n/2\pi$  of the current.

Using very fine platinum wires (10-4cm. thick), P. de Lange (Roy. Soc. Proc., 91, Ap. 1, 1915) demonstrated that the decrease and increase of heat took place synchronously with the A.C. supply. The air surrounding the wire was thereby rapidly heated and cooled, the corresponding expansions and contractions appearing as sound. Ordinary telephonic currents, of speech frequency, were shown to be sufficient to produce easily audible sounds in a small earpiece containing the fine wire heater and a small volume of air. This device is known as a Thermothone. The reproduction is of good quality, but somewhat feeble relative to the response of electro-magnet telephone receivers. Provided the frequency is not too high, the thermophone has a possible application as a metrical source of sound.

Directional Sources of Sound.—It is evident that a greater range of transmission will result if a given amount of sound energy is confined to a cone with a small angle of divergence instead of spreading uniformly in all directions. Other advantages of a directional transmitter will be equally apparent. Certain sources of sound exhibit inherent "directional" properties, due to properties, due to the fact that their dimensions are considerably greater than a wave length of the sound they emit. Other sources may show no inherent directional property but may be made directional by the use of some attachment such as a trumpet or a mirror. A line or an area of equally spaced non-directional sources vibrating

in phase may act as a directional compound source.

Sources of Large Area.—The linear dimensions not small com-pared with a wave-length. Rayleigh (vol. ii., p. 138) refers to the directional properties of a speaking trumpet when used to transmit high pitched sounds, such as a whisper or a hiss. An instructive example of this nature is the case of radiation of high frequency sound waves from one face of a quartz piezo-electric piston" oscillating with uniform amplitude and phase at all points of its surface (see R. W. Boyle, Proc. Roy. Soc. Canada, III, 1925, p. 167). The sound-distribution round such a source is analogous to that of plane waves of monochromatic light falling on an aperture and forming a diffraction pattern beyond. Consider the case of a circular piston source of radius a radiating waves of length  $\lambda$  ( $\lambda = c/N$  where c is the velocity of sound in the medium and N the frequency of vibration). As in the optical case, the sound is a maximum along the axis of the piston where all the elementary disturbances from the various points of the piston arrive in the same phase. In directions inclined to the

axis the intensity is less, diminishing steadily to a minimum when the difference in distance to the nearest and the furthest points of the piston is rather more than half a wave-length. «In this case, the effect of the further portion of the disc is just neutralised by the effect of the nearer portion. In directions still more inclined, the sound increases again to an intensity equal to 0.017 of that along the axis. This is succeeded by another minimum value and further maxima of small intensity-corresponding to the various diffraction rings in the optical analogue. angle  $\alpha$  at which the first silence occurs is  $\sin^{-1}(0.610\lambda/R)$ . Thus the central "beam" of sound will be confined to a cone of small angle when the radius R of the piston is many times the wave-length. The polar distribution of amplitude is somewhat similar to that shown in figure 8 for a line of small nondirectional sources. When the radius R does not exceed  $\lambda/4$  the elementary disturbances from the piston combine without much opposition in phase, and the intensity is nearly the same in all directions—the case of a nondirectional source of sound.

Rayleigh obtained general verification of this theory by means of a speaking trumpet and high pitched sounds-a considerable concentration of sound on the axis being obtained. Boyle, using a Langevin type of piezo-electric quartz disc (see p. 12) showed that the sound distribution (the polar diagram) in water was in good agreement with theory. In one example  $R=7.65^{\circ}\text{cm}$ , N=135.000 p.p.sec.,  $c=1.5\times10^{\circ}$  cm./sec. for water,  $\lambda=1.11$  cms. whence  $\alpha=5^{\circ}$  approximately. This angle was verified experimentally. The application of such a high frequency directional sound beam has already been mentioned.

Double Sources .- The "piston" radiator to which we have referred is a single source of sound—it radiates from one face only, the anterior face being suitably screened. A vibrating diaphragm mounted on a ring radiates from both faces, the radiation from one face being at any instant in opposite phase to that from the other face. Such a vibrator is described as a double source. As we have seen (see p. 13) a double source, such as a diaphragm on a ring, situated in an open space, air or water, is inaudible from any point in its equatorial plane, maximum sound being

received at right angles to this plane.

Nondirectional Source Used with Mirrors, Trumpets, Zone Plates, etc.-As in the case of piston sources of large area, a "directed" source, employing for example a mirror or a trumpet, can exhibit good directional properties only if the dimensions of the mirror, etc., are not small compared with the wave-length of the sound. This condition involves bulky apparatus if the wavelength is appreciable, the alternative being the use of high frequency sounds of short wave-length. If the beam is to be narrow, it is also desirable that the area of the source at the focus of a mirror for example should not be large. This involves a further difficulty when a large sound-output is required, for the source must then have a very large amplitude, a condition which leads to inefficient transmission both in air and in water. In air serious degradation of energy may take place at large amplitudes (see Hart, Roy. Soc. Proc., A. 105, 1924, p. 80) and in water "cavitation" troubles arise (see Boyle, Roy. Soc. Proc., Canada, 111, 1922, p. 157). The use of mirrors, trumpets, zone plates, etc., are consequently more suited to the directional reception of high frequency sounds-where such troubles do not arise. Concave mirrors of say 1 to 2 feet diameter and 6 to 12 inches focal length are fairly efficient reflectors of high pitched sounds like a watch tick or the notes from a Galton's whistle.

Multiple Sources .- As in the case of a large piston vibrator, a line of small "point," sources, suitably arranged, will have definite directional properties. Suppose we have "m" equidistant sources in a straight line vibrating with the same phase, amplitude, and frequency. We require to know the polar distribution of amplitude in any plane passing through the line of m sources. (See fig. 8a.) It is readily proved that the resultant amplitude r at a distant point P is given by

$$r = \frac{\sin(m\pi d/\lambda \cdot \cos\alpha)}{m\sin(\pi d/\lambda \cdot \cos\alpha)}$$

if d is the spacing-distance of the sources each of amplitude 1/m, and  $\alpha$  is the orientation of the point P with respect to the line source. An important case arises when  $d=\lambda/2$ , i.e., when the sources are spaced half a wave-length apart. Then

$$r = \sin(\pi/2 \cdot m\cos\alpha)/m\sin(\frac{\pi}{2} \cdot \cos\alpha)$$
.

This is zero whenever  $\sin (\pi/2 \cdot m \cos \alpha)$  is zero, i.e., whenever  $\cos\alpha \cdot m/2$  is an integer. Suppose, for example there are 6 sources spaced  $\lambda/2$  apart, then  $m \cos \alpha/2$  may be 1, 2, or 3, whence  $\alpha = 70^{\circ} 48'$ ,  $48^{\circ} 42'$  and  $0^{\circ}$  giving the directions OP of zero amplitude. The primary maximum occurs when  $\alpha = 90^{\circ}$  and secondary maxima at  $\alpha = 60^{\circ}$  and  $30^{\circ}$  approx. The polar distribution from o to  $\pi$  is shown in fig. 8b the value of r being plotted radially from O in the direction  $\alpha$ . This distribution is the same in all planes which include the line of sources. When d has other values, the polar distribution includes secondary maxima which may approach the primary in magnitude (see paper by H. Stenzel, Elecktrische Nachrichten Technik, Band 4, Heft 6, 1927, pp. 239–253). It will be seen that a vertical line of sources spaced  $\lambda/2$ apart will give a definite concentration of energy in a horizontal plane at right angles to the line of sources. Such a concentration is, for example, of considerable importance in a fog signalling device, where a maximum energy concentration is required in a horizontal plane surrounding a light-vessel. It may similarly be shown that a number of equidistant sources arranged on a circle and vibrating in phase will give a primary maximum of intensity on the axis, with a number of zero and secondary maxima positions as in the case of a disc.

Aeolian Tones .- The "singing" of telegraph wires and the "whistling" of the wind through tall grass and trees are very familiar sounds. The "thrumming" of a tightly stretched wire in a stream of water is evidently due to a similar cause. Aeolian tones are produced when wind rushes past a stretched wire, their excitation depending on the formation of unstable vortex sheets. When wind of sufficient velocity passes a wire, a double series of vortices are set up immediately behind it, one set revolving in the opposite direction to the other and the flow of air past the wire wavers from side to side. In this manner vibrations are set up in the surrounding air which, under the right conditions, will be audible. Strouhal investigated the effect by revolving a vertical stretched wire about a parallel axis. He found that the frequency was expressed by  $N=0.185 \ v/d$  where v is the velocity and d the diameter of the wire. When the speed is such that N corresponds with one of the natural frequencies of the wire the sound is greatly increased. Rayleigh showed that the vibrations of the wire are transverse to the direction of the wind. This is readily explained on the vortex theory; the oscillations of air flow behind the wire reacting on the wire itself. The Aeolian harp consists of a number of wires, all of the same low pitch but of different thicknesses stretched on a sounding-board and exposed to the wind. The varying thicknesses of the strings results in a series of different notes.

Noises in General.—In addition to the various sources of sound to which we have referred there are innumerable others. Almost every material object in motion is a source of sound vibration. In all parts of the world there has been a steady increase in traffic noise during recent years, the problem of the reduction of such noise becoming increasingly acute. Relative motion and intermittent contact between solid bodies, such as a vehicle on a road, results in a shock excitation of the numerous resonant vibrations which are possible in a complex structure. A heavy vehicle fitted with solid tyres and having many loose parts is an irritating example of this when it runs over a somewhat irregular road surface. The complex noise issuing from such a vehicle may be analysed into the simpler forms which we have considered above. The prevention of such noises involves many considerations, but obvious improvements may be obtained by (1) use of pneumatic tyres, (2) tightening of all loose "rattling" contacts, (3) balancing of all parts of machinery in rapid motion, (4) use of oil to reduce frictional noises, (5) use of

pressure reducers or "silencers" for exhaust gases, etc.

The noise of breaking waves or rushing water may be ascribed to the resonant vibrations of air cavities enclosed momentarily by the water.

#### TRANSMISSION OF SOUND

It is important now to consider what takes place in an extended elastic medium (solid, liquid or gas) containing a source of sound. Sound waves are the inevitable result when vibratory stresses are set up by any means at any point of an elastic medium. Such sound waves consist of alternations of condensation and rarefaction, corresponding to the successive forward and backward movements of the source. The state of compression is passed on from layer to layer of the medium, with the velocity of sound; this being followed in turn by a rarefaction, another compression, and so on, as long as the source continues to vibrate. The phenomena of propagation of such waves of condensation and rarefaction may be demonstrated very simply by means of a long helical spring supported at suitable intervals by thin threads. Simple harmonic longitudinal displacement of one end of such a spring results in the generation of waves which travel along the spring at a definite speed. In such waves, as in sound-waves, the displacements of individual particles are in the direction of propagation of the wave-the motion is consequently termed longitudinal, as distinct from transverse wave motion in which the displacements are at right angles to the direction in which the wave travels (e.g., ripples on water, or waves travelling along a stretched string). If the condensational wave travels with a uniform velocity c cms./sec and the source of sound has a frequency of N periods per second, it will be clear, without formal proof, that there are N condensation and N rarefactions in the distance c covered by the wave in one second. Now the distance, by which one condensation is ahead of the next, is called the wave-length \( \lambda \) of the sound in the medium; consequently we have  $N\lambda = c$ . When a simple harmonic vibration is transmitted through the medium the linear density of the particles, or their state of compression or expansion, is at any instant represented by a simple harmonic curve which repeats itself at regular intervals of a wave-length.

Plane Waves.—The problem in its simplest form is that of transmission of a plane (or non-spreading) simple harmonic wave in a positive direction along the axis of x. The particle displacement  $\xi$  at any time t of a point whose mean position is x will be given by

$$\xi = a \sin_2 \pi (t/\tau - x/\lambda) \tag{1}$$

$$\xi = a \sin_2 \pi (Nt - x/\lambda) \tag{2}$$

where a is the amplitude,  $\tau$  and N the period and frequency and  $\lambda$  the wave-length of the vibration. Writing  $c=N\lambda=\lambda/\tau$  we obtain other forms of these equations, viz.,

$$\xi = a \sin[2\pi/\lambda \cdot (ct - x)] \tag{3}$$

and 
$$\xi = a \sin n(t - x/c)$$
 (4)

where n has the usual significance and is equal to  $2\pi N$ . These four alternative expressions for the particle displacement  $\xi$  in a progressive plane wave are convenient for most purposes. Comparison of these relations shows that the phases, in the case of progressive waves, may be expressed in terms of fractions of a wave length  $\lambda$  which corresponds to a phase-angle of  $2\pi$ . Thus the difference of phase between the vibrations of two particles at  $x_1$  and  $x_2$  respectively from the origin will be  $2\pi \left(x_2-x_1\right)/\lambda$ . It will be evident that a system of waves travelling in the negative direction of x will be represented by the introduction of a positive instead of a negative sign inside the brackets in the above expressions for  $\xi$ . A system of simple harmonic progressive waves may, of course, be represented graphically with the displacement  $\xi$  plotted as ordinates and the time t as abscissae.

Velocity and Acceleration of Particles in the Wave.—Differentiating  $\xi$  with respect to t we obtain the particle velocity, thus

$$\frac{\partial \xi}{\partial t} = na \cos n(t - x/c) \text{ or } \frac{\partial \xi}{\partial t} = -c\partial \xi/\partial x.$$
 (5)

Differentiating again, we obtain the acceleration

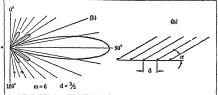
$$\frac{\partial^2 \xi}{\partial t^2} = -n^2 a \sin n(t - x/c) \quad \text{or} \quad \frac{\partial^2 \xi}{\partial t^2} = c^2 \frac{\partial^2 \xi}{\partial x^2}. \tag{6}$$

whence

in terms of wave velocity c and the slope and curvature of the displacement curve. Equation (6) is the differential equation which characterises wave motion. Its complete solution is

$$\xi = f(ct - x) + F(ct + x) \tag{6a}$$

which represents two independent systems of waves travelling in opposite directions with the same velocity c. This velocity is, within



FROM STENZEL IN "ELECKTRISCHE NACHRICHTER-TECHNIK" (WEIDMANN) FIG. 8

certain limits entirely independent of the form of the wave, being independent of wave-length \( \lambda \) and amplitude a. Within these limits, the velocity is determined solely by the physical properties of the medium. As we shall see, these properties are density and elasticity, corresponding to the factors mass and stiffness in the case of the vibrations of a particle. As the wave travels through the medium the volume and density fluctuate locally, these fluctuations being controlled by the properties of the medium and the applied forces. The following definitions are important:-

Dilatation  $\Delta$  is the ratio of the increment of volume  $\delta v$  to the original volume  $v_o$ , thus

$$\Delta = \partial v / v_o$$
 and  $v = v_o(\tau + \Delta)$ . (7)

Condensation s is the ratio of increment of the density  $\partial \rho$  to the original density  $\rho_0$  thus

$$s = \partial \rho / \rho_o$$
 and  $\rho = \rho_o(1+s)$  (8)

since 
$$\rho v = \rho_o v_o$$
 and  $(x+s)(x+\Delta) = x$  (8a)

and  $s = -\Delta$  neglecting  $s\Delta$  as a small second order quantity. Volume or Cubic Elasticity κ sometimes known as "bulk modulus" of elasticity.

$$\kappa = \delta p / \delta v / v_o = -v_o \delta p / \delta v = \delta p / s$$
 (9)

where  $\delta \phi$  is the stress and  $\delta v$  the strain; whence we have, for small variations of s,

$$p = p_o + \kappa s$$
 (10)

Compressibility C is the reciprocal of K. Thus

$$C = -1/v_o \cdot \delta v/\delta p = 1/\kappa \tag{11}$$

In the case of plane-waves travelling along the axis of x, the displacements of planes normally at x and  $x+\delta x$  will, at a time t, be  $\xi$  and  $\xi + \delta x \cdot \partial \xi / \partial x$  respectively. The thickness of the layer bounded by the two planes is therefore changed from  $\delta x$  to  $(1+\partial \xi/\partial x)\delta x$ . Consequently the dilatation  $\Delta = \partial \xi/\partial x = -s$ . The mass of unit area of the layer is  $p_0 \delta x$ . If the excess pressure on the  $(x+\delta x)$  face is  $\delta p$  we may equate this force to the product of the acceleration and the mass of the layer, thus  $\rho_0 \delta x \cdot \partial^2 \xi / \partial t^2 = -\delta p$  or  $\partial^2 \xi / \partial t^2 = -\delta p / \rho_0 \delta x$ . Now  $\delta p = \kappa s$  from (10), and  $s = -\partial \xi/\partial x$ ,

$$\frac{\partial^2 \xi}{\partial t^2} = \kappa / \rho_o \cdot \partial^2 \xi / \partial x^2 \qquad (12)$$

$$c = \sqrt{(\kappa / \rho_o)} \qquad (13)$$

or writing

$$\frac{\partial^2 \xi}{\partial a} = c^2 \frac{\partial^2 \xi}{\partial a^2} \tag{14}$$

which is equation (6) above, the complete solution being given in (6a). The velocity of plane-waves in the medium is therefore equal to  $\sqrt{(\kappa/\rho)}$ . The above method of treatment applies to all cases of transmission of small amplitude plane-waves in solid,

Relations (5) and (6) give the particle velocity and acceleration liquid, or ges, provided the appropriate modulus of elasticity is used. The bulk modulus  $\kappa$  is applicable only to large masses of fluid, where change of volume but not change of shape can take place. For a solid in bulk  $\kappa$  must be replaced by  $(\kappa + \frac{4}{3} \cdot \mu)$ where  $\mu$  is the rigidity whilst for a solid rod Young's modulus E is the appropriate elastic constant

Kinetic Energy in Plane-Waves. Intensity.—The rate of transfer of energy per unit area of cross section of the wave may be regarded as a physical measure of the intensity of the sound transmitted. The kinetic energy of a layer of unit area and thickness  $\delta x$  is  $\delta E = \frac{1}{2} \rho_c \, \delta x (\partial \xi / \partial t)^2$ . The maximum value of  $\partial \xi / \partial t$  is na (from eqn. [5]). Consequently the maximum kinetic energy per unit area and unit length (i.e. unit volume) of the wave =  $\frac{1}{2}\rho_0 n^2 a^2 - (15)$ . Since the sum of kinetic and potential energies is a constant,  $\frac{1}{2}\rho_o n^2 a^2$  must also be the total energy of the wave motion per unit volume. This quantity may be described as the energy density in the wave. Now the wave travels a distance c per second, therefore the transmission of energy per second per unit area of wave-front =  $\frac{1}{2}$ ,  $\rho n^2 a^2 c$  (16). This may be regarded as a measure of the intensity of the sound-wave. The intensity is therefore equal to the product of energy density  $(\frac{1}{2} \cdot \rho n^2 a^2)$  and wave velocity c. The maximum particle velocity \$\partial \eta d t\$ is from (5) equal to na and the maximum condensation

$$s = -\partial \xi / \partial x_{\text{max.}} = na/c,$$

that is, equal to the maximum particle velocity divided by the wave velocity. The expression for the intensity may therefore be written =  $\frac{1}{2} \cdot \rho c^3 s^2_{max}$ . Now

$$c^2 = \kappa/\rho$$
 and  $\delta p_{max.} = \kappa s_{max.}$ 

therefore the intensity or energy flow/sec. =  $(\delta \rho_{\text{max.}})^2/2\rho c$  (17) a useful expression giving the intensity of the sound-wave in terms of maximum pressure variation in the path of the wave.
Power of Sound Source. Radiation Impedance.—The

energy thus present in the sound-wave must be derived from the vibrating source. The rate at which the source does work, that is the power of the source, in producing sound-waves, is equal to the product of pressure variation and particle velocity, i.e., to  $\delta p \times \partial \xi / \partial t$  per unit area of wave-front. Now

$$\delta p = \kappa s = \kappa/c \cdot \partial \xi/\partial t$$
, and  $c = \sqrt{\kappa/\rho}$   
 $\delta p = \sqrt{\kappa \rho \cdot \partial \xi/\partial t}$ . (18)

Therefore the power expended by the source per unit area of wavefront =  $\sqrt{(\kappa\rho) \cdot (\partial \xi/\partial t)^2}$  (19). The relations expressed in (18) and (19) are closely analogous to the relations between e.m.f., current, and resistance in electrical circuits. If we regard  $\delta p$ ,  $\sqrt{\kappa p}$ , and  $\partial \xi/\partial t$  as corresponding to e.m.f. E, resistance (or impedance) R, and current i respectively we see that eqn. (18) is the mechanical analogue of Ohm's law in electricity, and that (19) is analogous to power dissipation Ri2 in an electrical circuit. The quantity Vκρ or ρc is consequently designated the radiation impedance per unit area of the medium transmitting the sound-wave. This quantity is important in the consideration of the transmission of sound waves through a succession of different media (see p. 18).

Spherical-Waves.- The results derived above for the energy in plane-waves hold equally well for spherical-waves at a sufficient distance from the source. Elementary considerations at once indicate that the energy density in the wave will vary inversely as the square of the distance from a point source of spherical-waves, whence it may be inferred that the amplitude. (of displacement, pressure or condensation) will vary inversely as the distance. This assumes, of course, that the amplitudes are small at all parts of the wave, and that there is no loss of energy due to viscosity, heat conduction and similar causes.

As in the case of plane-waves, it may be shown that the intensity at a point in the wave is given by  $(\delta p_{\text{max.}})^2/2\rho c$ .

Single and Double Sources. Energy Emission from Solid Vibrators .- A simple point source is a theoretical abstraction, but in practical cases where the source is a vibrating surface of appreciable area, each element of this area may be regarded as a simple source of spherical-waves, and the effect of the source as a whole obtained by integrating the effects of the elementary areas. Again, many vibrating bodies are not simple sources. For example a diaphragm radiating sound to air on both sides is, at any particular instant, sending out a compression pulse on one side and a rarefaction pulse on the other-thus behaving like two sources near together and in opposite phase; in other words acting like a double source. The prongs of a tuning fork each act as double sources in a similar way. Lamb (Dynamical Theory of Sound) shows that the rate of energy emission, or power, of a simple source is equal to  $\rho n^2 A^2 / 8\pi c$ , where  $\rho$  and care the density and velocity of sound in the surrounding medium,  $n/2\pi$  is the frequency, and A is the "strength" of the source (i.e., the maximum rate of emission of fluid at the source); the power of a double source is equal to  $\rho n^4 B^2/24\pi c^3$ , B being the "strength" of the double source. In both cases it will be seen that the rate of energy emission increases rapidly with increasing frequency. For the same strength and frequency, the energy emitted in different media will vary directly as the density and inversely as the wave-velocity (or the cube in the case of a double source). In gaseous media, where the velocity varies inversely as  $\sqrt{\rho}$ , the energy emission at constant frequency will vary inversely as (wave-velocity)<sup>3</sup> and (wave-velocity)<sup>5</sup> respectively in the two cases. These deductions account for the apparent feebleness of a bell or a tuning fork when vibrating in hydrogen as compared with air. The wave-velocity in hydrogen is 3.9 times that in air, therefore the energy emission from the same strength of source will be (3.9)5 or 900 times as great in air as in hydrogen. Another example:-the relative densities and wave-velocities for air and water are 1/770 and 1/4.4 respectively-the energy emission, on these grounds, being, for sources of the same strength and frequency, about 3,400 times as great in water as in air. The loading effect of the water and the limitations of output of sound generators must also be considered in dealing with actual cases. The quantities A and B in the above relations, denoting "strength" of source involve the area and form of the vibrating surface, amplitude and frequency. There is consequently for the same amplitude and frequency an increased rate of energy emission with increase of area in contact with the medium-exemplified by the increase of sound emitted when a tuning fork is brought into contact with a sounding board like the top of a table. The sounding board of a piano or a violin radiates practically all the vibrational energy of the strings, the damping of the latter being increased accordingly.

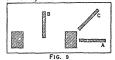
In designing "sound generators" it is important to observe that the sound energy radiated bears a definite relation to the total energy available at the source. The conditions governing efficiency in this connection are similar to the analogous case of an electrical generator supplying power to an external circuit.

"Local Flow."—When the vibrations of a solid body immersed in a fluid medium are very slow, the fluid behaves as if it were incompressible and simply flows locally from one surface of the "double source" to the other surface in opposite phase. In that case no sensible vibration is transmitted through the medium. As the vibrations increase in frequency the local flow is reduced, whilst true alternating pressure-waves, i.e., sound-waves, are set up in the medium. Again, at constant frequency, the higher the velocity of sound in the medium, the more nearly does the medium approach incompressibility, consequently the local flow is greater and less energy is radiated as sound.

On all grounds it is clearly preferable to use the simple source rather than the double source type of sound generator, for the local flow is reduced and there is no neutralising effect due to "out of phase vibrations" from a neighbouring surface. The increase of sound radiated from a tuning fork when "local flow" is reduced, may easily be demonstrated (see fig. 9). A piece of cardboard is held with one edge parallel and close to a prong of the vibrating fork, In positions A and B no effect is produced, whereas at C the sound is considerably increased in intensity.

The Principle of Superposition.—Huyghens first drew attention to the fact that the passage of one beam of light through an

aperture is in no way affected by the passage of another beam through the same aperture. It is a commonplace observation that any number of sound-waves may cross the same air space at the same time without the slightest evidence of confusion due to overlapping. This independence of the separate waves is explained by the principle of superposition, according to which the resultant effect of a number of displacements may be obtained by vector addition. The validity of this important prin-



ciple is dependent on the assumption that the elastic properties of the medium are such that the stresses are linear functions of the strains—a condition which is fulfilled in the case of small-amplitude sound-waves.

Huyghens' Secondary Waves.—Another important principle to Huyghens is the following:—The wave-front of. a, disturbance may at any instant be obtained as the envelope of the secondary waves proceeding from all points of the wave-front at some preceding instant. Thus the disturbance diverging from a point source may at any time t be regarded as represented by a thin spherical shell of radius ct, each point of which now serves as the origin of further spherical disturbances, the envelope of which becomes the new wave-front.

#### VELOCITY OF SOUND

It has already been shown that the velocity of sound-waves of small amplitude in an unlimited fluid medium is given by  $\sqrt{(\kappa/\rho)}$  where  $\kappa$  is the bulk modulus of elasticity and  $\rho$  the density of the medium. In the case of a solid in bulk,  $\kappa$  must be replaced by  $(\kappa + \frac{4}{\mu}\nu)$  where  $\mu$  is the rigidity of the solid. In special cases where the volume of material is limited, e.g., in solid bars or columns of liquid in tubes, it is important that the appropriate elastic constant be chosen.

In Gases.—When a gas is compressed it is heated, and when rarefied it is cooled. If the heating or cooling effects are not neutralised by removal or supply of heat, e.g., by convection, then the temperature of the gas will rise or fall accordingly. In ordinary sound-waves the alternate condensations and rarefactions take place so rapidly that there is no time for a transfer of heat between adjacent layers of gas. Consequently the temperature rises and falls with the same frequency as the waves of pressure. Such conditions are described thermodynamically as adiabatic. In an adiabatic compression, the relation between pressure p and density  $\rho$  of the gas is  $p/\rho \tau = \text{constant}$ , that is  $p/p_0 = (\rho/\rho_0)^{\gamma}$  where  $p_0, \rho_0$  and p refer to initial and final states of pressure and density, and  $\gamma$  is the ratio of specific heats of the gas. Thus  $(\tau + \beta p/\rho_0) = (\tau + \delta \rho/\rho_0)\tau = (\tau + \gamma s)$  for small values of the condensation  $s(=\delta \rho/\rho)$ . Now  $\kappa = \delta p/s$  (see equation 9). Therefore  $\kappa = \gamma p_0$ . Consequently the velocity of sound is given by

$$C = \sqrt{(k/\rho)} = \sqrt{(\gamma p_0/\rho_0)}. \tag{20}$$

Now Boyle's law indicates that  $t/\rho$  is a constant at constant temperature, consequently the velocity is independent of the pressure of the gas, for the density  $\rho$  changes in proportion to the pressure  $\rho$ . Taking  $\rho_0 = 10^6$  dynes/cm.<sup>2</sup> and  $\rho_0 = 0.00129$ , and assuming

 $\gamma = 1.41$  for air, we obtain a value for the velocity

$$c=3.31\times10^4$$
 cms./sec. at o° C.

This is in good agreement with observation.

Change of Velocity with Temperature.—Since  $\rho\theta = \rho_o/(\mathbf{x} + \alpha\theta)$  where  $\alpha$  is the temperature coefficient of volume expansion at constant pressure, and  $\theta$  is the temperature in degrees centigrade, we have  $c_\theta = \sqrt{(\gamma \rho_o(\mathbf{x} + \alpha\theta))/\rho_o|} = c_o\sqrt{(\mathbf{x} + \alpha\theta)}$ . Now for any gas  $\alpha = \mathbf{x}/273$  per degree centigrade nearly, therefore

$$c_{\theta}/c_{o} = \sqrt{T/T_{o}} \tag{21}$$

where T and T<sub>o</sub> are the absolute temperatures. That is, the velocity varies directly as the square root of the absolute temperature. The velocity given by (20) is independent of frequency, but is dependent on the nature of the gas. The velocity varies inversely

as the square root of the density, provided  $\gamma$  is the same—thus the velocity is four times as great in hydrogen as in oxygen.

Experimental Determinations of Velocity of Sound in Free Air.-The velocity of sound as measured in free air is affected by the wind, being greater with the wind than against it; in the first case the sum, and in the second the difference, of the velocities of the sound and the wind. It is also affected by humidity. The wind-velocity may be eliminated from the result by the method of reciprocal observation-the sound being produced first at one end and then at the other of a measured base line with a receiver also at each end. Alternatively the wind-velocity may be measured directly and a correction applied to the observed velocity of the sound. The latter method has been employed by Esclangon (Comptes Rendus, Jan. 20, 1919). The sound-waves from guns of various calibres were received by sensitive electrical sound-detectors at 1400 m. and 14000 m. along the same line. The time intervals were measured to ±0.002 second, the observations being made under various conditions of wind and humidity. The final result for the speed of sound in dry air at 15°C. was 339.9 metres per second which compares well with Regnault's value 339.7 metres/sec. (1863). Measurements of the velocity of sound at different levels (on mountain heights and plains) confirm the theory that there is no change of velocity with pressure. Observations at low temperatures in the Arctic give a value  $c_{\theta} = (333 + 0.6\theta)$  metres/sec. at  $\theta^{\circ}$ C. Other methods of measuring the velocity in free air are:-(1) Echo methods—the time t between the transmission of a sound and arrival of its echo from a reflector at a distance d being measured whence velocity = 2d/t, (2) Coincidence Method—The sound is transmitted at regular, accurately known, time intervals simultaneously from two points at a known variable distance apart. When close together, the sounds are heard together but when one is moved further away the sounds are separated by an interval, at first increasing and then decreasing, till coincidence is again established. The difference in distance between two such positions of coincidence, combined with a knowledge of the time intervals, gives a value of the velocity.

Probably the most accurate determinations were made during the war in connection with gun sound-ranging. Two sensitive resonant hot-wire microphones, at a known distance apart, received the gun-sounds which were automatically recorded by means of an Einthoven string galvanometer, the time intervals being measured to 0-001 second. A large number of such observations, under different atmospheric conditions (wind, temperature and humidity), gave a value 337·16 m/sec. at 10°C. in dry air, and 337·6 m/sec. at 10°C. in dry are supported by the effect of humidity, producing a slight change of density, being therefore very slight.

Velocity in Tubes or Small Volumes of Gas. Kundt's Dust Tube When a gas is only obtainable in small quantities the method of velocity measurement is entirely changed. best method available in these circumstances is one which is due to the work of Kundt. The gas is confined to a cylindrical tube containing a sprinkling of fine dry powder (lycopodium seed or cork dust) and is set into resonant vibration by any convenient means, e.g., by the longitudinal vibrations of a rod one end of which is inserted in the tube, or by the vibrations of the glass tube which contains the gas. The dust is heaped up in a repeated pattern indicating the nodes and loops in the vibrating gas column. Rayleigh and Ramsey used this method to determine the ratio of specific heats  $\gamma$  of the rare gases argon and helium. The velocity c in a gas is given by  $\sqrt{(\gamma p/\rho)}$  where p is the pressure and  $\rho$  the density. The value of  $\gamma$  found for the rare monotonic gases was 1.66. Kundt finally used a double-tube apparatus, in which stationary waves were produced simultaneously in two different gases by means of the same vibrating rod. The ratio of velocities in gas (1), rod, and gas (2), being equal to the ratio  $\lambda_1:\lambda_r:\lambda_2$ , the values of  $\lambda_1$  and  $\lambda_2$  are obtained from twice the nodal separation (indicated by the dust heaps), and the value of  $\lambda_r$  is equal to twice the length l of the rod when sounding its fundamental longitudinal vibration. When the frequency

N is determined (by monochord and tuning fork, or by a siren) the velocities c in the gas and the rod are known in absolute measure, for  $c_{gas} = N\lambda_{gas}$  and  $c_{rod} = N\lambda_{rod} = 2Nl$ . Alternatively the vibrations may be communicated to the gas by means of a steel diaphragm (a telephone earpiece) one end closed and excited electromagnetically, the frequency being varied until resonance is set up in the gas contained in the tube. This method has obvious advantages over the original "rod" excitation. Using a short steel bar and exciting the vibrations by striking one end, Lang (Proc. Roy. Soc., Canada, 1922) has observed the nodes and antinodes in a Kundt's tube up to a frequency of 50,000 cycles/sec. The mean velocity of sound in the air contained in the tube (1.4 cms. dia.) was found to be 339.3 metres/sec. at 22.8° C., and in the steel bar 5120 m/sec. approximately. Kundt's tube method of measuring sound-velocities, and indirectly, the ratio of specific heats of gases, has been applied by Dixon, Partington and others to vapours and gases at various temperatures, and as a means of measuring temperature coefficients of sound-velocity.

In Liquids.—As in the case of gases the velocity of sound in liquids is given by  $\sqrt{(\kappa/\rho)}$ , which  $\kappa$  is the adiabatic bulk modulus of elasticity. Taking the isothermal compressibility C of fresh water to be  $49\times10^{-12}$  per dyne/cm.<sup>2</sup>, at  $15^{\circ}$  C. the bulk modulus  $\kappa(=1/c)=2\cdot04\times10^{10}$ , and the velocity

 $\sqrt{(\kappa/\rho)} = 1,427 \text{ metres/sec.}$ 

The value found by Colladon and Sturm (1826) in Lake Geneva was 1435 m./sec. at a temperature of 8° C.

Velocity of Sound in the Sea .- The velocity of sound, particularly explosion-waves, has been measured in the sea by a number of observers with considerable accuracy. Marti (Comptes Rendus, Aug. 1919) used three under-water microphones (hydrophones) in a straight line in Cherbourg roadstead, the total base line being 1800 metres. The positions were accurately determined by theodolites. The passage of the sound-wave due to an explosion under water in line with the hydrophones, was registered by an electric chronograph with smoked paper and tuning fork time-trace. At a temperature of 14.5°C. the velocity was found to be 1503.5 metres/sec. in sea water of density 1.0245 gram/cm.3 More recently a careful series of observations has been made by Wood, Browne and Cochrane near Dover with four hydrophones covering a base-line of twelve miles in the sea (Roy. Soc. Proc., May 1923). Accurate temperature and salinity observations were made at points along the base line, and a new method (multiple charge method) devised to obviate errors arising through firing the charge at a point not quite in line with the base of hydrophones. The time intervals of passage of the explosion wave between pairs of hydrophones was recorded on four strings of a six stringed Einthoven galvanometer (photographic), the ticks of an accurate chronometer on the fifth, and a wireless signal sent from a destroyer at the instant of firing the charge was recorded on the sixth string. Thus the record showed to an accuracy of ± oor second the various time differences and the total time of travel of the explosion-wave to each receiver. The results obtained in summer and winter were 1510-4 m/sec. at 16-95°C. and 1477.3 m/sec. at 7°C. respectively, the salinity being 35%0 in both cases. (The theoretical values calculated by D. J. Mathews [see Tables for Velocity of Sound in Fresh and Sea Water-Stationery Office Publication H.D. 282 1927] are 1510-4 m/sec. and 1476.1m/sec. respectively.) experimental results are expressed by the relation,

$$velocity = 4756 + 13.8 \ t - 0.12 \ t^2 \ ft. \ per \ sec.$$
 (22)

at  $35\%_0$  salinity in  $\%_0$  at the temperature  $f^*$ C). The ratio of specific heats (isothermal and adiabatic) for sea water, deduced from these measurements, is r-cop4 as compared with r-copo obtained from thermodynamic data. The adiabatic compressibility at  $16\cdot95^\circ$ C and  $35\%_0$  salinity is  $43\cdot145\times10^{-12}$  per dyne as compared with Ekmann's isothermal value  $42\cdot744\times10^{-12}$  per dyne.

Liquids in Tubes.—As in the case of gas-filled tubes stationary waves may be set up in tubes filled with liquid. On account of the small compressibility of a liquid compared with that of gas, however, a correction is required due to the yielding of the walls of the containing tube. This yielding produces an apparent lowering of the wave velocity—the lowering being smaller the thicker the tube. If  $c_o$  be the theoretical velocity of sound in the liquid, and c the actual velocity in the liquid in a tube of small thickness k then

$$c_o = c\sqrt{1 + 2\kappa a/hE}$$
 (23)

where a is the internal radius, K the bulk modulus for the liquid, and E the value of Young's modulus for the material of the tube (see Lamb's Sound, p. 174). In the other extreme, when the walls are very thick

$$c_o/c = \sqrt{[(\kappa + \mu)/\mu]} \tag{24}$$

where  $\mu$  is the rigidity of the material of the tube. Kundt and Lehmann succeeded in obtaining "dust" (fine iron filings) figures in liquids, as in gases, and thus measured the velocity of sound in tubes of different diameters and thickness. Application of Lamb's formula to their experimental values gives a mean value 1436 m/sec. at 19°C for the velocity of sound in open water. At frequencies within the audible range, the resonance of a liquid column can be observed by ear. The vibration is readily excited for example, by means of a steel diaphragm electro-magnetically maintained by current of variable frequency from a valve oscillator.

When the wave-length of the sound in the liquid is sufficiently small compared with the diameter of the tube the "correction" disappears. Hubbard and Loomis (Nature, Aug. 6, 1927 and Phil. Mag., June 1928) using a quartz oscillator 100 mm. diameter emitting plane-waves at frequencies between 200,000 and 400,000, have determined the velocity of sound in various liquids in a tube, with an accuracy of 1 in 3,000. The results for fresh and salt water at different temperatures agree well with the values obtained by other observers for these liquids in bulk.

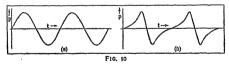
In Solids.—The velocity of sound in a solid rod of length l is very simply determined by observing the frequency N of its longitudinal vibration, the rod being clamped at the midpoint. The velocity is equal to  $N\lambda$  or 2Nl. The rod may be excited mechanically by striking or rubbing, or electro-magnetically. The velocity in steel or glass, for example, is about 5×10<sup>5</sup> cms./sec. as compared with 0.33 × 105 cm./sec. in air and 1.5 × 105 cm./sec. in water. The values of the velocity determined experimentally in this way agree very closely with the calculated velocities  $\sqrt{(E/\rho)}$  where E is Young's modulus of elasticity. The converse of the method is therefore convenient as a means of determining E approximately. Lang (loc. cit.) has determined the velocity in short steel rods (5 cms.) vibrating at a frequency of 50,000 using Kundt's tube as a means of estimating the frequency. The values of velocity at supersonic frequencies are found to be the same as at audible frequencies. Apart from seismic observations there is little or no experimental data relating to the velocity of sound-waves in solids in bulk.

Velocity of Waves of Large-Amplitude.-Explosion-Waves .- Hitherto it has been assumed that the displacementamplitude and condensation s are always small, and that the wave travels through the medium with velocity  $c = \sqrt{(\kappa/\rho)}$ without change of type. If, however, the condensation becomes large, as in an explosion-wave, the velocity may be considerably modified for the curve connecting pressure p and density  $\rho$  is not a straight line. The bulk modulus,  $\kappa = -v_0 \partial p/\partial v = \rho_0 \partial p/\partial \rho$ , increases as the density  $\rho$  is increased by compression, and diminishes as the density is reduced. Consequently the compression wave travels faster and the rarefaction slower than a small-amplitude" sound-wave. The result is a change of waveform as a large-amplitude wave travels through the medium. Lamb (Sound, p. 177) shows that the velocity of propagation is c(x+s) relative to the undisturbed medium (or  $c[x+s]^{\frac{1}{2}(\gamma+1)}$ in the adiabatic case) indicating increase of velocity with increase of condensation s. The parts of the wave of greater density

therefore gain continuously on those where it is less-i.e., the crests tend to overtake the troughs, as indicated graphically in figs. 10 a and b. The wave becomes steeper in front and more gradual behind. A continuation of such a process would eventually lead to a discontinuity when the wave-front becomes vertical-a condition which is physically impossible. As Rayleigh has remarked, such a tendency is held in check by the divergence of the wave and the influence of viscosity tending to diminish amplitudes and therefore reduce the velocity to its "normal" value. As an illustration, change of type in a progressive wave may be observed when sea waves approach a shelving beach. Here the crests gain on the troughs and the wave "fronts" become steeper and steeper until they curve over and break. A large amplitude explosion wave has initially a velocity considerably greater than ordinary sound-waves, gradually approaching this latter value as the distance from the origin increases. Regnault found that explosion-sounds increased in velocity with increase in the intensity of the explosion. Foley (Nat. Acad. Soc. Proc., June, 1920) showed that the velocity of sound from an intense electric spark varied from 660 m./sec. at a distance of 3.2 mm. from the spark to 380 m./sec. at a distance of 18 metres. The shadow of the high pressure region near the wave-front of the sound-pulse was photographed at known short time intervals after the instant of production of the spark, the velocities at various distances being deduced therefrom.

Shell-Waves. Onde de choc .- When a bullet or a shell, travelling with a velocity greater than that of sound, passes an observer it makes a sound like the crack of an explosion-described by the French as "onde de choc." The tips of the propeller of an aeroplane often exceed the velocity of sound and emit sounds of this nature as they revolve. In the case of a low speed bullet, the air at the nose is compressed, the compression being transmitted in all directions with the velocity of sound (approximately 330m/sec. in air). If however, the speed of the bullet is greater than the velocity of sound the condensation of the air at the nose can be transmitted laterally but not forwards. Photographs taken of bullets while in flight show this clearly and reveal the existence of two wave-fronts, one at the head and the other at the base of the projectile. The former can be simply explained on Huyghens' principle of secondary wavelets. If the velocity of sound at the nose of the bullet were normal, the wave-front would be a cone of semi-angle sin-1c/V (c normal velocity of sound and V velocity of projectile). But the velocity of sound increases with increased amplitude of condensation, consequently the wave-front is a blunted cone, as actually recorded in the Plate; see Fig. 2. From observations of the changing direction of the "onde de choc" it is possible to trace the bullet or shell to its source. (See Mallock, Proc. Rov. Soc., p. 115. 1908.) This method was used in the war to locate enemy guns.

Velocity of High Frequency Sounds.—Using a quartz piezo-electric oscillator (see p. 12) as a source of high frequency vibrations, G. W. Pierce (Proc. Amer. Acad., vol. 60, Oct. 1925) determined with considerable accuracy the velocity of sound in



air and carbon dioxide by the stationary-wave method. He found that the velocity of sound in air at °°C has the values 33.04, 432.47 and 33.64 metres/sec. at frequencies 1,000, 50,000 and 1.5×10<sup>8</sup> p.p.s. respectively. The effect of humidity was negligible, at 80% humidity differing by less than 0.02% from the velocity in dry air. In CO<sub>2</sub> the velocity at °°C was found to be 258.82 m/sec. at a frequency of 42,000 cycles/sec. increasing to 260.15 m/sec. at 200,000 cycles/sec. This gas becomes opaque to sound-waves at still higher frequencies. Boyle and Taylor (Proc. Roy. Soc., Canada, 1025) observed a diminution of velocity

of high frequency sounds in water at 16°C from  $r \cdot g_1 \times ro^5$  cms/sec. to  $r \cdot 42 \times ro^5$  cms/sec. at frequencies 43,000 and 508,000 cycles/sec. respectively. The measurements were made in a small tank. The velocity in a viscous oil was found to be the same at 570,000 cycles/sec. as at low frequencies. Lang (Roy. Soc., Canada, 1922) found no change in the velocity of sound in steel bars at any frequency up to 50,000 cycles/sec. Reference has already been made (p. 22) to the piezo-electric measurements of Hubbard and Loomis on the velocity of sounds of frequency  $3 \times ro^5$  in various liquids contained in tubes.

Change of Medium. Reflection and Transmission.—As in the case of light, when a wave of sound meets the surface of separation of two different media it is partially reflected, and a wave travels back (in the negative direction) through the "incident" medium, with the same velocity as it approached the bounding surface. The laws of reflection are the same as applied to Mght waves—angles of incidence and reflection being equal and in the same plane. With sound-waves however, we have often to deal with wave-lengths which are comparable with the dimensions of reflecting objects; the phenomena must then eventually be regarded primarily as diffraction. In the cases which we are now considering the wave-length may be regarded as small, or the reflector large, the ordinary optical laws being applicable.

Reflection of Plane-Waves at the Boundary of Two Extended Media.—It is shown in text-books of sound (Rayleigh, vol. [ii, p. 81) that the relative amplitudes r and a of the reflected and incident waves are given by

$$\frac{r}{a} = \frac{\rho_2/\rho_1 - \cot \theta_2/\cot \theta_1}{\rho_2/\rho_1 + \cot \theta_2/\cot \theta_1}$$
(25)

where  $\rho_1$  and  $\rho_2$  are the respective densities of the first (incident) and second (transmitting) media and  $\theta_1$  and  $\theta_2$  are the angles of incidence and reflection. The law of sixes of optical refraction holds in this case also, and we have  $\sin\theta_1/\sin\theta_2 = c_1/c_8$ , where  $c_1$  and  $c_2$  are the velocities in the first and second media. Consequently (25) may be written

$$\frac{\sigma}{a} = \frac{\frac{\rho_2}{\rho_1} - \frac{c_1 \cos \theta_2}{c_2 \cos \theta_1}}{\frac{\rho_2}{\rho_2} + \frac{c_1 \cos \theta_2}{c_1 \cos \theta_2}}$$
(26)

which becomes

$$\frac{r}{a} = \frac{\rho_2 c_2 - \rho_1 c_1}{\rho_2 c_2 + \rho_1 c_1}$$
(27)

at "normal" incidence (when  $\theta_1 = \theta_2 = 0$ ). If the velocity in medium (2) be greater than in medium (1), the incident waves being in the slower velocity medium, there will be a critical angle of incidence ( $\sin \theta_1 = c_1/c_2$ ) which, if exceeded, will result in total reflection.

As an example, let air and water be the media (x) and (2), sound waves being incident normally on the surface of the water. Equation (27) which expresses the reflection-amplitude in terms of the radiation impedances  $\rho c (= \sqrt{\kappa} \rho)$  per unit area of the two media (see above) gives r = 0.99940, since the values of  $\rho$  for water and air are  $14 \times 10^4$  and 40 respectively. In such a case, where the radiation impedances are widely different, there is almost complete reflection, even at normal incidence. The transmission is a maximum and reflection zero when  $\rho \iota c_1 = \rho_2 c_2$ , that is, when the radiation impedances of the two media are equal.

Reflection of Plane Waves from a Plate of Finite Thickness.—This case is analogous to the optical example of reflection from a thick plate of glass—the reflected wave being the resultant of multiple reflections at the two bounding surfaces. The ratio of reflected and incident amplitudes for normal incidence now becomes

$$\frac{\mathbf{r}}{a} = \left(\frac{\rho_1 c_1}{\rho_2 c_2} - \frac{\rho_2 c_2}{\rho_1 c_1}\right) / \left\{ 4 \cot^2 \frac{2\pi l}{\lambda_2} + \left(\frac{\rho_1 c_1}{\rho_2 c_2} + \frac{\rho_2 c_2}{\rho_1 c_1}\right)^2 \right\}^{\frac{1}{2}}$$
 (28)

where l is the thickness of the plate and  $\lambda_2$  the wave-length of the sound in it,  $\rho_1 c_2$  and  $\rho_2 c_2$  being the respective radiation resistances

of the medium (1) and the plate (2). Boyle and Rawlinson (Proc. Roy. Soc., Canada, 1928) have deduced a more general expression for any angle of incidence, and have determined the "critical angle" at which total reflection occurs. It will be seen that the reflected-amplitude r fluctuates between zero and a maximum as the thickness of the plate varies. In the case where  $c_4 > c_1$  the reflected amplitude is zero when l = 0 or a multiple of  $\lambda/4$ , and reaches its maximum value when l is a multiple of  $\lambda/4$ . A quarter wave-plate consequently reflects a maximum and transmits a minimum of the incident sound-energy.

These relationships for the reflection of plane-waves from flat plates have been verified by Boyle and Taylor and Boyle and Lehmann in the case of high frequency sound-waves passing through water in which the plate was submerged. Equations (26) (27) and (28) indicate that solid media in air are practically perfect reflectors, whereas in water they are relatively good transmitters of sound. An air film in water or in a solid mass constitutes a perfect reflector, with a reversal of phase at reflection. The practical application of such deductions is dealt with by H. Brillié (Le Génie Civil, Aug. and Sept. 1919) in relation to the problem of sound-reception under water.

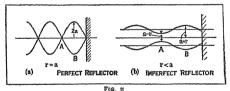
Stationary Waves.—Reflection and Absorption Coefficients of Materials. It has been shown in the case of strings that the resultant displacement y at a point in the stationary wave formed by combining the direct and reflected-waves is given by

$$y = a \cos n(t - x/c) - a \cos n(t + x/c) = 2a \sin nt \sin (nx/c).$$

The same relation applies to longitudinal-waves of condensation reflected normally from a plane perfectly reflecting obstacle. If, however, the obstacle is not a perfect reflector some of the incident sound energy is absorbed or transmitted. Consequently the reflected-amplitude r is less than a. The expression for y now becomes

$$y = (a+r) \sin nt \sin(nx/c) + (a-r) \cos nt \cos(nx/c)$$
 (29)

in the case of perfect reflection (r=a) we obtain the ordinary expression for stationary-waves. The general expression (2a) is applicable to all cases, and is represented by fig. 11. The incident energy is proportional to  $a^2$  and the reflected energy to  $r^2$ . The reflection coefficient of the obstacle is defined as the ratio  $r^2/a^2$ . Equation (2a) represents two superimposed stationarywaves of maximum-amplitudes (a+r) and (a-r) respectively, and displaced  $\pi/2$  in phase. Consequently the maximum and



minimum-amplitudes of the *resultant* stationary-wave are proportional to (a+r) and (a-r) respectively. If we write

$$\alpha = (a+r)$$
 and  $\beta = (a-r)$ ,

then the reflection coefficient

$$\frac{r^2}{a^2} = \left(\frac{\alpha - \beta}{\alpha + \beta}\right)^2 = \left(\frac{1 - \beta/\alpha}{1 + \beta/\alpha}\right)^2 \tag{30}$$

This expression for the reflection coefficient, in terms of the ratio min/max amplitude in the stationary-wave, serves as a basis for experimental methods of measuring the reflecting properties of materials and, of course, their absorption or transmission properties. The absorption coefficient (which is generally assumed to include transmission) is given by

$$(a^2-r^2)/a^2=4/(2+\alpha/\beta+\beta/\alpha)$$
.

This method of determining sound absorption coefficients of

materials was developed by Tuma (1902), Weisbach (1910) and Hawley Taylor (1913). More recently Paris (Roy. Soc., 1927) and Phys. Soc. Proc., 1927) has refined the experimental procedure by using the hot-wire microphone to obtain accurate values of the ratio  $\beta/a$ , and consequently of the reflection and absorption coefficients. The plane stationary-waves were produced in a tube closed at one end by the reflector under test. The absorption coefficient was found to increase with increasing thickness of the absorber (e.g., felt) and with increase in the frequency of the sound. Such measurements have an important application in the acoustics of buildings q.s. Stationary waves may readily be demonstrated when a high pitched sound, from a bird call or Galton's whistle, is reflected normally from a plane solid obstacle. A sensitive flame flares at all points in the path of the wave except at the nodes.

Echoes.—The direct reflection of a sound of short duration from a surface of large area such as a wall or a cliff results in what is familiarly known as "echo". The time-interval t between the initiation of a sound-impulse and the reception of the echo at the same point of observation is given by t=ad/c where d is the distance of the reflector and c is the velocity of sound in the intervening medium. Measurements of t will therefore lead to a value of the velocity c or the distance d according to which of these two quantities is previously known. The principle has important practical applications (e,g), see Echo Depth Sounding, p. 35) in

the measurement of distance.

Harmonic Echoes.—If the primary sound has a complex waveform, containing high harmonics of a fundamental tone, the component tones will be scattered or diffusely reflected in unequal proportions. The amplitude of the secondary-waves varies inversely as the square of the wave-length (and intensity as I/N), consequently the higher harmonics of the complex wave are scattered back in far greater proportion than the fundamental. To an observer near the source, therefore, the returning echo appears to be raised in pitch one or more octaves according

to the nature of the primary sound.

Reflectors as Sound Screens.—To produce shadows comparable with optical shadows, it is essential that the reflector should be large compared with the wave-length of the sound employed. The high pitched tick of a watch may be effectively screened by a relatively small reflector but the sound of a man's voice or of a motor horn requires a much larger screen. The wave-lengths in the two cases vary from a few inches to several feet, and the linear dimensions of the reflector must consequently vary in the same proportion to produce the same degree of screening. Behind the reflector the sound is generally found to have changed in quality, the high frequency components being more perfectly screened than the lower frequencies—on this account the sound appears to be "purified."

Musical Echoes from Palings. Echelon Reflectors. (Gratings).—If a sharp sound is made near one end of a row of palings, or similar "stepped" structure, the echo takes the form of a musical note. The successive palings each reflect the impulse (or, selectively, its higher harmonics) and the observer receives a succession of reflections which, if sufficiently rapid, blend into a musical note. The time intervals  $\delta t$  are equal to  $2\delta x/c$ , where  $\delta x$  is the path difference to the successive reflectors, consequently the frequency N of the note will approximate to  $C/2\delta x$  or some higher harmonic. If, for example, near a row of palings  $\delta x = 4$  inches, and c = 1 roo t/c, sec., N will be a multiple of  $t \cdot 65 \text{ cycles}/\text{sec}$ , i.e., a high pitched note. An echelon structure of this kind serves as the equivalent of a "grating" by which complex high frequency sounds might be analysed (see p. 26).

Reflection at Curved Surfaces. Spherical Mirrors.—It is shown in books on Optics that a parallel beam (plane-waves) of light when incident on a spherical mirror will be brought to a focus at a distance from the pole of the mirror equal to half the radius of curvature, and conversely a parallel beam of light emerges from such a mirror when a small source is placed at the focus. Similar results are observed with sound-waves of high frequency and reflectors of moderate dimensions.

Whispering Gallery Effects.-The well known whispering gallery of St. Paul's Cathedral, London, owes its peculiar acoustical properties to the reflection of sound by the walls. The gallery takes the form of a circle around the base of the dome. The exact mode of action is still a moot point. Rayleigh (Sound, vol. ii., p. 126) pointed out that the sound tends to creep round the inside of a curved wall, being continuously reflected by the wall, without ever getting far from it. whisper seems to creep round the gallery horizontally, not necessarily along the shorter arc, but rather along that arc towards which the whisperer faces. This is a consequence of the very unequal audibility of a whisper in front of, and behind the speaker. The abnormal loudness with which a whisper is heard is not confined to the position diametrically opposite to that occupied by the whisperer and therefore, it would appear, does not depend materially on the symmetry of the dome." It should be noted that whispers contain a higher proportion of high pitched sounds than ordinary speech, and whispering is heard more distinctly than ordinary conversation especially if the speaker looks along the gallery towards the listener. C. V. Raman (Ind. Assoc. Sci. Proc., 1922) describes an investigation of 5 whispering galleries in India which confirm a view held by Sabine of the importance of the inward slope of the wall of the gallery for giving the best effects, and the concentration by a spherical dome of a maximum sound at the opposite end of a diameter. Multiple sounds which are observed are shown not to be echoes, but sound-waves travelling circumferentially round the gallery several times before they are appreciably diminished in intensity.

Rayleigh suggests that the propagation of earthquake disturbances is probably affected by the curvature of the surface of the earth acting like a whispering gallery. It is not improbable also that sounds travelling long distances in the sea are dependent on a similar action, and on repeated reflection at the surface and bottom. Taking the depth of a sea as uniformly 24 fathoms (144 ft.) the maximum possible distance of direct propagation of a sound-wave in it will be 20; a miles approximately—whereas ranges 2 or 3 times this value have actually been observed in the North sea. The possibility of a curved path due to temperature gradients must also be considered in seeking an

explanation of these long ranges in the sea. Refraction of Sound-Waves.-The optical analogy which applies to reflection of sound may, as we have already seen, apply to refraction also. When plane-waves of sound cross the bounding surface between two different media having different wave-velocities c1 and c2 the direction of propagation is changed in accordance with the sine law, viz.,  $\sin \theta_1 / \sin \theta_2 = c_1 / c_2$  where  $\theta_1$  and  $\theta_2$  are the angles of incidence and refraction respectively. Hence the sound "rays" in passing from one medium to another are bent towards or away from the normal according as the velocity of the wave in the first medium is greater or less than in the second medium. Thus, for example, sound is refracted towards the normal when passing from air into CO<sub>2</sub>. "critical angle", when the sound is totally reflected, and there is no refracted beam, is given by  $\sin\theta_1=c_1/c_2$ . The critical angle from air to water,  $c_1 = 1,100$  ft./sec. and  $c_2 = 4760$  ft./sec., is therefore 1310 approximately; above this angle no sound whatever can enter the water (we have already shown, p. 23, that even at normal incidence the reflected amplitude is 0.99943 of the incident amplitude). From air to solid materials (steel, glass, wood, etc.)  $c_1/c_2 = 0.065$  approx. whence the critical angle is  $3\frac{1}{2}$ °. Sondhauss (1852) demonstrated the refraction of sound through prisms containing various gases, and determined the refractive index  $\mu$  relative to air,  $\mu = \sin \theta_1 / \sin \theta_2 = c_1 / c_2$ . He was also successful in demonstrating the focusing action of a convex lens of carbon dioxide enclosed in a thin envelope of collodion.

Refraction by Wind and Temperature Gradients.—It is well known that sound travels better with the wind than against it. This effect is due to the increase of velocity of the wind from the earth's surface upwards. The effective velocity of sound is equal to its normal velocity  $\sqrt{(\gamma p/\rho)}$  plus or minus the velocity of the medium. In still air the wave-front of a sound-beam will travel over the earth's surface parallel to its initial direction, say at right angles to the ground If, however, a wind is blowing in the same direction, the upper part of the wave where the wind velocity is greater, travels faster than that part near the ground, with the result that the wave-front tends to bend downwards towards the ground. An observer therefore hears by a direct ray which starts with a slightly upward inclination. Similarly a horizontal ray travelling against the wind is bent upwards and, at a moderate distance, passes over the head of an observer. A similar effect may be noticed when there is a gradual change in the temperature of the air from the ground upwards. The warmer the air, the greater the velocity of sound. If the temperature increases upwards, the wave-front will be bent downwards towards the ground; conversely, when the temperature diminishes upwards the sound-beam will be deflected upwards into the higher atmosphere and lost. The curvature of the ray is given by  $1/R = -1/c \cdot \partial c/\partial y$  where  $\partial c/\partial y$  is the velocity gradient with respect to height-this gradient may be positive or negative.

Audibility of Fog Signals. Tyndall (Phil. Trans., 1874) made extensive researches on the audibility of fog signals across the Channel from South Foreland, and came to the conclusion that "temperature refraction" and a "flocculent" condition of the atmosphere, arising from unequal heating or moisture, were responsible for large fluctuations in the observed ranges of audibility. Contrary to general opinion at the time Tyndall found that the presence of fog favoured the transmission of sound signals—the atmosphere being then in a more homogeneous condition, particularly in regard to temperature gradients. The problem of long-distance transmission of signals has recently been studied by King, Tucker, Paris and others. Using a doubly-resonated hot-wire microphone, Tucker and Paris have made intensity measurements at varying distances and orientations with respect to diaphones and sirens mounted in light-houses at sea. In a particular experiment it was found that the ratio of sound intensities at two miles from the source, with the wind and against it was 25 to 1. The effects of temperature refraction were also partly responsible for this high value of the ratio at such a short range. Certain fluctuations of intensity were ascribed to moving eddies in the atmosphere. Player, however, as a result of recent observations of a similar nature, reached the conclusion that humidity is the only factor in which the variations are at all comparable with the large and sudden variations in the range of audible transmission.

Zones of Silence. The sound of a large explosion is sometimes observed at very great distances, whilst at intermediate distances nothing at all is heard. Thus the explosion of a large ammunition dump in Holland (Jan. 1923) was recorded at a distance of 850 km, whereas at roo to 850 km, no sound could be detected. These intermediate zones of silence are not uncommon in such cases. They doubtless arise as a result of peculiar meteorological conditions at the time of the explosion. As we have seen, the action of temperature and wind gradients may cause upward or downward refraction of the sound. Esclangon (Comptes Rendus, 1924) has shown that these two factors are sufficient to account for one or a succession of zones of silence, with reinforcement of sound in particular directions. Zones of silence are in certain cases due to the interference between sound-waves reaching the observer by different paths. (See Interference above.)

Effect of Temperature Gradients on Sound Propagation Under Water.—The sea is a much more homogeneous medium for sound-transmission tnan the atmosphere. Sounds of moderate power may be heard at long ranges, 40 or 50 miles, without the corresponding fluctuations of intensity which are so troublesome in air. The effects of tidal currents (analogous to "wind"), say roft./sec, are in most cases negligible, the velocity of sound in water being about 5,000 ft./sec. Seasonal variations in range of signals have been observed (see H. Lichte, Phys. Zeits., Sept. 1919) these being ascribed to refraction produced by temperature gradients

in horizontal layers of the sea. Such a temperature gradient may cause a sound "ray" to curve upwards to the surface where it is reflected down again, only to rise once more. In this way it travels forward along a cycloidal or "festoon" type of track. A temperature gradient of opposite sign causes a bending downwards with analogous effects at the sea bed. Surface and bottom reflections play an important part in the long-range transmission of sound in the sea. With a particular sound-transmitter Lichte and Barkhausen (Ann. d. Physik, 62, July 1920) noted a change from 10 km. in summer to 20 km. in winter in the Baltic sea.

Interference.- The passage of sound-waves through a medium is in no way affected by the passage of other sound-waves through the same part of the medium. This important principle involving the independence of separate trains of waves is known as the Principle of Superposition and was first propounded by Huyghens in dealing with light-waves. The resultant displacement of a particle of the medium is obtained by adding the separate displacements vectorically (see p. 20). Thus two periodic motions of the same frequency, of amplitudes a1, and a<sub>2</sub>, and phase difference € combine to form a periodic motion having an amplitude whose square is  $(a_1^2 + \hat{a}_2^2 + 2a_1a_2 \cos \epsilon)$ . The principle of superposition applied to the squares of amplitudes (i.e., energies) would account for the first two terms only and the results would be erroneous. It is found under certain conditions that two trains of sound-waves may, at certain points in the medium, neutralize each other's effects and produce silence where previously there was a definite sound due to either of the trains of waves. Thus in the above case, if  $\epsilon = 180^{\circ}$ , i.e., the two independent sets of vibrations of the particle are in opposite phase cose=-r, and the resultant amplitude is  $(a_1-a_2)$ , which becomes zero when  $a_1=a_2$ ; if  $\epsilon=360^\circ$  or  $0^\circ$ ,  $\cos \epsilon = +1$  and the resultant-amplitude is  $(a_1+a_2)$  or 2a, when  $a_1=a_2$ . When the observed sound-distribution due to two or more wave-trains of sound is not found to be equal to the sum of the separate wave-trains, the latter are said to have inter-fered with each other and the phenomenon is described as interference. Interference is a direct result of the principle of superposition. The phenomena of interference may be observed in any smooth water surface which is disturbed simultaneously at two different points. J. H. Vincent has obtained very beautiful photographs of such effects on the surface of mercury (see Phil. Mag., 1897, 8 and 9). The crests and troughs of the two sets of ripples in certain places reintorce each other, whilst in others they neutralize; the result is a definite "interference pattern" superposed on the ordinary wave systems. When sounds of the same frequency and amplitude reach the ear by different paths, or originate with different phases, interference effects may readily be observed. Thus the waves sent out from the prongs of an ordinary tuning fork interfere, producing approximate silence in certain directions and increased intensity in others-the rise and fall of intensity, four times per revolution, as a vibrating fork is rotated near the ear is easily demonstrated. Any "doublesource" of sound, such as a vibrating diaphragm exposed on both sides, shows these effects. If sound is led from its source to a receiver by two tubes of equal diameter and length the two sets of waves will arrive together, i.e., in phase. If the length of one tube is gradually varied relatively to the other the path difference will be successively  $\lambda/2$ ,  $\lambda$ ,  $3\lambda/2$ ,  $2\lambda$ , and so on; the resultant effect at the receiver alternating between zero, and maximum. These phenomena can be demonstrated by means of a tuning fork and two tubes of adjustable length, with a common exit placed to the ear. Stationary-waves to which we have already referred (p. 23) form a good example of the interference between a primary and a reflected train of waves. Interference between the waves from two sources of sound of nearly equal frequency appears as an increase and decrease of intensity with time-known as the phenomenon of beats (see p. 6) and exemplified by two tuning forks of nearly equal pitch. In certain cases the zones of silence observed by Tyndall when listening on a ship to the sound of a fog siren on a neighbouring cliff, were ascribed to the interference between the direct sound beam with that reflected from the surface of the sea-if these the effect of the first zone, i.e., the same as if no obstacle at all paths differ by any odd multiple of half a wave-length the two trains of waves neutralize each other and the siren is not heard. Wood and Young (Proc. Roy. Soc., 100, 1921) observed interference zones under water due to a similar cause. Such effects are of considerable importance in the case of long distance sound transmission in the sea. The sound-wave is reflected with reversal of phase when it reaches the water-air surface. At a considerable distance from the source, the path difference between the direct and surface-reflected wave may become very small compared with the wave-length, resulting in almost complete neutralization. Fortunately, however, the surface of the sea is never smooth and the sea-bed reflects sound very efficiently. The bottom-reflected-wave may therefore, in certain cases, be solely responsible for the sound heard at long ranges.

Diffraction. Sound-Shadows - The bending of sound-waves round the edges of obstacles is one of the most familiar of everyday observations. If it were not for this effect, short distance intercommunication by means of sound would be much more difficult. Fast motor traffic on our roads is vitally dependent upon such a possibility at turnings and crossings. This bending of sound "round the corner" may be regarded as evidence of its nature as a form of wave motion; the effect being similar to that of "diffraction" in the case of light-waves. The sound-shadow and the geometrical shadow of an obstacle are therefore not coincident. The study of diffraction effects is greatly assisted by the use of a principle which is due to Huyghens:- The wave-front of a disturbance may at any instant be obtained as the envelope of the secondary-waves proceeding from all points of the wave-front at some preceding instant. A disturbance diverging from a point source with velocity c may at any time t1 be represented by a thin spherical shell. This shell may therefore be regarded as the disturbed region, and the disturbance at a subsequent time t2 determined by drawing spheres of radii  $c(t_2-t_1)$  round each point of the shell. The outer spherical envelope of these spheres will be the new wave-front at the instant t2. By this construction it will be found that the direction of advance of the wave is normal to the wave-front. Huyghens' principle of secondarywaves is directly applicable to diffraction problems provided that due allowance is made for the contribution of each surface element of the wave-front to the amplitude at the point P under consideration. This estimation of amplitude involves the use of a device due to Fresnel-in which the initial wave-surface is divided into "half-wave zones" (see text-books on Optics). These zones are such that their resultant effects at some distant point P are alternately in opposite directions (being  $\lambda/2$  different in path length measured from P). Two successive zones therefore neutralize each other's effects at P.

Plane-Waves of Sound Passing a Straight Edge.—Employing the Huyghens-Fresnel principle the distribution of sound beyond the edge of a totally reflecting wall may be determined. Outside the geometrical shadow there is a fluctuation of intensity which settles down, after a few oscillations, to the normal value in the absence of the wall. Inside the geometrical shadow the intensity steadily falls off from one quarter its normal value at the edge to zero at some distance inside the geometrical shadow. The relatively feeble diffracted sound behind the wall is easily observed by the ear if the incident sound-wave is of audible frequency and of moderate intensity. With high pitched sounds (e.g., from a Galton's whistle or a high frequency diaphragm excited electro-magnetically) and a sensitive receiver the variations of intensity at a diffracting edge can be observed experimentally. A sensitive flame may be used as the indicator of sound intensity or alternatively, if the sound is in the audible range, a stethoscope tube with a small funnel opening may be used to listen directly. The gradual fading away of sound within the geometrical shadow is a common observation at all frequencies.

Circular Obstacle. Scattering of Sound-Waves.—Constructing Fresnel zones outside the edge of a circular obstacle, it will be found that the total effect at a point on the axis is equal to half

were interposed This is true whatever the size of the disc relative to the wave-length of the sound. Immediately surrounding the central spot there is a ring of almost complete silence and beyond that a further increase of intensity, and so on. These effects can be demonstrated in the manner suggested above for a straight edge. This case is analogous to that of the bright spot at the central point of the optical shadow of a circular discone of the "classical proofs" of the wave theory of light. It finds an important application in the directional reception of sound (sec p. 28).

Scattering by Small Obstacles .- Rayleigh has shown that the intensity of the sound scattered in all directions by an obstacle is directly proportional to the volume of the obstacle and inversely proportional to the fourth power of the wave-length of the sound. This law also applies to the scattering of light and is used to explain the blue colour of the sky. We have already referred to an illustration in sound, viz., harmonic echoes, in which the higher constituents of a complex sound are scattered more readily than the fundamental, with the result that the scattered or diffusely reflected sound appears raised in pitch by one or more octaves.

Circular Aperture.-The transmission of sound through a circular opening in an extended wall has already been considered in the analogous case of sound radiation from a piston (such as a Langevin quartz oscillator), the sound distribution beyond the opening consisting of a primary beam and a number of secondaries separated by silent regions. An experiment showing the antagonism between the parts of a wave corresponding to the first and second Fresnel zones is described by Rayleigh (Sound, Vol. II., p. 141). Sound-waves from a high pitched source fall on a screen with a circular opening of variable diameter. A sensitive flame is situated on the axis on the opposite side of the screen. The flame is unaffected by the sound which gets through a large opening, comprising two opposed Fresnel zones but flares violently when the area is reduced to one zone.

Zone Plates .- Let circles be drawn, on a plane reflector, with radii,  $r_1 r_2 r_3$ , etc., given by  $r_n^2 = n\lambda d$  where n = 1, 2, 3, etc., and d is the distance of the centre O from a point P on the axis normal to the reflector. The circles divide the surface of the reflector into Fresnel half-wave zones with respect to the point P. It will be seen that these annular zones are of equal area. If alternate zones are cut away, a plane sound-wave falling on the plate and passing through the annular openings will arrive in phase at P, resulting in a considerable increase of intensity at that point. A zone plate of this kind therefore acts like a convex lens of focal length  $\hat{O}P = f = r_n^2/n$ ,  $r_n$  being the radius of the *n*th zone and  $\lambda$  the wave-length of the sound. The focusing properties of such zone plates were demonstrated by Rayleigh by means of high pitched sounds and sensitive flames.

Diffraction Gratings. Reflection from Stepped or Corrugated Surfaces.—The diffraction grating, so familiar in optics, has its counterpart in sound. When sound-waves are reflected from a regular periodic structure, such as a row of palings or a corrugated surface, the reflected-waves may assist or neutralize each other in certain directions depending on the wave-length \( \lambda \) of the sound and the spacing d of the reflectors. The diffractedwaves have maxima in directions  $\theta$  given by  $\sin \theta = \pm n \lambda/d$  where n = 1, 2, 3, etc. When d is smaller than  $\lambda$  there are no diffracted waves and the incident beam is reflected in the ordinary way. Thus a row of palings or a rough wall reflects sounds of moderate pitch like a perfectly smooth surface, little or no sound being returned towards the source, except in the case of normal incidence. When the sound is high pitched, however, \u03b4 being less than d, it is thrown back in all directions reinforcing along certain lines and neutralizing in others. A regular row of palings may serve as a "reflection" or a "transmission" grating. W. Altberg (Ann. d. Physik, 23, 1907) demonstrated a diffraction grating of this nature by means of glass rods r cm. apart, using a concave reflector to produce plane-waves of sound incident on the grating. The sound was produced by means of a high

frequency electric spark emitting waves only a few millimetres in and falls in pitch once per revolution. The observed pitch of the length. A second concave mirror received the diffracted sound and brought it to a focus at a sensitive detector. The sound spectrum was obtained by rotation of the grating with respect to the source and receiver. Wave-lengths of the order 0.2 mm., corresponding to a frequency 1.5 million per second, were measured in this way.

Experimental Study of Wave Transmission .- Many of the "optical" characteristics of sound which we have mentioned may be studied on a laboratory scale by the following methods: (a) Spark Photography. The progress of a sound pulse may be observed either by the "Schlieren Method" (due to Topler 1867) or the "Shadow Method" (due to Dvořák 1880). In the latter case, the sound pulse is produced by an electric spark (the sound spark), followed by a second spark (the light spark, between magnesium electrodes) at a known short interval of time. The highly compressed region forming the envelope of the sound pulse casts a shadow, when illuminated by the light spark, on a screen or a photographic plate. A succession of photographs at varying time-intervals after production of the sound-spark indicates the progress of the sound-pulse. The various phenomena of reflection, refraction and diffraction have been demonstrated in this way (see for example, Foley and Souder, Phys. Rev., 35. 373. 1912). Photographs of this nature are shown in the Plate, figs. 1a to f. (b) Ripple Photography. Results of a similar character may be obtained more easily by means of the ripple tank. This method is based on the fact that impulsive ripples on the surface of a liquid, e.g., water or mercury in a small tank, bear a striking resemblance to impulsive soundwaves. The ripples are reflected, refracted and diffracted from objects placed in the liquid, as shown in the Plate, Fig. 12. The method was first used by Vincent (Phil. Mag., 43. 17. 1897) to demonstrate interference phenomena, but more recently it has received a wider application in the study of complex reflections occurring in models of buildings (see Article on Acoustics of Buildings; and Davis, Proc. Phys. Soc., 38, 234, 1926). (c) Bullet photography. The "bow" wave from a high speed bullet (see Plate I., fig. 2) has been utilised to demonstrate the reflection and diffraction of a sound-pulse. Thus in C. V. Boys photographs of a bullet in flight (Nature, 47. 415. 440. 1893) the pulse is seen to be reflected according to optical laws. Cranz (Handbuch der Physik, Vol. VIII, Geiger and Scheele) has photographed the track of a bullet passing between two parallel plates, and the multiple reflections of the bow-waves are beautifully shown. The method is not so convenient as the spark and ripple methods, but it possesses certain novel features.

Doppler's Principle.-Moving Sources and Receivers.-The pitch of a sound is liable to be modified when the source and receiver are in relative motion. Thus an observer approaching the source with velocity v will encounter more sound-waves per second than if he had remained at rest, the number of sound waves per second (the pitch of the note) being increased in the ratio (c+v)/c where c is the normal velocity of sound in the medium. Similarly when the observer is at rest and the source moving, the change of pitch will be in the ratio c/c±v according as the source is approaching or receding. The whistle of a locomotive is raised in pitch as it approaches, and falls in pitch as it recedes from an observer. The principle of change of pitch by relative motion is due to Doppler, who first enunciated it in connection with the change of colour of certain stars moving in the line of sight of an observer. If the medium is also in motion (e.g., wind) with velocity w in the direction of the soundwave, the observed pitch N1 relative to the actual pitch N will be  $N^1/N = (c \pm w \pm v)/(c \pm w)$ . When v = 0,  $N^1 = N$  irrespective of the velocity of the medium. The latter velocity w only affects the ratio N1/N slightly when the source and observer are in relative motion also. The Doppler effect can be produced in the laboratory by the simple expedient of rotating a maintained source of sound at the end of a bar or cord. Preferably the source should be maintained in vibration by virtue of the rotation. The observer in the plane of rotation hears a note which rises

sound from an aeroplane may vary by 20% according to the speed and direction of flight.

Attenuation of Sound-Waves. Viscosity and Heat Conduction .- We have hitherto considered plane or spherical waves travelling through various media without loss of energy. Apart from other considerations it will be evident that energy loss must take place wherever there is relative motion between the various particles comprising the medium, such loss being due to ordinary viscous forces which tend to degrade the sound energy into heat. In addition to this viscous loss there must be energy loss due to thermal conduction and radiation consequent on the compression and rarefaction of the medium. If the compressions and rarefactions succeed each other with sufficient rapidity the process will be strictly adiabatic, that is, there will be no transfer of heat between compressed and rarefied regions or to the parts of the medium unaffected by the sound-wave. Sound-waves of small amplitude in air are propagated under almost perfectly adiabatic conditions. Otherwise, as Stokes proved in 1851, the sound would be rapidly stifled, which is contrary to experience. In the case of sounds of very large-amplitude however (an explosion impulse, or the sound-wave emerging from a very powerful source), it is conceivable that the large temperature fluctuations in each cycle of pressure may be such as to involve appreciable temperature losses due to conduction and radiation even in a very short time interval. This would result in a more rapid decrease of sound-energy with distance than the inverse square law requires, the effect becoming increasingly serious the lower the frequency and the greater the amplitude of the sound waves. With regard to energy loss due to viscosity, Maxwell pointed out that the factor involved is the "kinematic viscosity coefficient" v, which is equal to the ordinary "static" coefficient µ divided by the density  $\rho$ . Thus for air  $\nu=0.132$  and for water ν=0.013 at 10°C. The amplitude ξ of the progressive wave therefore diminishes exponentially on account of energy loss on the way. In the case of plane-waves we have

$$\xi = ae^{-x/l} \cos n(t - x/c)$$

where l is the distance travelled by the wave before the amplitude falls to 1/e of its initial value. In this expression  $l = (3c/8\pi^2\nu)\lambda^2$ , indicating a rapid increase of attenuation with diminishing wave-length  $\lambda$  (i.e., with increase of frequency). To include the losses due to heat conduction also Maxwell multiplied  $\nu$  in the above expression by 2.5, the effect being therefore equivalent to a marked increase (to  $v^{l}$ ) of kinematic viscosity. On the above grounds there is clearly a physical upper limit to the frequency of vibration which can be transmitted an appreciable distance1. Rayleigh (Vol. 11, p. 28) concludes that the effects of energy losses of the above nature are to be sought for in the damping of the vibration rather than in the altered velocity of propagation. It should be mentioned that changes of velocity with frequency have actually been observed by Pierce in air and CO2 and by Boyle and Taylor in water, although no such change could be detected by Lang in the case of steel bars.

With regard to attenuation there is ample evidence confirming the above theory which indicates a rapid decrease of range with increasing frequency. For example in air, for sound-waves of frequency 1000,  $\lambda = 33$  cms., we find l = 40 kilometres since  $v^1 = 2 \cdot 5v = 0 \cdot 33$  for air. The value of l at a frequency 100,000 is consequently 4 metres only. In sea water  $\nu = 0.013$  that is  $v^1 = 0.0325$ , and  $c = 1.5 \times 10^5$  cms./sec., whence  $l = 3.9 \times 10^4$  kilometres at a frequency of 1000 ( $\lambda=150$  cms.), and l=3.9 kilometres at a frequency of 100,000 ( $\lambda = 1.5$  cms.). It is thus evident the attenuation of sound-waves in sea water due to viscosity and heat losses is almost negligible compared with the attenuation at corresponding frequencies in air. This accounts to some extent for the relatively large ranges of transmission observed under the sea compared with those in air for the same amount of sound energy at the source. A small charge (9 oz.) of guncotton ex-

<sup>1</sup>G. W. Pierce has shown experimentally that CO<sub>2</sub> becomes opapic to sound-waves at a frequency of 2×105 p.p.s.

ploded under water can be detected (and recorded by an Einthoven galvanometer) at 40 miles (see Wood and Browne, Phys. Soc. Proc., 1923). It is extremely improbable that such a range could be obtained in air. This comparison is of course only of a rough nature, for the wave form and the initial "amplitudes" would not be the same in the two cases. There is ample evidence to show, however, that the attenuation of bell sounds and other noises under water is less than in air. On account of other factors (nature of sound sources, homogeneity of medium, etc.) a strict comparison is somewhat difficult. Attenuation by scattering in a heterogeneous medium may be a serious factor in regard to loss of range in signalling by sound-waves. Tyndall found that a homogeneous atmosphere, clear or uniformly foggy, transmitted a sound signal to far greater distances than a "patchy" atmosphere containing masses of air at different temperatures, wind eddies, etc. Similarly when sound travels through water it may be seriously interrupted if it meets with a mass of bubbles. The sound of a ship's propeller does not pass very well through the bubbly water in the wake. Air bubbles in the sea may therefore be a serious cause of attenuation, the effects of viscosity and heat conduction being relatively small.

Sound Absorption in Narrow Tubes and Cavities. Porous Bodies.—When sound-waves fall on certain bodies which may be regarded as a mixture of solid and gas, e.g., cork or felt, it is found that a large proportion of the incident energy is absorbed due to viscosity and heat conduction. The influence of these factors is enormously increased on account of the large surface of solid matter in contact with the vibrating gas particles. Viscous forces are increased at the surface of the solid, and the latter serves also as an effective means of reducing the temperature fluctuations in the compressed gas, i.e., the compressions and rarefactions are no longer adiabatic. Rayleigh has shown theoretically (Sound, Vol. II, p. 331) that the attenuation of sound-waves in a narrow tube of circular section is proportional to the square root of kinematic viscosity p<sup>1</sup>, and the frequency N, and inversely proportional to the radius of the tube. Porous materials like felt, wool, cork, etc., are effective sound absorbers, and are used to reduce reverberations in auditoriums.

#### RECEPTION OF SOUND

The manner in which sound-energy is abstracted from the medium carrying the sound-waves is dependent on a wide variety of circumstances and each case must be treated accordingly. In the first place the choice of a receiver must depend on the medium of transmission-a receiver suitable for air being generally quite unsuitable under water or in a solid medium. Again the selection of a receiver will depend on the frequency and wave form of the vibration-sounds of frequencies 500 or 50,000, or a single explosion impulse, requiring entirely different treatment. If the sound-wave is employed in long-range signalling it is important that the receiver should be efficiently designed and tuned to the incoming sound, in order to obtain maximum response to weak signals. Distortion of wave-form in this case may be of secondary importance. On the other hand, if it is required to obtain a faithful record or reproduction of the sound-wave, energy considerations are relatively unimportant whereas an accurate reproduction of the wave-form is vital. In this connection we have to distinguish between resonant and non-resonant receivers. As a general rule a resonant receiver is employed where maximum sensitivity and efficiency are required, whilst a non-resonant receiver is used for faithful recording or reproduction of the sound.

All forms of sound-receivers involve the introduction of some obstacle into the path of the sound-waves, this obstacle either partaking of, or otherwise influencing, the motion of the particles of the medium, or responding in some way to the pressure variations on its surface. Energy may be lost due to reflection and readiation from this obstacle, but in a good receiver a moderate amount of sound-energy is transferred from the medium and converted into a form convenient for observation. It is often desirable to trensform the mechanical vibrations of the medium

into another type of vibration or into some other form of energy. For example, longitudinal sound-waves passing through the air from the mouth of a speaker fall on the diaphragm of a telephone transmitter which is set into transverse vibration. This transverse vibration controls electrical energy which is transmitted to a distant diaphragm receiver and reconverted into mechanical energy in a form suitable for transmission to the ear. Many well known forms of sound-recording apparatus (e.g., Webster's Phonometer, Millar's Phonedeik, and the Hilger Audiometer) employ a diaphragm receiver with some optical means of indicating and recording the transverse vibrations. Other forms, exemplified by magnetophones, microphones, piezo-electric receivers, condenser microphones, etc., involve the conversion of mechanical into electrical energy. Sound-vibrations may also be observed by means of such devices as optical interferometry and sound shadow photography or by means of manometric and sensitive flames. Metrical forms of receiver such as the Rayleigh disc and the sound-radiometer (measuring radiation pressure of sound-waves) form another class, which might also include the various "phonometers," the hot-wire microphone, and piezoelectric receivers. The amplification of received sounds by mechanical devices, "mechanical transformers," mirrors, trumpets and resonators, or by electrical means, microphone and valve amplifiers, must also be considered. In certain cases special devices are required, as in sound-reception under water (hydrophones) or in the detection of sounds travelling through the ground (geophones). The above remarks will be sufficient to show the difficulty of attempting a comprehensive classification of soundreceivers. In what follows we shall deal with the more important types, some of which have already been mentioned.

The Ear .- Sensitivity and Audible Limits .- By far the most important and most universal receiver of sound is the ear. This 'organ of hearing" has a marvellous range of frequency and sensitivity; it can perceive vibrations of frequency varying from 20 to 30,000 cycles/sec., and can detect a sound of amplitude less than 10-8 cm. whilst it is not destroyed by a vibration having an amplitude a million times as great. The ear with its associated nerve endings has also remarkable powers of analysis. It can distinguish one complex sound from another and can ' intelligently" to a number of different sounds at the same time. For a complete description of the complicated structure of the ear, reference should be made to text books of physiology or anatomy. Briefly, it consists of a device which brings the waves of sound to act on a terminal expansion of the auditory nerve. This device is divided anatomically into three parts, the external ear with the auditory meatus, the tympanum and the internal ear. The external ear in the case of the lower animals is very movable, presumably to assist in sound-location. This function in man is rudimentary so that he can hear almost normally with his ears cut off. The external ear is separated from the tympanum by the "drum" of the ear or membrane tympani, which is set in vibration when sound-waves fall upon it. These vibrations are transmitted with diminishing amplitude but increased pressure by a chain of bones (malleus, incus and stapes) acting as a system of levers, to the fluid (perilymph) in the internal ear. The vibrations travel through the perilymph from the vestibule and the 'oval window" up the turns of the cochlea and ultimately to the basilar membrane thus affecting the haircells and the ends of the auditory nerve. Many theories, notably the resonance Theory of Helmholtz, have been proposed to explain the function of the various parts of the ear, in particular the cochlea and the basilar membrane (with the "rods of Corti" and the haircells), but none appears to be really satisfactory. It is certain, however, that the more highly developed the cochlea the more perfect is the hearing of an animal. This is shown in birds and mammals which have a far more perfect cochlea than is found in reptiles and fishes.

Sensitivity of the Ear to Intensity and Frequency Variation.— The relation between sensation (loudness) and stimulus (intensity) applicable to all sensations, is generally expressed by Weber's law—"The increase of stimulus necessary to produce the minithat is.

mum perceptible increase of sensation is proportional to the a sound proceeding from the right or the left is readily determined pre-existing stimulus." From this law Fechner derived the relation  $S=k\log E$  or  $\partial S/\partial E=k/E$ , where S is the magnitude of the sensation, E the intensity of the stimulus and k a constant. The "law" obviously approximates to the truth, for the sensitiveness of the ear  $\partial S/\partial E$  diminishes rapidly with increase of the total intensity E of the sound. Feeble sounds which are easily heard at night when E is small, cannot be distinguished from the general noise in the daytime when E is much greater. Wood and Young (Proc. Roy. Soc., A. 100, p. 264 and p. 266, 1921), in judging equality of two sounds of the same pitch, remark that under favourable conditions it was possible to distinguish a difference of intensity of 10%. A similar conclusion was reached by  $V_{\delta}$  O. Knudsen (*Phys. Rev.*, 21 Jan. 1923). Measuring the "intensity sensitivity" of the ear  $\delta E/E$  where  $\delta E$  is the least perceptible difference of energy and E the total energy of the tone, Knudsen found  $\delta E/E$  to be about 0-10 for moderate and large intensities E, but increased to the limiting value of unity as the intensity decreased to the threshold value Eo (the minimum energy of audibility). To include this region of very feeble intensities Knudsen proposed a modification of the Weber-Fechner law, namely,  $\delta E/E = k + (1-k) (E_o/E)^n$  where k = 0.10app. and n varies somewhat with frequency, being 1.65 for 200 cycles/sec. and 1.05 for 1,000 cycles/sec., nevertheless at the same loudness level e.g.,  $10^4 E_0$ ,  $\delta E/E$  is nearly independent of frequency. More recently R. R. Reisz (*Phys. Rev.*, 31, May, 1928) has found that  $\delta E/E$  lies between 0.05 and 0.15 according to frequency. He found also that  $\delta E/E$  is a minimum at 2,500 p.p.s.—this minimum being more sharply defined at the smaller sound-intensities. This frequency corresponds to the region of greatest absolute sensitivity of the ear. Fig. 12 indicates the range of the average human ear with regard to both intensity and frequency. The upper curve gives the sound-pressures (root mean square) which produce a sensation of feeling, and serves as a practical upper limit to the range of auditory sensation (Wegel, Bell System. Tech. Journ., 1, Nov. 1922) whilst the lower curve indicates the pressures at the threshold of audibility. It will be seen that the ear is most sensitive in the region of frequency 500 to 5,000 p.p.sec. The range of intensity (proportional to square of pressure) appreciated by the ear in this range is of the order The smallest detectable pressure-amplitude is of the order 10-3 dyne/cm.2, i.e., 10-9 of atmospheric pressure, corresponding to a displacement-amplitude of the order of 10-9 cm. Knudsen, Fletcher and Reisz independently conclude that near a frequency of 2,000 the ear can distinguish, under favourable conditions, from 300 to 400 gradations of loudness between the threshold of audibility and the threshold of feeling (a painful intensity 1012 times as great)—each step being recognisable by the ear as just perceptibly louder

than the one before it. Audible Limits of Frequency.-The lower and upper limits of frequency for tones audible to the human ear vary according to different observers. A very good average range of frequency may be taken as 20 to

20,000 cycles/sec. Very high

CM<sup>2</sup> 10000 £ 100

and very low pitched sounds of great intensity are felt rather than heard. The ear loses its power to discriminate variations of pitch at very high frequency. The frequency range employed in music extends from about 40 to 4,000 cycles/sec. When two notes within the range 500 to 4,000 cycles/sec. are sounded alternately, the ear can detect a difference of frequency of about 1 in 300. When the two notes are sounded together the discrimination is greatly improved—a frequency difference of one in 20,000 being readily discernible by "beats" (see p. 6). Kohlrausch demonstrated experimentally that the sensation of pitch may be excited even with so few as two vibrations.

Perception of Direction. Binaural Audition. - The direction of 21---B

with fair accuracy, but there is little difference observable between a sound approaching from behind or ahead. For high pitched sounds of short wave-length these directional effects might be explained by the difference of intensity of the sound reaching the two ears, since the head acts to some extent as a screen to the ear which is more remote from the source of sound. When the wave-length of the sound exceeds the perimeter of the head, however, the intensity difference must be very slight and we must look for another explanation of the directional effect. Rayleigh (Sound, Vol. II., p. 440) who has examined this question carefully, arrived at the conclusion that the perception of direction is dependent on the relative phase of the sounds as they reach the two ears, a small difference of phase being sufficient to indicate the required direction. He found that if the same tone be led by different paths to the two ears, the sound could be made to appear to come from the right or the left at will, by adjusting the path-lengths and consequently the relative phase. The origin of the sound was always attributed to that side on which the phase is in advance (by less than half a period). No explanation of this effect has yet been given.

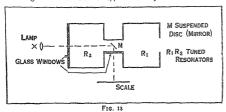
Pressure of Sound-Waves .- Radiometers .- Sound-waves, like light-waves, exert a slight pressure on any surface upon which they fall; and radiometers for measuring sound-intensity have been constructed on this principle. Rayleigh (Phil. Mag., 10, 1905) has determined this pressure on theoretical grounds, but a more simple treatment due to Larmor will suffice here. Planewaves are incident on a perfectly reflecting wall free to move, the wall being pushed with velocity v to meet the advancing sound-waves of velocity c and mean energy density E (see p. 28). The total energy density in front of the wall, if stationary, would be 2E due to the incident and reflected trains of waves. The length of the wave-train incident per second on the advancing wall is (c+v) this being compressed during transmission into a length (c-v) due to the approach of the wall. The energy density in the reflected-wave is therefore increased in the ratio

$$(E+\delta E)/E = (c+v)/(c-v) = 1 + 2v/c,$$
  
$$\delta E = E \cdot 2v/c.$$

The increase in the total energy in the region of length c in front of the moving wall is consequently  $c \cdot \delta E$ , and this must inevitably be due to the work done by the wall in compressing the radiation. If P is the radiation pressure, the work done by the wall per second is Pv, whence  $Pv = c \cdot \delta E = E \cdot 2v$ , that is, P = 2E, the mean radiation pressure being equal to the energy density in the medium in front of the wall. If the wall is a perfect absorber there will be no reflected-wave and P = E. Now the intensity of the sound is equal to the energy density × the wave-velocity c (see page 22). Provided therefore that the radiation pressure can be measured. and the reflection characteristics of the wall can be determined, we have here an absolute method of measuring sound-intensity. Radiometers for measuring the intensity of high frequency soundwaves under water have been constructed on the above principle by Langevin, Wills, Boyle and others. Boyle (Proc. Roy, Soc., Canada, 1925) constructed torsion pendulums for use with high frequency quartz oscillators under water. The pressure of the "ultra sonic" radiation on the pendulum vane causes a deflection which is reduced to zero by a torsion head. This gives a measure of the twisting moment and consequently the radiation pressure. Comparative measurements with such radiometers confirm the theoretical deduction that the radiation pressure is proportional to the energy density. All absolute measurements of radiation pressure must, of course, make allowance for diffraction at the edge of the reflecting vane. Using the radiometer method, Boyle measured the energy output of high frequency quartz oscillators and the reflection and transmission coefficients of various materials under water. Torsion radiometers have similarly been used to measure sound-intensity in air (Altherg, Ann. d. Phys., 11, 1903). They are only of value, however, in cases where the sound-intensity is very great.

Rayleigh Disc.—A device which is often used in sound-in-

tensity measurements is due to Rayleigh (Sound, Vol. II., p. 44). A delicately suspended disc (a small mirror about  $\frac{1}{2}$ -in. diameter) will tend to face a stream of air (or other medium) flowing past it, whether the flow be direct or alternating. The torque M on the disc tending to diminish  $\theta$ , the angle which the normal of the disc makes with the stream, is given by  $M = \frac{4}{3} \cdot \rho a^{2} \rho^{2} \sin 2\theta$ , "a" being the radius of the disc,  $\rho$  the density of the medium and



v the velocity of the stream. If the stream be alternating instead of steady, it is only necessary to employ the mean value of v2. The maximum torque is obtained when  $\theta = 45^{\circ}$ . A light galvanômeter mirror suspended on a fine quartz fibre provides a very sensitive arrangement, particularly when used inside a double resonator (see fig. 13) tuned to the frequency of the sound it is desired to measure. When accurately tuned to the sound falling upon the open end of the resonator R, the instrument can be used to compare the intensities of sounds of the same frequency. The sensitiveness is comparable with that of the ear. The deflections, if small, are proportional to the square of the particle velocity in the undisturbed field. It is important that the diameter of the disc should be small compared with the wave-length of the incident sound. As the double resonator and disc system is very sharply tuned, a large number of instruments would be required to cover a moderate range of frequency and intensity. A disc mounted in the mouth of a single resonator of continuously variable tuning is more generally useful, but is less

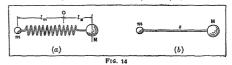
Resonant Receivers .- When the incoming sound-waves have a predominant frequency it is clearly advantageous to "tune" the receiver to obtain maximum sensitivity. The tuning of a receiver, e.g., an air cavity or a diaphragm is similar to the tuning of a sound transmitter. In many electrical cases the same device may serve either as a transmitter or a receiver, e.g., a telephone earpiece (magnetophone), a Fessenden electro-magnetic oscillator or a piezo-electric oscillator. Under these circumstances it is possible for the tuning to be very exact. A resonant air cavity develops a relatively large amplitude of vibration at its mouth, this amplitude being considerably in excess of that in the surrounding medium. The sound-field near such a resonator is affected by its behaviour as a secondary source, the energy which the resonator emits being drained from the other parts of the sound-field. It can be shown that the area of wave-front from which energy is extracted (and re-radiated) by a small resonator is  $\lambda^2/\pi$  where  $\lambda$  is the wave-length of the incident sound to which it is tuned. This area may be considerably greater than the area s of the resonator, the energy amplification being  $\lambda^2/\pi s$ . In actual resonators, however, only a part of this energy is reradiated, the remainder being absorbed. The latter portion is partly dissipated in viscous damping and partly converted into a useful form, i.e., is utilised in operating a detector, such as a microphone, or a magneto-phone, or in deflecting a mirror. The efficiency of the receiver is dependent on the proportion of the total energy which is usefully absorbed. Absorption of energy involves damping. The receiver is inefficient if it is underdamped, little or no energy being absorbed, or if it is over-damped, too much or all the energy being absorbed. If the receiver is underdamped it re-radiates too large a proportion of the received energy back into the medium. Overdamping reduces the sharpness of resonance and consequently reduces the area from which

energy is obtained, the main advantage of tuning being lost. The most efficient receiver lies between these extremes, i.e., the energy absorbed is equal to the energy re-radiated. In other words, in an efficient tuned receiver the damping due to the medium must be equal to the internal damping in the receiver. It is of course, equally important that the internal damping must be useful damping, i.e., the absorbed energy must be used efficiently. Thus if the receiver is electro-magnetic (a telephone receiver) it is important that the ratio of motional impedance (measured electrically) to total electrical impedance should be as great as possible. A solid resonator such as a tuned metal diaphragm in air is necessarily inefficient, for a large proportion of the incident energy is reflected or scattered from its surface as from a rigid obstacle. The energy re-radiated to the medium due to the vibration of the diaphragm is extremely small.

Mechanical Transformers.-It is sometimes desirable to convert an oscillation of large displacement and low pressure to one of small displacement and high pressure; a mechanical process analogous to the electrical transformation of a large alternating current at low voltage to a small current at high voltage. Hahneman (Inst. Radio Eng. Proc., II., Feb. 1923) has employed this principle in the design of sound-transmitters and receivers for use under water. As a rule, in such apparatus, one part of a vibrating system is actuated in air whilst another, coupled to it, vibrates in contact with water. In transferring vibratory pressure from air to water a "step-up" pressure transformer is required, and conversely. For this purpose Hahneman employs a mechanical lever of a novel type, the ordinary pivoted lever and link system being useless at even moderate frequencies. He also considers it desirable, as far as possible, to separate the mass and spring factors of the vibrating system, like a weight on a spring, rather than a combined mass and spring as in the prong of a tuning fork. The lever principle is as follows: Two masses m and M are connected as in fig. 14a by a spring of stiffness At resonance, neglecting energy radiated, the system will vibrate about its centre of gravity, the amplitudes a and A of m and M being inversely proportional to the masses, i.e., a/A =M/m. The spring will be undisplaced at the centre of gravity of the system, i.e., at some point O such that  $l_m/l_M = M/m = a/A$ . The natural frequency of the two parts on opposite sides of O is

$$N = \frac{1}{2\pi} \sqrt{s \left( \frac{1}{M} + \frac{1}{m} \right)}$$

In applying this principle to under-water sound transmitters, Hahneman replaces the diagrammatic helical spring by an elastic rod or tube, as in fig. 14b, which combined with the loads m and M tunes to the required frequency. The masses may be pistons or diaphragms suitable for electro-magnetic excitation and for the transmission of vibrations to the water (see fig. 3, plate, and Technical Applications: Sound-Signalling). S. T. Williams (Journ. Franklin Inst., Oct. 1946) refers to the



use of mechanical "transformers" in the design of a gramophone sound-box.

Diaphragm Receivers.—Unless special precautions are taken to ensure sufficient damping, the diaphragms of microphone transmitters and electro-magnetic receivers used in telephony will have marked resonant frequencies at which they are abnormally sensitive. For speech reception such resonances are undesirable. When maximum sensitiveness is required at one particular frequency it is a great advantage, however, to use a diaphragm tuned to that frequency. Tuned diaphragms with

. ¹ The "mechanical advantage," "velocity ratio" and "mechanical efficiency" of this alternating lever are analogous to those for static levers. either microphone or magnetophone (electro-magnetic) attachments have been used extensively in under-water signalling beamb has shown theoretically that for diaphragms having the same frequency in water the amplitude at resonance is inversely proportional to the area of the diaphragm. When an additional damping factor, such as a granular microphone, is introduced there is a "best size" of diaphragm, increasing with increase of the added damping. (See Powell, Phys. Soc. Proc., Feb. 1925.)

Electro-magnetic Receivers .- The vibrations of a diaphragm may be employed to excite currents in an electrical circuit embracing or lying in a magnetic field. The iron diaphragm of a telephone earpiece by its vibrations varies the magnetic flux passing through a coil and consequently induces alternating currents of the same frequency as the sound vibrations falling on the diaphragm. Similar results are obtained when an iron reed clamped at one end is set into vibration by sound-waves falling on a stiff cone attached to the free end of the reed. In an alternative form the diaphragm or reed, which now may be of nonmagnetic material, is attached rigidly to an annular coil of wire which lies in a strong magnetic field. Vibrations of the diaphragm and coil induce currents in the latter of the same frequency as the sound-waves. Telephone, microphone, and loud speaker movements are constructed on these principles. Such instruments can also be used to generate sound-waves by supplying the coil with alternating current of the required frequency. Diaphragm and reed receivers have usually marked resonant frequencies, the sharpness of resonance increasing with the load attached to the diaphragm (see p. 8). They may if required be used as "non-resonant" receivers, provided their natural resonances are reduced by damping or are far removed in frequency from that of the sound it is desired to receive. The efficiency of electro-magnetic receivers is determined from observations of damping and motional impedance (see p. 9).

Resonant Air Cavity. Hot-Wire Microphone -One of the most sensitive and metrical forms of resonant receiver for sounds in air, is a Helmholtz resonator fitted with a hot-wire microphone. In the hands of Tucker and Paris (Phil. Trans., 221. 1921) this combination has proved of great value in its technical applications and as a laboratory instrument for sound-measurement. It consists essentially of an electrically heated grid of fine platinum wire (0.0006 cm. diameter) placed in the neck of a Helmholtz resonator, or in the second neck of a "double-resonator" such as that shown in fig. 13. The oscillating air currents in the neck at resonance cool the hot grid, the extent of this cooling being measured (by a Wheatstone's bridge) as a change of electrical resistance. This resistance-change is a measure of the intensity of the sound. The instrument is calibrated by observing the cooling produced by steady air streams of known velocity. The sensitivity increases with increase of heating current. The tuning of the microphone and resonator is fairly sharp; in a typical example the response fell to one tenth of its maximum by "detuning" 7%, i.e.,  $n/p = 1 \pm 0.07$ . In common with other forms of Helmholtz resonator receivers, therefore, a series of instruments is required to cover a moderate range of frequency. The hot wire-microphone increases in sensitiveness towards the lower frequencies (say 100 per second); its upper limit being about 500 to 1,000 cycles/sec. The device has proved extremely useful in measurements of intensity and distribution of sound, particularly for testing trumpets, lenses, mirrors and other sound-concentrating devices and also for investigating the reflection and diffraction of sound-waves generally. Used in connection with resonators of very low frequency the hot-wire microphone proved of great value during the war in detecting and locating the positions of enemy guns. (See p. 22.)

Non-Resonant Receivers.—The ideal non-resonant receiver, equally sensitive at all frequencies, is not known. The best approximations aim at uniform sensitivity over a limited range of frequency—the better the receiver the more extended the range. Non-resonant receivers are, as a general rule, considerably less sensitive than the resonant type at a particular frequency but have a good average sensitivity over a wide range.

A good example for use in air, is Wente's condenser microphone (see Microphone) which employs a tightly stretched diaphragm of high natural frequency and a considerable amount of airdamping. Piezo-electric receivers are perhaps the best examples of the non-resonant type, for their natural frequencies are always very high (104 to 108). Rochelle salt, quartz and tourmaline suitably mounted give electrical effects which are an extremely faithful counterpart of the incident sound vibrations, over the whole sonic and a considerable region in the super-sonic range of frequencies. As Boyle, Langevin and others have shown, however, such receivers are most suitable for use in a medium like water. In air they are extremely insensitive, although Nicholson has obtained fairly good results with Rochelle salt receivers (see also p. 12). A multi-resonant receiver with a number of fairly flat overlapping resonance peaks, due to the various components which make up the receiver, could be designed to have a fairly uniform high sensitivity over a wide frequency range. The principle has been applied with success to gramophone recorders and reproducers (see p. 34). (See GRAMOPHONE)

Sensitive Flames are very convenient detectors of high frequency sounds in air. A long narrow gas flame, issuing from a "pinhole" orfice and adjusted to the point of flaring, becomes unstable, flares and shortens when high pitched sounds fall upon it. The action of such flames and sensitive jets of gas is discussed in Tyndall's and Rayleigh's Sound. The flame is commonly used to demonstrate the presence of nodes and antinodes in stationary-waves of high frequency, and to indicate the position of the sound focus of a concave reflector.

Under-Water Receivers. Hydrophones .- During recent years rapid progress has been made in sound-signalling under water, and the allied navigational problems of sound-ranging, echo-depth-sounding, submarine detection, etc. The earliest and most simple of all subaqueous receivers was known as the "Broca" tube which consisted of a long metal tube with a thin metal capsule fitted with a diaphragm stretched over the end. A similar, but less resonant, device employs a thick-walled rubber bulb in place of the diaphragm. The arrangement is fairly sensitive but is very inconvenient in use-observation at a distant point (on a ship, or at a shore station) being almost impossible. Electrical devices have replaced such tubes, both on the grounds of sensitiveness and convenience. Microphonic and electro-magnetic devices, attached to diaphragms and enclosed in watertight cavities have proved very satisfactory. Such subaqueous soundreceivers are generally known as hydrophones. Generally speaking, the diaphragms for use under water are much more massive than those used in air, on grounds of strength, durability and efficiency. A microphone or magnetophone (an electro-magnetic device like a telephone earpiece) attached to a metal diaphragm and immersed in water forms a system which may have one or more resonant frequencies. Such a receiver is therefore suitable where sensitivity is more important than "faithfulness"—i.e., for reception of under-water signals of a definite frequency, a suitably tuned diaphragm and microphone are desirable. paratively non-resonant receivers have been constructed of thick rubber—the sensitivity being correspondingly low—these being found valuable in discriminating between various types of ships' noises under water. Receivers of the diaphragm type are essentially pressure receivers. Another type of receiver known as the "light body" displacement receiver (see Wood and Young, Proc. Roy. Soc., 100, 1921) is essentially responsive to displacement or velocity of the water particles and is relatively insensitive to pressure. The two types may be compared with voltmeters and ammeters as electrical pressure and current measuring devices (see Drysdale in Mechanical Properties of Fluids, p. 293. See also Bragg, World of Sound, pp. 161-177). Reference has already been made to the use of piezo-electric devices for production and reception of high frequency sounds under water (see p. 12).

Geophones.—A simple device first used to detect enemy tunnelling operations in the war, serves to detect sound pulses travelling through the ground. It consists essentially of a cylin-

drical wooden box of about 3 in. diameter and 2 in. deep, divided into three compartments by two mica discs. The space between the discs is filled with mercury, whilst the two air compartments are connected to the ears by stethoscope tubes. The "geophone" is laid on the ground and vibrations are detected by the relative motion of the box and the mercury. The air spaces are alternately expanded and compressed, the sound pulses being conveyed to the ears via the tubes. Two such instruments, one compartment of each connected to each ear, give a sense of direction as in binaural audition.

Directional Reception.—This may be regarded as the converse of directional transmission of sound which we have already considered (see p. 18). We have referred also to the directional properties of a vibrating diaphragm when free to radiate, or receive, waves on both sides (see p. 29), and to the perception of direction by a pair of ears (see p. 29). These principles have been developed both for air and under-water reception of sound.

Diaphragms.—A single diaphragm or membrane mounted in a heavy annular ring and carrying a microphone at its centre forms a bi-directional receiver. A section of such a receiver is shown in fig. 15 (a) with its "figure of 8" polar curve of sensitivity. The microphone is unaffected when the sound pressure falls symmetrically on both sides of the diaphragm, whilst the response is a maximum when the sound-waves fall broadside on the diaphragm. The mode of action is discussed by Wood and Young in a paper dealing with the Admiralty pattern of "Single Plate Direction Finder" for use under the sea (Proc. Roy. Soc., 100. 1921). A disc of tightly stretched parchment mounted on a ring, with a light "button" microphone at the centre, gives excellent results in air. By means of a suitable screen ("bias" or "baffle plate") on one side of such a diaphragm it is possible to obtain a unidirectional instrument having the polar curve of sensitivity shown in fig. 15 (b). This baffle plate, when used under water, consists of a compound hollow disc containing air and lead shot (or some other suitable damping material to prevent excessive vibration of the walls of the cavity). Its exact function is somewhat complicated, but no doubt it acts partly as a sound screen and partly as a phase-shifting device with respect to the sound vibrations reaching the diaphragm. See Plate, figure 5.

Binaural Receivers.—The principle of binaural listening expounded by Rayleigh has been extended to the use of artificial "ears" which can be made very sensitive to a given type of sound and can be arranged at any convenient distance apart or with any orientation with respect to the source of sound. The principle has been applied to aeroplane and to submarine location (see Mechanical Properties of Fluids—"Submarine Listening," Drysdale). For example if two similar receiving trumpets are connected by equal lengths of tube to each ear, the trumpets

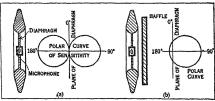


FIG. 15

being mounted a fixed distance apart on a rotatable platform, it is possible to locate a source of sound such as an aeroplane with considerable accuracy. The trumpets amplify the sound received by the ears and the directional accuracy is increased by increasing the distance apart of the trumpets. As the platform is swung round, the path-difference of the sound reaching the two ears diminishes on one side and then increases on the other, giving the impression of the sound crossing from one ear to the other. At the point of "cross-over", i.e., of binaural balance, the line joining the trumpets is at right angles to the direction of the

source. The same principle can be applied to a pair of underwater receivers. As an alternative to rotation of the line of the receivers it is often more convenient to vary the path-length to the two ears, the difference of path, relative to the distance apart of the receivers, being a measure of the "rotation" required to bring them symmetrical with respect to the source. This is known as the binaural compensator principle. The principle has been extended to multiple receivers, that is, to a considerable number of similar receivers equally spaced on a long base line. Instead of rotating the whole base line, a suitable rotary compensator is provided, the direction being indicated at the point of binaural balance. The directional properties of multiple receivers are the same as for corresponding multiple sources (see p. 31). In the case of electrical receivers the binaural method may be replaced by the Sum and Difference Method-the effects at the ear being due to the receivers assisting or opposing each other. The sound received by the ear is a maximum or a minimum respectively, when the normal to the line of the receivers is in the direction of the source of sound.

Receivers of Large Area .- Just as a directional source of sound is obtained by using a vibrating surface of large dimensions compared with a wave-length, so a receiver becomes increasingly directional as its dimensions increase. The piezo-electric quartz directional transmitter used by Boyle and Langevin serves equally well as a directional receiver. Similarly, large trumpets, mirrors and other focusing devices exhibit directional properties with increasing size or with increase in the pitch of the sound (i.e., with diminishing wave-length) Reference has already been made to the reflection which takes place at the open end of a cylindrical pipe or a trumpet acting as a sound receiver. The extent of this reflection diminishes, and the trumpet becomes a more efficient receiver, as the size of the opening increases, provided the length of the trumpet is always large. A parabolic mirror converges the sound energy towards a focus, but it must not be assumed that this is in any way an "optical focus," although it approximates more and more to it as the wave-length of the sound diminishes. A watch tick, the sharp crack of a pistol or an electric spark may be focused very effectively by a mirror of moderate dimensions. The increase of loudness due to curvature depends on the area of the reflecting surface, from which disturbances of uniform phase arrive, as compared with the area of the first Fresnel's zone of a plane reflector in the same position. If the "focal length" of the reflector is considerable and \(\lambda\) is not small, the first Fresnel zone is fairly large, therefore for a reflector of moderate dimensions there is little to be gained by making it concave.

Diffraction Disc Method.—On p. 26 reference was made to the fact that the sound intensity at a point on the axis of a circular obstacle placed normal to a beam of sound is as great as if the obstacle were not present, i.e., the sound "shadow" of the disc has, to quote the optical analogy, a bright spot at the centre. A microphone, tuned to the frequency of the incident sound, and placed at a suitable point on the axis of such a disc forms a very sensitive directional receiver, the response being a maximum when the sound is normal to the disc. Discs 20 feet or more in diameter have thus been used in combination with resonant hotwire microphones as an extremely accurate and sensitive means of locating distant sources of sound in air.

The location of sounds of an explosive nature by the use of a number of receivers on measured base lines is described in the section on Sound-Ranging (see p. 35).

Sound-Analysis and Recording.—It is sometimes desirable to determine the nature of a complex sound, more particularly in regard to the relative amplitudes and the frequencies of the component tones. The frequency analysis is relatively simple, but the amplitude measurement is much more difficult. There are numerous ways of determining the various frequencies present in a sound-wave, e.g., we have already referred to the use of Helmholtz resonators for this purpose. In frequency analysis it is more convenient to employ resonators of continuously variable frequency, e.g., by varying the volume of the resonator by

means of a sliding piston or a water column. Resonance in such a receiver may be detected in a number of ways, e.g., by ear, optical devices, Rayleigh disc, or some form of microphone, such as the hot-wire microphone. The use of resonators, whilst giving reliable information in regard to the frequencies of the tones present in the sound-wave gives only approximate information regarding the relative intensity of these tones.

Numerous instruments have been devised which are described as intensity or sound-energy-meters, many of which give indications in some way related to sound-intensity. In no case, however, is the device universally applicable to all frequencies and intensities. Many attempts have been made to record waveforms of sound by means of diaphragms and stretched membranes. The movements of a vibrating diaphragm excited by sound-waves have been recorded in various ways, mechanically, optically and electrically. Mechanical recording is exemplified in the gramophone, where a needle attached via a lever mechanism to the diaphragm traces the wave-form on a revolving disc or cylinder. (See GRAMOPHONE.) Optical methods have been very commonly used, e.g., in Kenelly's analysis of the motion of telephone diaphragms, in Webster's phonometer, in Millar's phonodeik and in the Hilger audiometer. In all these examples a small mirror reflects the vibrations of the diaphragm on to a moving photographic film. Electrical methods involve the use of a microphonic or electro-magnetic device which responds to the vibrations of the diaphragm, the corresponding electrical oscillations being recorded by means of some form of oscillograph, e.g., the Duddell strip, the Einthoven string or the cathode ray oscillograph (see Instruments, Electrical; see also Irwin, Oscillographs). The majority of such diaphragm receivers are subject to resonances at certain frequencies with the result that the record is a distortion of the actual wave-form, the distortion being greatest in the neighbourhood of the resonance frequencies of the instrument. The defect may be exaggerated or partially compensated by the use of a cone or trumpet to collect the sound and increase the amplitude of the diaphragm. Great care is necessary in the choice of a receiver, and recorder, for a particular type of sound, otherwise a number of factors may contribute to the distortion. Thus in electrical recording, distortion may be caused by resonance in the diaphragm, the microphone mounting, the trumpet or cone collector, the electrical circuit, and in the oscillograph. In addition to this, there may be distortion introduced solely on account of the dimensions of the receiver relative to the wave-lengths of the various components of the sound. As we have seen, a receiver which is large compared with a wave-length exhibits directional properties depending on the ratio  $\lambda/D$  (where D is the diameter of the receiver). One of the best non-resonant receivers developed during recent years is the stretched diaphragm condenser microphone of Wente (Phys. Rev. 10. 39. 1917). This was specially designed for sound-measure-

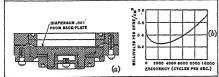


FIG. 16

ments and is used extensively in analysis and recording of waveforms of sounds lying within the frequency ranges of speech and music. The microphone, shown in diagram fig. 16a, consists essentially of a tightly stretched thin steel diaphragm (.oor in. thick) separated from a parallel back-plate by an air gap of o oor in. approximately. The diaphragm shown with its back-plate form an electrical condenser, the capacity of which is varied when vibration takes place. When 200 volts are applied through a fluctuating electromotive force. The variation of sensitiveness means for reproducing the original sound, using selenium or

of such a microphone with frequency is indicated in fig. 16 b. It will be seen that the output in milli volts (10-3 volt) per dyne/ cm.2 is fairly constant over a frequency range 500 to 5,000 cycles/ sec. The microphone is very insensitive when compared with other, more familiar, types (granular and electro-magnetic) but its freedom from resonance over a wide range of frequency renders it most valuable for purposes of sound analysis. The lack of sensitiveness can easily be remedied by the use of a "distortionless" valve-amplifier (resistance-capacity coupled valves). Crandall (Bell. Syst. Tech. Jour., 4. 1925, p. 587) employed Wente's condenser microphone in conjunction with such a valve amplifier to record speech sounds. A well designed amplifier will give practically constant amplification over the range of speech frequencies and will give an output proportional to input. The amplified e.m.f. is recorded by means of an oscillograph which must itself be non-resonant over the range of frequencies to be recorded. With certain limitations a high frequency Duddell strip well damped may serve the purpose, or alternatively an Einthoven oscillograph with a critically damped fibre of silvered quartz may be used. Perhaps the most perfect form of sound recording system is one proposed by Sir J. J. Thomson, namely a piezo-electric crystal receiver used in conjunction with a cathode ray oscillograph. Such a combination was used by Keys (Phil. Mag., Vol. 42, 1921) in recording the pressure-time curve of an explosion-wave under water. The piezo-electric receiver has a very high natural frequency and is consequently non-resonant over a very wide frequency-interval which includes the audible range. The cathode ray oscillograph (see A. B. Wood, Proc. Inst. Elect. Eng., Nov., 1925) is a perfect nonresonant recorder of electrical oscillations, having the same sensitivity at all frequencies from zero to the highest "radio" frequency. The combination may therefore be regarded as distortionless. The sensitivity for sounds of moderate intensity is, however, very small and amplification is necessary. The faithfulness of reproduction is ultimately dependent on limitations of the amplifier.

Measurement of the Amplitude of a Vibrating Body .-W. H. Bragg has described a very simple and ingenious method of measuring the amplitude of a vibrating surface (e.g., of a diaphragm). A small mass supported by a spring is brought into contact with the vibrating surface and the fixed end of the spring displaced through a distance A until there is no longer "chattering" between the mass and the diaphragm. At the point where chattering ceases, the maximum acceleration of the diaphragm is just equal to that of the mass attached to the spring. Thus if a and n and A and N represent the maximum amplitude and the frequency of the diaphragm and the spring respectively, we must have  $an^2 = AN^2$  or  $a = AN^2/n^2$ . sequently if N is very small compared with n, A will be very large compared with a, in this way yielding a large "magnifica-tion" of the amplitude to be measured. As an example, if n=1,000 p.p.s. N=1 p.p.s. and A=1 cm., then  $a=10^{-6}$  cm. The method permits of the measurement of very small amplitudes, the chattering being observed electrically. It is important of course to observe that the measuring device is sufficiently light so as not to interfere with the motion of the vibrating surface whose amplitude is required. Measurements of the amplitude of vibration of a diaphragm have also been made by making it one of the reflecting surfaces of a Michelson interferometer (Webster, Nat. Acad. Sci., 5, p. 179, 1919). The displacement of the interference fringes, photographed in vibration as a wavy line, gives a measure of the amplitude in terms of the wavelength of light. Such a diaphragm then forms a standard source of sound. Known amplitudes of vibration may also be obtained by applying measured alternating voltages to piezo-electric crystals, provided resonance-frequencies (usually extremely high) are avoided. Rankine has described (Proc. Phys. Soc., Aug. 1919, and Feb. 1920) a method of recording sound vibrations by means of variations in the intensity of a beam of light, the high resistance to the condenser, the vibration results in a resulting film, of varying transparency, forming a convenient other photoelectric cells. When a wave-form has been recorded by any of the methods indicated above, it may be analysed into a Fourier series (see p. 7) which gives the frequencies and relative amplitudes of the tones of which the sound is composed.

#### TECHNICAL APPLICATIONS

The past ten or fifteen years mark a period of considerable progress in the technical application of the principles of sound. It is proposed in what follows to deal with the more outstanding of these applications apart from those already mentioned in the foregoing sections. The exigencies of war stimulated the development of apparatus for detecting, identifying, and locating sounds at long ranges. Numerous forms of directional sound-receivers, sound-ranging and sound-signalling devices were realised and applied to urgent problems on land and sea. Since the war, the growth of radio-telephony and "broadcasting" has resulted in improved methods of reproducing sounds of audible frequency. The phenomena of piezo-electricity, discovered by Curie in 1880, have in the hands of Cady and others developed into a means of standardising mechanical and electrical frequencies over a range extending up to millions of vibrations per second. In this respect also improvements in tuning fork design have played an important part. A further application of piezo-electricity, initiated by Langevin and developed by Boyle, employs the supersonic oscillations of quartz in depth sounding at sea and in the echo detection of icebergs. At the other end of the frequency scale. Constantinesco has developed a system of power transmission through water-filled pipes, employing generators, motors, transformers and transmission lines closely analogous to the corresponding electrical devices. Such alternating mechanical systems are capable of dealing with large amounts of power in the form of low frequency pressure-waves. The elimination of objectionable resonance from gramophones and loud-speakers represents a marked degree of progress in the development of apparatus for reproducing speech and music. The study of the characteristics of speech and hearing, notably the work of the staff of the Bell Telephone Laboratory U.S.A., has greatly increased our knowledge of these subjects. The results have proved of great value in the improvement of telephone apparatus, microphones, electro-magnetic receivers, transmission lines, etc., and in the design of all forms of apparatus for recording or reproducing speech and music. In this connection also the introduction of the conception of acoustic impedance. as the analogue of electrical impedance, in dealing with complex acoustical systems has proved of great value. In a recent discourse before the Royal Aeronautical Society, Tucker has dealt with the problem of noise-reduction in aircraft, the deafening roar in the cabins of civil aircraft being a serious hindrance to commercial development. The general question of reduction of traffic noise is becoming increasingly insistent as an urgent practical problem still awaiting solution.

Reproduction of Sound .- The telephone (q.v.), the gramophone (q.v.) and the radio loud-speaker are among the most familiar types of reproducers of the sounds of speech and music. Any practicable device of this character for reproducing sound must necessarily have its limitations, for the faithful reproduction of even the simplest sounds is very difficult. As we have seen (p. 32), however, the ear is sufficiently accommodating to ignore fairly large defects in reproduction. Thus a 10% error in intensity, or possibly more than this, may pass unnoticed; the accuracy of intensity reproduction therefore need not be very great to conform with such a standard. Frequency reproduction, however, must be much more accurate to satisfy the ear, and it is indeed fortunate that the practical difficulties in this case are relatively small. Reproduction of sounds involves reception, and possibly transmission and amplification, as a preliminary. The process is well illustrated in the gramophone with either mechanical or electrical recording and reproduction. The recording system involves the direct mechanical action of sound-waves on a diaphragm, lever system, and engraving stylus, or alternatively on a system employing a microphone and a recorder

operated electro-magnetically. In reproduction the process takes place in the reverse order, some form of horn, cone or diaphragm being utilised to couple the vibrations of the sound-box or electrical "pick up" with the external body of air. The present practice in design is to regard the complex mechanical system, e.g., of a gramophone, as analogous to a corresponding electrical system. In this respect the analogy with electrical filter circuits, as stated by G. W. Stewart, has proved an extremely fruitful one. S. T. Williams and A. Whitaker have both applied this principle with considerable success in designing gramophone recorders and reproducers. By suitably choosing the inertia, stiffness and damping of the various elements of the sound-box and horn, a moderately good response-curve is obtained free from pronounced resonance within the speech-music range 150-4,000 p.p.sec. Electrical methods of recording and reproducing have recently yielded even better results. The desirable features in gramophones and loud-speakers are dealt with in a number of papers by various authorities in Proc. Inst. Electrical Engineers, Nov. 1923. The practical considerations are far too numerous to mention here but the essence of the problem of faithful reproduction lies in the avoidance of predominant resonances in the electrical and mechanical systems. This result may be achieved in some degree (a) by arranging that the natural frequencies of all elements of the system are far removed from any frequency it is desired to reproduce. (b) by the use of heavy damping, or (c) by making use of multiple resonance, i.e., arranging the various resonance peaks to overlap in such a way as to give a fairly uniform response. (See Rothwell, Nature, Feb. 24, 1923, and Porter, Phys. Soc., Feb. 1924.)

Mention has already been made of the recording of sounds on a film by means of light of variable intensity (Rankine, loc. cit p. 33). When a beam of light, after passing through such a film moving at the recording rate, falls on a sensitive cell (selenium, thalofide or photoelectric) the original sounds may be reproduced in a telephone or loud-speaker connected in circuit with the cell and a suitable amplifier. "Speaking films" have been produced successfully on this principle, the speech record being made on the edge of the film simultaneously with the cinema pictures. (See SELENIUM CELL.) Numerous other optical methods have been employed, with more or less success, to modulate a beam of light as a means of sound-reproduction, e.g., use has been made of the Kerr electro-optical and the Faraday magneto-optical effects, and of the luminous electric discharge in rarefiel gases.

Musical Instruments.—To deal adequately with the technical application of sound to the design and construction of musical instruments would require a very lengthy article in itself. Occasional references to such applications will be found above (section on Sources of Sound), but for detailed information the reader is referred to treatises such as The Dictionary of Applied Physics or Millar's Science of Musical Sounds.

The Acoustics of Buildings.—This subject is discussed in a separate article under that title.

Sound-Signalling.-In the section on sources of sound, reference has been made to various types of siren and the diaphone (p. 15) for producing powerful sounds in air, mainly for use in fog-signalling from light-houses and light-ships. Under the sea, large bells are used for a similar purpose. A more powerful under-water signalling device, due to Fessenden, employs a large diaphragm forced into resonant vibration under water. The apparatus consists essentially of a transformer, the secondary of which is free to move in a strong radial magnetic field. The primary is supplied with alternating current, and the resulting periodic motion of the secondary (a copper cylinder) is communicated to the submerged steel diaphragm which gives rise to sound waves in the water. The Fessenden oscillator is illustrated on the Plate, figure 4. The same device operates, conversely, as a receiver of sound-waves, these being converted into electrical oscillations by the vibration of the copper cylinder in the magnetic field, the induced currents in the primary coil being amplified and passed through telephones. Fessenden has used the apparatus to transmit signals through water to dis-

tances exceeding 30 miles and has even used it to transmit speech for a distance of half a mile. The oscillator has also been applied to detect icebergs and to take continuous depth soundings by echo methods (see below). In another form of oscillator, which is manufactured by the Signal Gesellschaft. Kiel, Hahneman has obtained powerful signals by means of a diaphragm excited in a different way. The diaphragm forms one member of a coupled system of two masses connected by a stiff spring (metal tubes). A powerful alternating current magnet causes periodic stretching of these tubes with corresponding vibrations of the diaphragm. A transmitter of this type weighing about 5 cwts. and having a diaphragm 18 inches diameter, gives a sound output of 300 to 400 watts, the mechanical efficiency being about 50% Reference to supersonic directional transmitters of the Langevin type, and to directional receivers, has already been made (see pp. 31 and 32 respectively).

Eche Depth Sounding .- Since the war considerable progress has been made in the development of new systems of sounding at sea. These new methods all employ, most appropriately, sound-waves as a means of measuring depths. The saving of time and labour is enormous and such methods are steadily replacing the old lead and wire systems which have survived so long. A sounding in 4,000 fathoms can be made in about 10 seconds by the new "echo" methods, whereas many hours labour arc involved to obtain a somewhat uncertain value by the old "wire" system. An additional advantage lies also in the fact that observations of depth can be made whilst the ship is in motion, up to speeds of 15 or 20 knots. The echo method involves the measurement of distance in terms of the time interval between the initiation of a sound impulse and the reception of an echo. This requires a knowledge of the velocity c of the sound waves in the medium, water or air; and depends on the fact that sound is reflected from the sea-bed in the same way that it is reflected in air from buildings and cliffs. The distance travelled by the wave in the time t is 2D, the depth D is therefore equal to c/2t. Various systems have been devised in America, France, Germany, and Great Britain, differing in the manner of producing and receiving the sound impulse and in the measurement of the time interval. In the Behm system, a small detonator is fired under water thereby operating a microphone and relay and setting a graduated disc in motion; the arrival of the echo stops the disc which is engraved in "depths." The angle through which the disc has revolved is a measure of the time interval t and consequently of the depth D. The system developed by the British Admiralty depends on the indirect measurement of the time interval. The transmitter consists essentially of a steel diaphragm which is struck a powerful blow by an electro-magnetic hammer. thereby emitting a heavily damped sound-wave of about 2,000 p.p.s. The receiver is au ordinary "button" carbon granule microphone mounted on a small diaphragm and enclosed in a watertight container. The transmitter and receiver are mounted in water-filled tanks fitted inside the ship's plates at points screened by the hull. A small motor drives two commutator switches at constant speed. One of these commutators actuates the hammer three times per second whilst the other short circuits a pair of brushes across the listening telephones except at one particular moment during which they can "listen." position of these brushes may be displaced by hand relative to the corresponding brushes in the transmitter circuit, so that a short time interval, proportional to the angular displacement of the brushes, separates the initial sound impulse and the moment when the telephones listen. Nothing is heard therefore unless this moment coincides with the moment of arrival of the echo. The angular displacement of the brushes measures the time interval (360° = 1 second). The dial attached to the rotatable telephone brushes is graduated in feet, or fathoms, and depths may be taken continuously whilst the ship is in motion. Two types of apparatus have been developed, (a) The shallow water set (described above), up to 150 fathoms, and (b) Oceanic depth apparatus, up to 4,000 fathoms or so. Both types are in regular service in numerous British and foreign commercial vessels and

in the survey ships of the British Navy. Fessenden (U.S.A.) has devised a depth sounding system similar to the above, using his "oscillator" for the purpose of generating the short sound impulses. He claims in addition to depth sounding, to have used the apparatus to detect icebergs at distances up to  $2\frac{1}{2}$  miles, a somewhat remarkable and surprising result, in view of the dimensions of icebergs, the wave-length of the sound (10 ft.approx.) employed, and the poor reflecting properties of ice under water. Boyle and Reid, using a Langevin directional quartz oscillator at supersonic frequencies could not detect an iceberg beyond 200 yards. The echo from ice was found to be very feeble compared with that from a rocky shore. The supersonic method has also been employed by Langevin and by Boyle in depth sounding; a good echo from the bed of the sea being easily distinguishable at considerable depths.

Sound-Ranging.-The location of hostile guns on land, and of submarine explosions at sea, constitutes one of the most important practical applications of sound during the war. Ordinary directional receiving devices such as those already considered are of little service when the sound consists of a sudden impulse or shock. The location of the explosion originating the impulse requires a special technique which is generally called soundranging. We shall deal first of all with the war-method or multiple-point sound-ranging. In this method three or more receivers are mounted at known positions on surveyed base lines. The spherical explosion wave WF passes over, say, four receivers, o, 1, 2, 3, in succession, the times of passage being recorded at instants t1 t2 t3 respectively. The construction shown in fig. 17 indicates in a simple manner how the explosion E is located. If we draw circles of radii ct1 ct2 and ct3 with centres at 1, 2, 3, respectively, c being the appropriate velocity of sound, then a circle WF which passes through the receiver o and is tangential to the three small circles will have the point of the explosion E at its centre.

The accurate mathematical method of determining E from the values h h and h depends on the fact that this point lies at the intersection of hyperbolae having the various receivers o, 1, 2, 3, as foci.

Army Sound-Ranging.—Six microphones were generally used, spaced along a base about 9,000 yards long and 4,000 yards behind the front line, a central recording station, to which the microphone leads were brought, being situated 5,000 or 6,000 yards from the front line. For hostile gun-ranging a special type of microphone, particularly sensitive to the low frequency disturbance of the sound of discharge of the gun, was devised. This microphone, known as the resonant hot-wire microphone, invented by Tucker, has already been described (see p. 31). The hot-wire

grid was mounted in the opening of a large Helmoltz resonator of about 16 litres capacity; the system responding only to very low frequency gun-sounds, whilst ignoring shell-wave (onde de choc), detonation of shell, and noises such as speech, traffic, or rifle fire. The resonance set up by a gun-sound produced cooling of the grid with consequent variation of the electrical current flowing through it. This current-change was photographically

recorded at the central station by means of an Einthoven string galvanometer fitted with six strings, one for each microphone. The resulting record, which was automatically developed and fixed, showed the six gun "signatures" on lines running parallel to the film. Across these lines, i.e., at right angles to the film, were a series of time marks every hundredth and tenth of a second, providing a direct means of measuring the time intervals with an accuracy of ooor second, if required (see the illustration on the Plate, fig. 6a). The record was started when a forward observer, or a "sentry" microphone, heard the gun, i.e., a few

seconds before the sound-wave reached the first receiver on the base. The measured time intervals were corrected for temperature and wind, which have a considerable influence on the velocity of sound (see p. 5). Variation of these factors with height results in troublesome refraction corrections, and under certain conditions of wind gradient, sound-ranging became impossible. The sound-ranging method could, under certain conditions, be employed to locate both an enemy gun and the answering shell-burst, in which case the comparative records eliminate uncertainties arising from atmospheric conditions.

Navy Sound-Ranging .- The method employed at sea during the war was based on the same principles, but the receivers were essentially different. Under water, the sound of an explosion was received on a steel diaphragm on which was mounted a sensitive granular microphone. The diaphragm formed the cover of a watertight case mounted on a large tripod which rested on the sea bed. Four or more of such "tripod hydrophones" were laid in accurately surveyed positions on a 12 mile base line. They were connected by means of cables to a six-stringed Einthoven galvanometer in the recording station on shore, the subsequent procedure to obtain photographic records of an explosion being essentially the same as outlined above. Specimen records are illustrated on the Plate, figure 6b. During the war, explosions of mines, depth charges and torpedoes could be located with great accuracy at distances of 50 or 60 miles from the base line of hydrophones. Since the war the method has been applied to the accurate location of buoys and light-vessels, a small charge being fired under water in the vicinity of the point to be surveyed. For such purposes it was necessary to know the velocity of sound in sea water at different temperatures and salinities, with great accuracy (see p. 20). As an alternative to the Einthoven photographic recorder system of measuring time intervals, A. B. Wood and J. M. Ford (see *Jour. Sci. Instr.*, Mar. 1924) have devised a "Phonic Chronometer." This consists essentially of an electromagnetically operated stop-watch with three sets of dials for measuring three independent time intervals. The speed of the chronometer is governed by a tuning fork and phonic motor giving an accuracy of 1 in 10,000. Time intervals are indicated directly on the dials to o-oor second. Special diaphragm shock receivers were designed for use with the chronometer, which was started and stopped as the explosion-wave passed the various receivers, the time intervals being read directly on the dials.

Radio-Acoustic Sound-Ranging.-This method which for obvious reasons could not be used in war time, was first proposed by Joly, and has recently been developed by A. B. Wood and H. E. Browne for the British Admiralty (*Proc. Phys. Soc.*, April 1923). It consists in the simultaneous emission of a "wireless" signal and an explosion impulse. The former travels with the velocity of light (186,000 miles/sec.) the latter with a velocity about 1 mile a second in water. If, therefore, one string of the Einthoven galvanometer on shore records the radio-signal whilst the others record the arrival of the explosion wave at the various hydrophones, we have a very simple and direct means of locating the explosion. The distance of the explosion from the hydrophones is given by ct1 ct2 ct3, etc., where c is the velocity of the sound in the sea and t1 t2 t3 are the time-intervals between the arrival of the wireless signal and the explosion-wave at the respective hydrophones. A g oz. charge of guncotton can be located in this way at 40 miles, whilst larger charges have been located up to 80 miles or more. At 80 miles the sound-wave through the sea arrives 12 minutes after the wireless signal which denotes the instant of firing the charge. The method permits of very great accuracy and has important applications in navigation and hydrographical survey. For navigational purposes great accuracy is sacrificed to speed, it being possible to give a ship in fog 40 miles away a positfon within a radius of half a mile in less than 10 minutes of receiving her request for a location. In hydrographical survey work the method has been used successfully to fix accurately the positions of buoys and light-vessels out of sight of land. The method is accurate in rough or foggy weather and at all seasons of the year. Various ingenious proposals have

been made to safeguard ships in fog, by application of radioacoustic methods (see Joly "Scientific Signalling and Safety at

acoustic methods (see Joly "Scientific Signalling and Safety at Sea," Phil. Mag, July 1918).

Bibliography.—Lord Rayleigh, Theory of Sound, 2 vols., and Collected Papers; H. Lamb, Dynamical Theory of Sound; H. von Helmholtz, On the Sensations of Tone (1885); John Tyndall, On Sound; E. H. Barton, Test-book on Sound; D. C. Millar, Science of Musical Sounds; W. H. Bargg, The World of Sound; W. C. Sabine, Collected Papers on Acoustics; Davis and Kaye, Acoustics of Buildings; I. B. Crandall, Vibrating Systems and Sound; Collective, Mechanical Properties of Fluids; A. B. Wood; Sound—a test-book; H. Bouase, Acoustique; E. G. Richardson, Sound—a test-book; H. Bouase, Acoustique; E. G. Richardson, Sound—a test-book; Geiger and Scheele, Handbuch der Physik, Bd. VIII. Akustik, Glazebrook, Dictionary of Applied Physics; F. Aigner, Unternasserschallecknik; Hydrographical Review, Monaco, Vols. 1, 2, 3, Recent Papers in Proceedings of Royal Society and Physical Society, Physical Review, Royal Society of Canada, Philosophical Magazine, Bell System Teckn. Journal, Journal of the Franklin Institute, etc.

SAILIND THE the easternwoot of the straits giving entrance

SOUND, THE, the easternmost of the straits giving entrance to the Baltic Sea from the Cattegat, between the Danish island of Zealand and Sweden (Danish Oresund). Its extreme length from the promontory of Kullen to that of Falsterbo is 70 m. Its narrowest point is between Helsingör in Denmark and Helsingborg in Sweden, which are 3 m. apart. Its extreme width, 30 m., is where Kjoge Bay indents the coast of Zealand. Three islands lie in it-Hven, belonging to Sweden, and Saltholm and Amager, belonging to Denmark. The strait between Amager and Saltholm is called Drogden, and is used by large vessels passing through the Sound. The extreme depth of the Sound is about 14 fathoms. Navigation is open in winter, though three instances are recorded of the Sound being frozen over: in 1306, 1830 and 1836.

SOUNDING. The determination of the depth of the sea has been practised from very early times for purposes of navigation, but it is only since the introduction of submarine telegraphy that extensive efforts have been made to obtain a complete knowledge of the contour of the ocean-bed (see Ocean).

For depths over 20 fathoms sounding machines are often employed and wire has entirely superseded hemp gear. Its smooth surface and minute section, reducing friction to a minimum, give a rate of descent of about 100 fathoms per minute. Reeling in may be accomplished at nearly the same rate. Such soundings can be obtained in any weather short of a fresh gale. A sounding of 1,000 fathoms may be obtained in 25 minutes and 3,000 fathoms in 75 minutes. But beyond that depth, great caution is required, the time occupied is increased, and reeling in must be done very deliberately. A sounding of 5,269 fathoms was obtained near the island of Guam by the U.S. cable-surveying ship "Nero." Soundings at such depths may occupy a period of time lasting as long as five or six hours.

Lucas Machine.-Among the sounding machines in general use the Lucas carries nearly 6,000 fathoms of 20-gauge wire, and is fitted with two brakes-one a screw brake for holding the reel when required, the other an automatic brake for stopping the reel when the weights strike the bottom. A guider for winding the wire uniformly is also attached. After leaving the reel the wire passes over a registering wheel, the dial of which indicates the length of wire run out. Smaller machines are used in boats.

Sounding Rods and Sinkers .-- Under 1,000 fathoms a lead of 30 to 40 lb. weight can be recovered, and no detaching rod is necessary. For greater depths the "Baillie rod" is the best apparatus. It is a tube about 2 ft. long, having a rounded conical top, through which passes a movable steel rod. The lower part of the tube screws on and off, and contains a double flap valve to retain the bottom specimen. The sinkers, each 25 lb. in weight, conical in form, and pierced with a cylindrical hole through which the Baillie rod passes loosely, are slung by wire or cod line secured to a flat ring and passing over a projection on a movable rod to which the sounding wire is attached. The weight of the apparatus being taken by the sounding wire, the sinkers remain suspended; but on striking the bottom, the wire slackens, and the weight of the sinkers drags the movable rod down till the projection bears against the curved surface at the top of the rod. The wire sling is forced clear of the projection and the sinkers are slipped. In descending, the valves opening upwards, allow the

water to pass through freely; but on drawing up they are closed thus retaining the material with which the tube is filled. For depths under 2,000 fathoms two sinkers are sufficient. In deeper water a third cylindrical weight of 20 lb. should be put between them. It is important to interpose a hemp line, some 20 fathoms long, between the end of the wire (into which a thimble is seized) and the lead or rod. This prevents the wire from kinking on the lead striking the bottom.

Method of Sounding .- The machine is placed on a projecting platform on the forecastle. As the wire runs out the brake must be gradually screwed up, so as to increase the power in proportion to the amount of wire out. The regulating screw is marked for each 500 fathoms. In fairly smooth water the brake will at once act when the weight strikes the bottom and the reel stops. Under 3,000 fathoms one spring is sufficient, beyond that depth

two springs are required.

Handling the Ship .- Sounding from forward is preferable as it enables the ship to be handled with greater ease; in heavy weather when impossible to work on the forecastle, soundings may be obtained from a machine mounted over the stern. The ship's head must be kept in a direction which is the resultant of the direction and force of the wind and current; and this is arrived at by altering the course while sounding, point by point, until the wire can be kept up and down by moving the engines slowly ahead as necessary.

Observations of Temperature.-The temperature of the water is usually taken at intervals of 100 fathoms to a depth of 1,000 fathoms, and at closer intervals in the first 100 fathoms. If a second wire machine is available, the observations may be made from aft whilst the sounding is being taken forward. A 30-lb. sinker is attached to the end of the wire, and the registering thermometers are secured to the wire by the metal clips at the back of the cases, at the required intervals. To avoid heavy loss, no more than four thermometers should be on the wire at

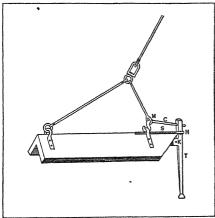


FIG. 1.-SUBMARINE SENTRY

one time. When sounding a thermometer is usually attached to the line a short distance above the lead.

Submarine Sentry.-The primary object of the machine called the "submarine sentry" is to supply an automatic warning of shallow water; it has been instrumental in discovering many unsuspected banks in imperfectly surveyed waters. By means of a single stout wire the sinker, an inverted kite, called the "sentry," can be towed steadily for any length of time, at any required

when a given length of wire is paid out is not changed by any variation of speed between five and 13 knots.

The kite in its position when being towed is indicated in fig. 1. The point of the catch C, passing through a thimble M in the short leg of the sling, is slipped into the hole at the top of trigger T, which is hinged at K and kept in its place by the spring S attached to the hook H. On the trigger striking the bottom the catch is released, the short leg of the sling slips off, and the sentry, which then rises to the surface, is left towing by the long leg. The winch is fitted with two handles for heaving in the wire; one gives great power and slow speed, and the other, acting on the drum spindle direct, winds in quickly. The wire supplied with the machine has a steady breaking strain of about 1,000 lb.

Echo Sounding .- This new method depends upon the principle that any sound originating at or near the surface travels through the water at a known speed, and after striking any large object or the bottom of the sea is reflected back to the surface, the time being a matter for accurate measurement.

The time necessary for obtaining a sounding is almost infinitesimal, the sounding in extreme depths taking little more time than one in the shallowest water. The speed of the vessel is maintained throughout the soundings, the soundings themselves may be accurately taken at extremely short intervals and bad weather does not affect the work. See also CHART and SOUND.

See Echo Sounding published by H.M Stationery Office. (J A. Ep.) SOUND MOTION PICTURES: see Motion Pictures: Sound Motion Picture Technology.

SOUP, a liquid food consisting usually of stock (water in which meat or vegetables have been boiled) with or without other ingredients. Soups are also made without stock. As clear soups are largely water, they have little food value in themselves, but they act as appetizers. Cream soups, vegetable purées and chow-ders are higher in food value and may be used as main dishes. (See also Cookery.)

SOUR-SOP, called also guanabana (botanical name Annona muricata; family Annonaceae), a small evergreen tree, about 20 ft. high, native to tropical America. It bears a large, dark-green, bluntly conical or heart-shaped fruit, 6 to 8 in. long and 1 to 5 lb, in weight, covered with short fleshy spines. The white, juicy, slightly acid, aromatic pulp has a flavour of mange and pine apple and makes excellent jelly and preserves. The sour-sop is cultivated in the West Indies, tropical South America, Mexico, India, Cochin China, parts of Polynesia and the west coast of Africa. With some frost protection, it can be grown along the Florida coast as far north as Palm Beach. It is propagated by growing seedlings and by shield-budding. (See Cherimova; Custard Apple; Sweet-sop.)

SOUSA, JOHN PHILIP (1854-1932), American composer and bandmaster, was born at Washington, D.C., on Nov. 6, 1854. His grandparents were Portuguese refugees. He was a pupil of John Esputa and G. F. Benkert for harmony and composition, beginning his musical education at six. At 19 he conducted for Milton Nobles; played in Offenbach's orchestra, Centennial exhibition, Philadelphia, in 1876, and conducted H.M.S. Pinafore before Gilbert and Sullivan went to America, in 1879, for the New York production. In 1880, he became bandmaster of the U.S. Marine Corps band, which acquired a high reputation under his control. The title of the "march king" was bestowed upon him by an English brass band journal for his many marches. In 1892 he organized Sousa's band, which won great renown. It visited Europe (1900, 1901 and 1903) and toured the world (1910-12). The golden jubilee of this veteran bandmaster and composer was celebrated in 1927. Belgian, English and French decorations were awarded him. His compositions include the comic operas, The Smugglers, Désirée, Queen of Hearts, El Capitán, The Bride Elect, The Charlatan, Chris and the Wonderful Lamp, The Free Lance, The Glass Blowers and The American Maid; many songs; 15 suites; more than 100 marches, of which the most popular were The Washington Post, High School Cavertical depth to 40 fathoms; should it strike the bottom, it will dets, Liberty Bell, Semper Fidelis and The Stars and Stripes free itself and rise to the surface, simultaneously sounding an Forever; The Chariot Race (Ben Hur), a symphonic poem. alarm gong. The vertical depth at which the sentry sets itself He wrote The Fifth String, Pipetown Sandy, Through the Year with Sousa and an autobiography He died March 6, 1932.

SOUSA, LUIZ DE [MANOEL DE SOUSA COUTINHO] (1555-1632), Portuguese historian, was born at Santarem, a member of the noble family of Sousa Coutinho. In 1576 he broke off his studies at Coimbra university to join the order of Malta and shortly afterward was captured at sea by Moorish pirates and taken prisoner to Argel, where he met Cervantes A year later Coutinho was ransomed and, landing on the coast of Aragon, passed through Valencia, where he made the acquaintance of the poet Jaime Falcão, who seems to have inspired him with a taste for study and a quiet life. National disasters and family troubles increased this desire, which was confirmed when he returned to Portugal after the battle of Alcacer and had the sorrow of witnessing the Spanish invasion and the loss of his country's independence Between 1584 and 1586 he married Settling at Almada, on the Tagus opposite Lisbon, he divided his time between domestic affairs, literary studies and his military duties as colonel of a regiment. His patriotic dislike of an alien rule grew stronger as he saw Portugal exploited by her powerful partner, and it was ultimately brought to a head in 1599. In that year, to escape the pestilence that devastated Lisbon, the governors of the kingdom for Philip II decided to move their quarters to Coutinho's residence Finding his protest against this arbitrary resolution unificeded, he set fire to his house, and to escape the consequences of his courageous act had to leave Portugal Going to Madrid, he not only avoided any penalty, owing no doubt to his position and influence at the Spanish court, but was able to pursue his literary studies in peace and to publish the works of his friend Falcão (Madrid, 1600). Nothing is known of how he passed the next 13 years, although there is a tradition that, at the instance of a brother, resident in Panamá, who held out the prospect of large commercial gains, he spent some time in America. It is said that fortune was unpropitious, and that this, together with the news of the death of his only child, caused his return home about 1604. In 1613 he and his wife agreed to a separation and he took the Dominican habit in the convent of Bemfica, while his wife entered the convent of Sacramento at Alcantara.

In 1616, on the death of Frei Luiz Cacegas, another notable Dominican who had collected materials for a history of the order and for a life of the famous archbishop of Braga, D. Frei Bartholomew of the Martyrs, the task of writing these books was confided to Frei Luiz. The Life of the Archbishop appears in 1619, and the first part of the Chronicle of St. Dominic in 1623, while the second and third parts appeared posthumously in 1662 and 1678; in addition he wrote, by order of the government, the Annals of D. John III, which were published by Herculano in 1846. After a life of about 19 years spent in religion, he died in 1632, leaving behind him a memory of strict observance and personal holiness.

The Chronicle of St. Dominic and the Life of the Archbishop have the defect of most monastic writings—they relate for the most part only the good, and exaggerate it without scruple, and they admit all sorts of prodigies, so long as these tend to increase devotion. Their order and arrangement, however, are admirable, and the lucid, polished style, purity of diction, and simple, vivid descriptions, entitle Frei Luiz de Sousa to rank as a great prose writer. His prose is characterized by elegance, sweetness and strength, and is remarkably free from the affectations and false rhetoric that characterized the age. In addition to his other gifts, Frei Luiz de Sousa was a good Latin poet.

There are many editions of the *Life of the Archbishop*, and it appeared in French (Paris, 1663, 1679 and 1825), in Italian (Rome, 1727-281), in Spanish (Madrid, 1645 and 1727) and in English (London, 1890). The *Historia de S. Domingos* may be read in a modern edition, 6 vol. (Lisbon, 1866).

Bibliography — Obras de D Francisco Alexandre Lobo, ii, 61-171; Innocencio da Silva, Diccionario bibliographico portuguez, v, 327, xvi, 72; Dr. Sousa Viterbo, Manoel de Sousa Coutinho (Lisbon, 1902).

SOUSLIK (Citellus: Sciuridae), the Russian name for a group of small squirrel-like animals, with cheek pouches and flattened tails, comprising some 80 species, found in unforested regions of the northern hemisphere. One species formerly inhabited Great Britain. In the United States some 20 species

occur. These are commonly called ground squirrels or gophers, of which one of the best known is the striped gopher (C. tridecemlineatus), found from Ohio to Montana and New Mexico.

SOUSSE, a city of Tunisia on the gulf of Hammamet, in 35° 49' N. and 10° 39' E, 36 mi by rail N E. of Kairouan, of which it is the port, and 93 mi. SE of Tunis Pop. (1946) 36,566 (of whom 5,937 were French), nearly three times that at the time of the French occupation in 1881. Sousse (formerly Susa) occupies part of the site of the ancient Hadrumetum, an important Phoenician city which served Hannibal as his base of operations at the end of the Second Punic War Trajan made it a colony. and about AD. 300 it became the capital of the new province of Byzacena. Later it received the name of Justinianopolis In the 9th century it was fortified by the Aghlabite rulers of Kairouan. It shared the general fortunes of Tunisia and became a noted haunt of pirates who raided the coast of Italy. In 1537, it was unsuccessfully besieged by the maiguis of Terra Nova, in the service of Charles V, but in 1539 was captured for the emperor by Andrea Doria. As soon as the imperial forces were withdrawn it became again the seat of Turkish piracy. The town was attacked by the French and the Knights of St. John in 1770 and by the Venetians in 1764. It remained, however, in the possession of the bey of Tunis In 1881 it was captured by the French, and in April 1943 by the British 8th army during the North African campaign in World War II, after advancing 80 mi, from Sfax in two days

The town is built on the side of a hill sloping seaward and is surrounded by a crenellated wall, strengthened by towers Recesses in the inner side of the wall are used as shops and warehouses. The kasbah, or citadel, built on the highest point within the town, was thoroughly restored by the French after their occupation of the country. Interesting buildings in the old town are the Kasr-er-Ribat, a square fortress with a high tower and seven bastions, built not later than the 9th century A.D., and the Kahwatel-Kubba (Café of the Dome), a curious house, square at the base, then cylindrical, and surmounted by a fluted dome. It was probably a church during the Byzantine period Southwest of the town are vast Christian catacombs, excavated by Abbé Leynaud in 1904 which contained some 10,000 burials. The ancient harbours are silted up, but vestiges of the Roman breakwaters may be seen. The modern port was completed in 1901. Exports are chiefly phosphates and other minerals, olive oil, esparto and cereals

SOUTH, ROBERT (1634-1716), English divine, was born at Hackney, Middlesex, in Sept. 1634. He was educated at Westminster school and at Christ Church, Oxford. Before taking orders in 1658 he was in the habit of preaching as the champion of Calvinism against Socinianism and Arminianism. He also at this time showed a leaning to Presbyterianism, but on the approach of the Restoration his views on church government underwent a change. On Aug. 10, 1660, he was chosen public orator of the university, and in 1661 domestic chaplain to Lord Clarendon. In March 1663 he was made prebendary of Westminster. In 1667 he became chaplain to the duke of York. He was a zealous advocate of the doctrine of passive obedience, and strongly opposed the Toleration act. In 1676 he was appointed chaplain to Lawrence Hyde (afterwards earl of Rochester), ambassadorextraordinary to the king of Poland. In 1678 he was presented to the rectory of Islip, Oxfordshire. In 1693 South published with transparent anonymity Animadversions on Dr. Sherlock's Book, entitled a Vindication of the Holy and Ever Blessed Trinity, in which the views of William Sherlock were attacked with much sarcastic bitterness.

Sherlock, in answer, published A Defence in 1694, to which South replied in Tritheism Charged upon Dr. Sherlock's New Notion of the Trinity, and the Charge Made Good. The controversy was finally stopped by the king. In 1710 he ranked himself among the partisans of Henry Sacheverell. He declined the see of Rochester and the deanery of Westminster in 1713. He died on July 8, 1716, and was buried in Westminster abbey.

His Sermons (6 vol., 1692) were reprinted many times; there is a modern edition in Bohn's classics (2 vol., 1845), and a complete edition

of his Works (5 vol , 1842). See also W. C. Lake, Classic Preachers of the English Church (1st series, 1877)

SOUTH, THE, a large area of the United States with certain distinctive characteristics The nation's southeastern quarter includes six of the original 13 states-Delaware, Maryland and the District of Columbia, Virginia, North Carolina, South Carolina and Georgia; and 11 states added after formation of the union-Kentucky (1792), Tennessee (1796), Louisiana (1812), Mississippi (1817), Alabama (1819), Missouri (1821), Arkansas (1836), Florida (1845), Texas (1845), West Virginia (1863) and Oklahoma (1907) Delaware, Maryland, West Virginia, Kentucky and Missouri often are referred to as border states because of their locations between the south and north and consequent mingling of northern and southern characteristics During the American Civil War the border states, although slave-holding, did not second from the union Today only southeast Missouri exhibits southern characteristies, the rest of the state is midwestern. Delaware and much of eastern Maryland consider themselves northern areas. while industrialized northern West Virginia closely resembles Pennsylvania Peninsular Florida is not "southern." since its environments, settlements and economic development differ from the rest of the south Western Texas and Oklahoma exhibit primarily western characteristics although settled primarily by southerners

Regional Features.-The distinctive features of the south are the following: a uniformly mild, humid climate with a long growing season; soils of moderate to low fertility, called red-yellow earths, which generally are productive under proper management but are easily eroded, gently rolling to dissected plainsland terrain, interspersed with alluvial valleys and extensive areas of hill-lands and low mountains; a biracial population consisting of a white majority of Scotch-Irish oiigin, and a Negro minority descended from the ante-bellum slave population; the plantation heritage, which disseminated the Negro and large landholdings throughout the southern plainslands; share-cropism and rural tenancy, which appeared as the large landholdings were fragmented during reconstruction; incipient farm mechanization; the yeoman farmer tradition and small farms, found in the nonslaveholding Appalachian hill-land areas; the one-party political system; and the rural agrarian tradition.

Only one of these features applies to all segments of the area called the south: the uniformly mild climate. While definitely a southern feature and an asset, and while it has been conducive to much that has happened in southern history—such as cotton, rice and tobacco culture and the associated plantation and slavery institutions—it is not climate that provides distinctiveness to the area. Instead, it is a complex of cultural and economic aspects which distinguish the region.

These unique cultural and economic facets stem primarily from the reconstruction period following the Civil War. Biracism became more than a population statistic during that time. Whereas formerly the dominance of the white was unquestioned, with abolition of slavery the landowner found it necessary to combat what were considered "carpetbag" and "scalawag" impositions in favour of the Negro. The share-crop system was devised. Reconstruction created conditions unattractive to outside capital and to European immigrants, and fixed a rural-agrarian pattern which only now is being torn apart. It was during reconstruction that the one-party Democratic tradition was developed. Finally, low per capita incomes, rural poverty, and inadequate public services (especially schools) which plagued the south were in large part consequences of capital losses during reconstruction.

The core of the south consists of those areas which experienced federally-supervised reconstruction and occupation by federal troops. These are the states comprising the Gulf and South Atlantic coastal plains. The border states and Appalachian hill-lands, since they escaped reconstruction, exhibit progressively fewer and fewer southern characteristics and now are "southern" primarily by geographical position and only secondarily by characteristics of landscape, culture and economy.

Climate.—A long growing season (generally 200 to 290 days frost-free) during which temperatures are warm to hot, together

with abundant rainfall during all seasons is experienced throughout the south. Winters are mild, the areal majority of the south averages 40° F, or higher during January, and extended snowcover is rare except in the Appalachian hill-lands Annual rainfall averages 45 to 50 in for most of the region, with greatest precipitation occurring during late winter and early spring. Late summer and autumn are drier and sunnier than other seasons-which facilitates crop harvesting. Summer rainfall is characterized by numerous thunderstorms and torrential downpours. Each autumn some parts of the Florida, Gulf and South Atlantic coasts experience heavy rains from hurricanes which move inland from adjacent seas; two or three of these storms each year contain winds of destructive force. The south experiences more tornadoes than other U.S. areas; they occur most frequently during spring and are most common in the Mississippi valley and adjacent states. The long growing season and abundant moisture permit production of a large number of agricultural and horticultural specialties, because of mild winter temperatures many field and truck crops can be produced on a year-round basis.

Landforms.—Two great landform categories predominate. hilllands which are deeply dissected (including some low mountains), and broad, gently rolling to moderately dissected plains.

The Appalachian hill-lands, consisting of the Blue Ridge, Appalachian ridge and valley, and Cumberland plateau, is the largest hill region in the south

The Blue Ridge, an area of intensely metamorphosed and crystalline rocks, begins in northern Georgia, widens to include extensive areas in eastern Tennessee and western North Carolina (where it reaches elevations exceeding 6,000 ft, and relief in excess, locally, of 2,000 ft. and is known as the Great Smoky mountains), narrows again and extends as a thin ridge throughout western Virginia and Maryland into Pennsylvania. The Appalachian ridge and valley, consisting of deeply folded sedimentary Palaeozoic rocks, is situated immediately northwest of the Blue Ridge. Broad, open, limestone-floored valleys which trend northeast-southwestward. approximately parallel to one another, are separated from one another by steep-sided, level-crested linear hills of sandstones and The valleys are drained by such famous streams as the Shenandoah, the upper James, the Holston and the Clinch. Historically, the limestone valleys have served as passageways for traffic moving southwestward and have acted as funnels between the Blue Ridge and the steep east-facing escarpment (Allegheny Front) of the Cumberland plateau. The limestone valleys are fertile, densely settled, and sites of the larger cities in the Appalachian hill-lands. The Appalachian ridge and valley extends from Birmingham, Ala., through eastern Tennessee (Chattanooga, Knoxville, Morristown, Elizabethton) and western Virginia (Bristol, Salem, Staunton, Lexington, Winchester) into central Maryland and Pennsylvania. The Cumberland plateau, consisting of nearly-horizontal layers of sedimentary rocks, forms the northwestern boundary of the Appalachian ridge and valley. The plateau consists of sandstones which slope gently westward. Its undissected surface rolls gently and in northern Alabama and eastern Tennessee is occupied by many small farms. Westwardflowing streams have cut into the plateau vigorously and deep, steep-sided valleys have resulted. Dissection by streams is intense on its westernmost third. Valleys support most of the set-tlements and cultivated land. Throughout the Appalachian hilllands slopes and uplands generally are heavily wooded.

The Ozark-Ouachita hill-lands of southern Missouri, western Arkansas and eastern Oklahoma are similar to the Appalachians although local relief is not as great and the areas involved are smaller.

Southern hill-lands differ from the plainslands in certain cultural and economic characteristics. In the hill-lands, the percentage of rural population is greater, but settlements are concentrated in favourable locales—valleys, mountain "coves" and lower valley slopes. Extensive sparsely populated areas occur in the hill-lands. The Appalachian hill-lands were originally settled by Scotch-Irish frontiersmen who moved from Virginia and central Pennsylvania down the open valleys; these settlers did not espouse the plantation system. Consequently small landholdings pre-

dominate in the hill-lands, and the percentage of population which is Negro is small. Virtual absence of the Negro explains the Union sympathy expressed throughout the Civil War and the widespiead loyalty to the Republican party throughout these areas in later years. Landholdings, soils and cultivation practices have not been suited to the great staple crops of the lower south—cotton, cane sugar and rice. Diversified livestock and subsistence farming have prevailed historically. Except for petroleum, the Cumberland plateau and the Appalachian ridge and valley areas have been and are the south's leading mining areas, notably in iron ore (Binningham and Gadsden, Ala.) and bituminous coal output (northern Alabama, eastern Tennessee, Kentucky and West Virginia).

The South Atlantic and Gulf coastal plains, coupled with the southern Piedmont and limestone-basin plains of central Kentucky and Tennessee are the southern cultural coreland These plains extend from the Atlantic coast to the Blue Ridge, and from the Potomac southwestward across the lower Mississippi valley to the Rio Grande river. Southern plainslands are of four types: (1) alluvial river valleys such as those of the lower Mississippi, the lower Rio Grande, Colorado, Brazos, Red, Arkansas, Alabama, Chattahoochee, Altamaha, Santee and Roanoke rivers; (2) fertile plains underlain by limestones which have decomposed into dark chestnut-brown or brownish-black soils such as the Louisville-Lexington bluegrass basin of central Kentucky, the Nashville basin of central Tennessee, the black belt extending from Columbus, Ga., westward through Montgomery and Selma, Ala.; Columbus, Miss.; ending north of Tupelo, Miss.; and the black wax prairies of central Texas, which extend from the Red river near Sherman and Denison, south-southwestward including Dallas, Fort Worth, Waco, Austin and San Antonio, Tex; (3) the southern Piedmont, whose inner margin is the Blue Ridge and whose seaward boundary is referred to as the fall line, a region of crystalline, commonly highly metamorphosed, rock whose rolling surface has been strongly dissected by numerous streams; (4) the coastal plains, extending from the Mexican border to Maryland, consisting of loosely consolidated, or unconsolidated sedimentary materials which generally range from coarse to sandy and whose moderate stream dissection has created undulating to moderately rolling plains. Seaward margins of the coastal plains are flat, poorly drained, and indented by many tidal marshes. Along the fall line changes in stream gradients flowing from the Piedmont onto the coastal plains cause rapids (whence the name fall line) which constituted heads of navigation for small vessels during colonial times.

Stream valleys are flat, poorly drained to marshy, heavily wooded and relatively difficult to cross throughout the coastal plains. On the lower Piedmont stream flow is more rapid, valleys are narrower, better drained, and more easily traversed. Interfluves are broad and well-drained. The Scotch-Irish of Virginia and Pennsylvania, the south's frontiersmen, preferred travel on the lower Piedmont to migration across the inner coastal plains for obvious topographic reasons. When the frontiersmen swung out of the ridge and valley of western Virginia on to the Piedmont through the Roanoke gap, they pushed the frontier along the lower Piedmont toward the Alabama black belt, creating a tonguelike settled area from which settlements subsequently rippled out toward both the Blue Ridge and the coastal plains to the south. Subsequent migrations of planters, from tidewater Virginia, North and South Carolina, followed the same route when the cotton plantations of the lower south were established during the early 1800s. Other Scotch-Irish frontiersmen moved southward through the Appalachian ridge and valley to gaps (such as the Cumberland gap in southwestern Virginia) through the east face of the Cumber-land plateau, thence followed valleys into central Kentucky and Tennessee. Some tobacco planters followed this frontier wedge into the limestone basins. Plantation migration via the gaps, howc.er. was numerically much smaller than via the lower Piedmont. Since settlement the southern Blue Ridge has been a serious barrier to migration and transportation and has diverted the main streams i raffic around the southern margins of the hill-lands.

As tidewater planters moved into the interior they searched for and sufficiently level to permit large fields for efficient employment of large gangs of slaves. The lower Piedmont and coastal plains provided such land; the hill-lands did not. Consequently, except for isolated instances, the plantations were located outside the hill-lands and, since migration of the planters spread the Negro slaves throughout the plantalands, it is in these areas that large farms—descendents of the plantations—and the southern Negro population are found today.

Soils.—Predominantly lateritic soils of reddish-yellow colour and coarse texture are characteristic of most of the south. In the Appalachian hill-lands and upper (northern) south generally, podsolizing processes have created grayish-brown surface colours and coarse substrata. As a whole, southern soils are mediocre in fertility; commonly they are deficient in calcium, nitrogen, phosphorous and potassium compounds. These soluble alkalines never were present in large amounts because southern soils formed under heavy rainfall, which caused alkalines to go into solution and disappear readily. Most southern soils were exhausted quickly after cultivation began; characteristically the south has consumed slightly more than half the nation's commercial fertilizer output. The average soils are moderately to strongly acid, are easily cultivated and, when lime and appropriate fertilizer are added, respond readily.

Certain southern regions are notable for inherently high soil fertility; they are an areal minority, however. The limestone plains of central Kentucky, central Tennessee, the black belt, and the black wax prairies are outstanding, as are also the limestone-based soils of the Appalachan ridge and valley. Soils developed upon alluvium in river-valley plains, as in the Mississippi valley. characteristically are well above the regional norms in fertility and productivity as are also the brown silt loams immediately east of the Mississippi river flood-plain and parallel to it from southern Illinois to Louisiana.

Soil depletion and erosion have been major problems in the south since before the Civil War. Soil depletion was accelerated during plantation decades by emphasis upon cash crops, and following the Civil War the necessity for cash staples such as cotton and subsistence grains caused further depletion. Constant summer row-cropping, associated with haphazard or no crop rotation was the custom as late as 1920. These practices in a region with a humid climate characterized by frequent torrential rains and virtually no extended soil freezing during winter led to widespread soil erosion. By 1930 major erosion damage characterized most of the south. Topsoil had virtually disappeared in large areas, notably in the Piedmont. The soil conservation service and associated agencies of the U.S. department of agriculture after 1033 promoted adoption of conservation practices to counteract depletion and retard erosion by incentive payments to farmers who employ approved land management practices. By 1950, erosion ravages had been checked in most southern areas, although erosion itself was by no means eliminated.

Biracial Population.-The biracial character of the south is distinctive. The original Atlantic coast settlements on the James river, Virginia, at Charleston, S.C., Brunswick, N.C., and Savannah, Ga., were established by English settlers, and migrants did not move inland from these centres until Scotch-Irish frontiersmen had migrated southwestward along the lower Piedmont behind the coastal nucleii. As settlers migrated inland from the coastal centres, they joined with the Scotch-Irish to populate virtually all of the south except the French settlements of lower Louisiana. The south was not attractive to the great majority of European immigrants who entered the United States between 1870 and 1920 because the region contained no free land which could be homesteaded and few industries which could offer ready employment, and because wages for agricultural labour competitive with former Negro slave labour were unattractive. Since the south did not share in European migration into the nation, it remained distinctively uniform in the composition of its white population-most of whom are descended from early immigrants from the British Isles.

Negro slaves were imported into the coastal tobacco areas of Virginia as early as 1619 in small numbers, but their use as the labour force for plantations originated elsewhere. Slave importation in numbers began in approximately 1695 near Charleston,

S.C., under the aegis of former Barbadians who had discovered opportunities for rice production. These settlers transplanted the plantation system of large-scale sugar production, with associated Negro slave labour, into the new rice area. After 1742 indigo developed as a plantation crop in South Carolina and Negro slaves also became the labour force in its production. Use of Negro slaves as a plantation labour force spread into tidewater Maryland-Virginia settlements, and into Georgia after 1752. Prior to the Revolutionary War the West Indian Islands were principal sources of imported slaves. Importation ended in 1808; approximately 450,000 had been imported and the national population of Negroes -slaves and free-was approximately 1,378,000 in 1810. 1950 American Negro population of 15,073,776, of which about two-thirds resided in the south, had descended almost entirely from imported slaves.

Invention of the cotton gin in 1793 reduced the cost and the time spent in separating cotton fibres from the seed, and generated tremendous increases in cotton production. Accelerated demand for cotton in Europe, as a consequence of the industrial revolution, stimulated seaboard landowners to migrate to the interior and commence cotton cultivation. Cotton production rose to 178,000 bales annually by 1810, and to 4,508,000 bales in 1850.

Negro slavery and the plantation system were readily adaptable to cotton culture. As settlements rapidly spread westward after 1810, the slavery and plantation institutions were dispersed throughout the southern plainslands and predominated in areas most favoured by natural conditions for cotton production. Such areas as the lower Georgia-Carolina Piedmont and inner coastal plains, southwest Georgia and southeast Alabama, the Alabama black belt, the lower Mississippi valley and the black wax prairies became noted for plantations. Their former status was reflected in modern times by the large percentage of Negroes in their population and large individual landholdings. Following 1810, the tidewater plantation tobacco industry found new lands in Kentucky and Tennessee, and sugar plantations developed rapidly in southern Louisiana; in both instances slavery was intrinsic to production of the staple crop. The modern concentration of the Negro on the plainslands resulted from the association of slavery with plantation land occupance. Had it not been for widespread dispersal of the plantations the south would not be biracial.

Plantations and Tenancy.—The plantation was an essential aspect of the ante-bellum south. Former plantations are still recognizable in altered form in many southern areas. In 1790 the populations of north and south were practically equal (1,967,197 and 1.062.428 respectively), and their influences within the federal government were about equal also. In succeeding decades up to 1860 the northern population grew at a greater rate than did that of the south. The consequent proportional loss (1860: 20,-309.960 northern; 11,133,361 southern) forced the south to wage a desperate struggle to retain its influence in the federal government to protect its particular interests, chief of which were slavery and the plantation system. As long as the number of free and slave states remained about equal, the south retained its influence in the U.S. senate. However, admission of California as a free state in 1850 foretold the decreasing power of the south in the senate, and led the south to espouse the doctrine of state sovereignty to protect its interests. In defense of slavery, primarily, the southern states followed the doctrine of state sovereignty to its ultimate conclusion and seceded from the union, forming the Confederate States of America. After four years of civil war the south was left beaten, exhausted and economically destitute. Freedom for the Negroes destroyed the slavery institution and the economic and social aspects of the plantation system as well, but did not remove the geographic basis of the plantations. The large landholdings intrinsic to the plantations became the areal bases upon which southern rural tenancy and share-crop agriculture developed during the reconstruction era.

At the close of the Civil War plantation owners were without operating capital or labour supply. Former slaves were without personal resources and had neither land, tools nor work stock with which to farm. Gradually the two groups evolved a system of land use, reasonably satisfactory to each, known as the sharecrop system. The former slaves no longer worked in gangs, directed successively by a central management to one large plantation field after another. They no longer were closely supervised in the routine tasks of farming, nor did they reside in a centrally located plantation slave row. Each Negro became a semiindependent operator farming a small subunit of 20 to 70 ac. Each subunit contained two or three small fields, and the former slave usually resided in a cabin at the edge of one of these Customarily his landlord provided him with tools, work stock, seed, and sufficient credit (called furnish) to purchase foodstuffs and a minimum of other goods until cash was on hand at harvest time.

When the staple crop was harvested, landlord and sharecropper split the crop proceeds half-and-half (hence the term "sharecropper"). The landlord received half the crop as rent for his land, buildings, animals and tools, and payment for his share of seed and fertilizer; the cropper received his half for his labour. Payment of the landlord's furnish came at harvest time from the cropper's share and took precedence over any other encumbrance

on the cropper.

The legislatures of southern states enacted crop-lien laws during reconstruction. These laws insured payment of the landlord's furnish ahead of other obligations and legalized the cropperlandlord relationship. Most landlords possessed insufficient capital to furnish croppers during the postwar period. They borrowed funds not only for their own support but also to reloan to their croppers. Crop-lien laws covered this relationship also. These laws still are operative; in no other section of the nation did it become customary to mortgage a crop or commodity that does not exist to relend to individuals who possess insufficient capital goods to secure the loan. Obviously these laws are outgrowths of reconstruction exigencies.

As the plantation workers changed from slave gangs to sharecroppers, settlement patterns shifted from centralized housesites to widely dispersed ones, from large fields to many small ones, from large compact woodlots to numerous small, irregularly shaped ones. Thus the plantations were fragmented. (The U.S. bureau of the census first recognized each share-crop unit as a separate farm in 1870). Only the land itself remained under central ownership, with fragmentation central management disappeared.

Another phase of plantation fragmentation created the tenancy system. The tenants represented a more advanced economic group in that they owned their work animals and tools. Since the landlord furnished the tenant only with land and buildings, his rent customarily amounted to one-third of the crop while the tenant retained two-thirds. Otherwise tenant relationships paralleled cropper relationships and were legalized under crop-lien laws. Tenancy arose largely during the period 1880-1900 in response to the modest financial independence of many croppers. Cropper and tenant systems still predominated in the former plantation areas in the 1950s though not to the extent that they did until 1930.

The Neoplantations.-During the decade 1940-1950 machines appeared on southern farms in large numbers for the first time. Many former plantation owners found it necessary to abandon cropper or tenant systems of land management when machines were purchased because most machines do not operate efficiently upon small land units. When cropper or tenant subunits of the fragmented plantations were coalesced into large fields, centralized management reappeared. Former cropper houses were abandoned, and housesites in use were clustered around the operator's home. Fields were fenced. A smaller labour force was applied as a unit to the entire plantation area to produce one or two commodities in which the plantation specialized and which also were capable of production with machines. These "neoplantations" were observable by 1950 in every former plantation area of the south and, while not as numerous as fragmented plantations, were increasing in importance. Labourers employed on neoplantations customarily received their houses and gardens free, and were paid a cash wage plus annual bonus. The labour force on a neoplantation was one-fourth to one-third that on a fragmented plantation with the same cropland acreage.

The Small Farm Tradition .- The southern landscape is distinctive since it shows the effect of two great processes in national settlement: migration of the frontier and of the plantations "Poor whites" who possessed only a few simple implements fanned out to either side of the lower Piedmont channel of migration and settled the upper Piedmont in North and South Carolina and Georgia, northern Alabama, the Blue Ridge, the lower coastal plains in southeastern Georgia, southwestern Alabama, southern Arkansas and eastern Texas. The Ozark-Ouachita hill-lands, also unattractive to planters, were settled in small farms by independent landholders. The term "yeomen farmers" has been applied to the smallholding group by historians.

During the decades 1930–1950 numerous small farms appeared around the south's growing urban centures. They represented one phase of national "rurban-suburban" growth Many are operated by "sun-up farmers"; i.e., operators whose primary income is from urban employment but who live outside the city on small units which they farm before working hours and on weekends. Many small landholdings are sandwiched among large units in every former plantation area. Except in the Mississippi valley, small landholdings, each containing less than 100 ac of cropland, are more numerous than plantation landholdings; however, the largeholdings usually occupy greater total area.

Following settlement, smallholdings were primarily subsistence farms with a single cash-crop specialty such as cotton, tobacco or corn grown on a minority of the acreage. After 1930 many of these farms shifted toward specialized commercial operations such as broiler chicken production (northern Georgia), burley tobacco (eastern Tennessee and western North Carolina), fruits and truck crops (northwestern Arkansas), and dairying (northeastern Alabama and southeastern Tennessee). Many of these farms were too small for effective support of farm families. They became an important source of labour to supply the south's expanding textile mills, wood-processing plants and chemical industries. Outside of "rurbar-suburban" locales, the number of smallholdings declined between 1940 and 1950, and their average size increased.

Democratic Vote in the South.—Another distinctly southern characteristic is the one-party political system. The "solid south" is a political fact. Loyalty to the Democratic party began during the reconstruction period. Approximately \$1,000,000,000 of southern capital vanished in freeing the slaves. Cotton produced during the war, which had been stored in public warehouses because of the Federal blockade, was confiscated by the Federal government without indemnity. Most southerners had only land left. Work animals and implements necessary for cultivation had been subjected to pilferage by freedmen, marauding bands from both armies, and occasional systematic confiscation.

Swarms of opportunists called carpetbaggers poured into the south determined to make fortunes quickly by capitalizing upon the prostrate land. They were joined by local opportunists known as scalawags. These groups co-operated openly with Federal military governments established in 1867, and exploited the freed Negroes, many of whom sat in state legislatures. The extravagances of legislatures consisting of these three groups created such heavy bonded indebtedness that all southern states later were compelled to repudiate their debts, an action which destroyed public credit for many years. It was a Republican administration which defeated the Confederacy; other Republican administration sadministered reconstruction. Carpetbaggers, scalawags and Negroes had ruled, under the protection of federal occupation, as Republicans. The freed Negroes espoused the Republican party.

The white population of the plainslands associated the Republican party with the bitterest experiences in the life of the south; thus the Democratic party became both a refuge and a tool for overthrow of the carpetbag governments in the minds of the great majority.

The solidly Democratic preference continued from the close of reconstruction with three exceptions. In the 1928 presidential campaign, numbers of southern Democrats bolted in favour of Herbert Hoover over Alfred E. Smith. In 1948 a minority of southern states bolted the Democratic party to form a short-lived "splinter"-party known as States' Rights Democrats. This group contained conservative Democratic southerners who were opposed to the Fair Deal policies of Democratic candidate Harry S. Tru-

man, but who could not accept the Republican party and its nominee. Thomas E Dewey The States' Rights group consisted of a dwindling but powerful minority who were political inheritors of the state sovereignty concept of ante-bellum times, albeit "sovereignty" had been altered to "rights" in the process of inheritance. Again in 1952 parts of the solid south slipped into the Republican column in support of Dwight D. Eisenhower.

Notable exceptions to dominance of the Democratic party are found in the Appalachian hill-lands. Eastern Tennessee and Kentucky, western North Carolina, and segments of southern West Virginia, southwestern Virginia and northern Georgia have been predominantly Republican since the Civil War When the Confederacy was founded these small-farm areas, with virtually no Negro population, opposed secession and were sympathetic to the Union cause. These hill-lands provided the Republican leadership during reconstruction and received the bulk of state patronage As a result these areas became the Republican strongheld in the south But the hill-lands did not occupy sufficient area in any one state at mid-20th century to influence materially its political life except in western North Carolina where a large Republican area could exercise balance of power in the event of a factional split among the Democrats.

The Democratic controlled state legislature gerrymandered county boundaries to create long east-west oriented counties, the eastern segments of which included sectors of the densely populated, strongly Democratic Piedmont The preponderant Democrats in each county thus could hold the divided Republicans of the Appalachians in check

Throughout the south it is taken for granted that the Democratic slate will win in a general election. Major political campaigns are fought to win nomination in the Democratic party primary. As a consequence, there are several factions within the Democratic party in each state. Most factions represent certain economic groups, areas or classes, such as the small landholders Factions in several states have won elections upon the issue of white supremacy, and still do. Normally the successful faction espouses two or three "causes" or special groups within its state.

The Rural-Agrarian Background.—The south has been historically a region of rural settlements devoted to agrarian pursuits. As late as 1940, 65,5% of the population was rural (1940 total: 38.915.061, excluding Delaware. Maryland and Missouri), and of the rural residents almost two-thirds resided on farms. Antebellum preoccupation with staple crops continued into the 1930s. Thereafter agricultural diversification proceeded at tremendous rates, but the agrarian economic basis persisted. By the 1950s the southern states had become the nation's largest producers of tobacco, peanuts, cane sugar, rice, peaches, pecans, watermelons, broilers and frying chickens, and of course cotton. The region also had become noted for its large corn, soybean, winter wheat, oats and legume seed production, and its expanding livestock industries, though it had not assumed leadership in any of these.

Despite rapid growth of urban centres and industrial pursuits, the rural-agrarian background continued to persist in the south. The fact that the population was overwhelmingly of rural origin conditioned economic and social viewpoints in the region to an extent not duplicated elsewhere in the nation.

Population Changes.—In 1940 the south's population of 38, 915,061 (exclusive of Maryland, Delaware and Missouri) constituted 29,55% of the national total; by 1950, 44,536,002 southerners accounted for 29.02% of national population. The south's population increase amounted to 12.39% and the nation's to 14.45% during the 1940–50 period.

Southern birth and net survival rates were higher than for the rest of the nation; had it not been for substantial emigration of both Negroes and whites, southern population would have increased more than it did.

The south's population changed most in place of residence and employment from 1940 to 1950. In 1940 urban population consisted of 13,407,609 (34.45% of the south's total) but by 1950 had increased to 20,338,560 (46.5% of the total). The number of rural residents declined from 25,507,452 (1940) to 23,395,264 (1950), or from 65,54% of the 1940 to 53,49% of the 1950 total.

The increment in percentage of urban residents represented an increase of approximately 51%, the largest of any American region Rural-farm population decreased from 16.055,181, or 62 0% of the regional total (1940), to 11,678,440, or 26.7% (1950), a decline of 4,376,721. This number does not balance the actual increase in urban population (6,930,851). Rural nonfarm population. which includes numerous small landowners in the suburban fringes. rose from 9,452,271 (1940) to 11,716,824 (1950). Whereas rural nonfarm residents accounted for slightly more than one-third of the rural population in 1940, they comprised slightly more than one-half of it in 1950 Thus primary population shifts during 1940-50 consisted of a major increase in urban numbers, an important increase in rural nontarm residents, and a major decline in farm population. Roughly half of the south's counties (almost all of which were rural ones) suffered decreases in population. The south was the only major region in the nation to experience an absolute as well as a relative decline in rural farm residents.

Southern Negro population urbanized and migrated from farms at approximately the same rates as did the total population during the 1940-50 period. In one important respect Negro population trends differed, the Negro migrated from the south faster than the white The proportion of Negroes in the south's population had decreased by 1950 to the lowest point in 100 years. Of 12,865,-518 Negroes in the nation in 1940, 9,379,546, or 72.9%, resided in the south, constituting 24.1% of the southern population. By 1050, national Negro numbers had increased to 15,073,776, virtually 10% of the total population. Negroes in the south totalled 8,911,933, or approximately 20 4% of all population, a decrease of 467,613 since 1940. Thus in 1950 the Negro was about twice as numerous in the south as in the nation. In 1860, when 38% of the south's population was Negro, the Negro was more than five times more numerous in the south than in the rest of the nation. During the 1949-50 decade. Negro population changes shifted the south's population composition much closer to the national average than it was prior to 1940.

Changes in Income and Income Sources .- Between 1930 and 1950 southern average per capita incomes increased approximately 300%, two-thirds of which occurred after 1940. Per capita incomes in the south in 1950 averaged approximately 62.5% of the national average of \$1,600. Part of the 1940-50 per capita income increase was attributable to a 34% decline in percentage of labour force employed in agriculture (32% in 1940, 21% in 1950). The proportion of employment provided by manufacturing, service and secondary industries rose greatly. In 1950 manufacturing alone accounted for 18% of the region's workers, an increase of about 7% over 1940. Manufacturing had become a larger source of income than agriculture by 1950 (agriculture \$3,100,000,000, manufacturing \$3,900,000,000, using a 1939 index dollar). This reversal of traditional income relationships was not a consequence of reduced agricultural income; income from agricultural sources rose from a pre-World War II average of approximately \$2,000,-000,000 (1939 index) to the figure noted above. Approximately 36% of the industrial structures contracted for in the nation between 1946 and 1949 were built in the south.

In 1950 trades and services accounted for approximately \$11,000,000,000 (1939 index), or about 26% of all southern income. The proportion of total income provided by this group had increased only about 2% since pre-World War II days. Income payments from federal and state government sources increased from approximately \$1,250,000,000 (1939 index) to about \$5,000,000,000 in 1950. This income source grew in proportionate significance from approximately 9% (1940) of all income to about 20% (1950).

# RURAL LAND USE

Changes in Farm Numbers and Acreage.—The number of farms in the south declined from 3,007,170 in 1940 to 2,650,803 in 1950. About 439,000 farms of less than 220 ac. in size vanished; 37,627 new farms of more than 220 ac. appeared. An estimated 100,000 tenant and share-crop farm units were absorbed into the large landholdings of which they were parts. Total land in farms increased from 370,168,461 ac. (1940) to 394,237,903 ac. (1950),

and average farm size rose from 123 to 149 ac. Greatest farm size increases occurred among farms larger than 220 ac.; however some increases were registered for smaller farms except those ranging from 3 to 30 ac. in size Cropland harvested per farm rose only from 34.3 to 36 ac during the 1940–50 decade; land pastured increased considerably, however. Average southern farm value increased 163%, from \$3,231 in 1940 to \$8.495 in 1950, and value per acre slightly more than doubled, nsing from \$26.75 to \$58.30 The greatest value per-acre increments occurred on farms of less than 30 ac.; these farms underwent about a threefold value increment—largely as a consequence of rising real estate values in the "rurban-suburban" locales in which many of them were situated. Value increases during the decade were significant nationally, since in 1950 about 49% of the nation's farms were in the south.

Forests and Forest Industries.—The south is more nearly a forest belt—not a cotton belt—than anything else. Excluding western Oklahoma and Texas, more than 55% of the regional area in 1950 was in forests, which together accounted for slightly more than 30% of the national forest acreage. About 40% of the nation's commercial forests are in the south. Public ownership of forest land is much less significant than elsewhere: roughly 86% of the forested acreage in 1947 was privately owned and about 40% of it on farms

Southern forests are of three major types. Largest in area and commercially most important is the southern coniferous forest of the coastal plains, which extends from Chesapeake bay to eastern Texas. Much of the forest land of the Piedmont, northern Alabama and Mississippi also is devoted to the southern pines although these areas originally were vegetated by hardwoods. Pines were introduced into these areas as second-growth because they were more valuable and reached merchantable size more rapidly than the hardwoods. Four varieties, loblolly, longleaf, shortleaf and slash pine predominate; the latter two are most important ereally. The pines are most valuable because they supply excellent structural lumber, are the best southern pulpwood source, and also may be used to produce naval stores. Mixed deciduous hardwoods predominate throughout the Appalachian and Ozark-Ouachita hilllands, and also throughout the plainslands of Kentucky, Tennessee, northern Mississippi and Arkansas. Predominant hardwood varieties are red and white oaks, hickories, maples, poplar and chestnut (virtually gone as consequence of the chestnut blight). The third type consists of alluvial-riverbottom hardwoods, including cypress, tupelo, red and sweet gum, and some white oak and lowland hickory varieties. Bottomland hardwood forest stands are most numerous in the Mississippi valley and valleys of its tributaries; Memphis, Tenn., is the nation's leading hardwood market largely because of its nearness to these forests.

Pulp, paper and timber companies own huge tracts, especially on the coastal plains east of the Mississippi river. By the 1950s the south was supplying half of the nation's annual timber growth. and about 55% of the annual saw-timber growth on only 21% of the national forest acreage devoted to trees of saw-timber size. There were about 1,650,000 small southern landholdings which included an average of 75 forested acres each. Southern forests were producing (1952) approximately 45% of the nation's lumber and timber, 50% of its fuel wood, and 58% of its pulpwood output. Southern forests produced the entire national supply of naval stores-turpentine and rosin. About 65% of all turpentine was produced from pine wood as a by-product of pulp-paper manufacture-a remarkable change since 1930, when less than one-seventh of the national output was so recovered. In 1951 the south produced approximately 708,000 bbl. of turpentine and 2,137,000 drums of rosin.

Restocking and replanting of southern forests proceeded rapidly, and inadequate forest stands were upgraded. In 1949 production goals for state-owned tree nurseries were set at 98,500,000 seedilings (almost entirely pine), and the U.S. forest services indicated that this output—about double that of the preceding year—would not remotely satisfy demand.

By 1952 there were about 670 paper, pulp and paperboard plants in the region, many of them of small size; 43 plants, each with a daily capacity exceeding 250 tons of processed products, ac-

counted for the vast majority of regional production. Five new plants were under construction, including a mammoth newsprint plant near Cleveland, Tenn., utilizing both pine and hardwoods for pulp. The gross value of products from these plants in 1951 exceeded \$2,300,000,000. Georgia (2,500,000 cords), Mississippi (1,865,000 cords), Alabama (1,609,000 cords) and Florida (1,583,-

000 cords) were the leading pulpwood producers.

The percentage of area in forest is so great in certain parts of the south that these locales must be considered forest regions. These regions are (1) the Appalachian hill-lands from northern Georgia through the western Carolinas, eastern Tennessee and western Virginia; (2) the lower coastal plain in northern Florida, southeastern Georgia and southers Mississippi; (4) southern Arkansas; (5) west-central Louisiana and southeastern Texas; (6) northern Arkansas; and (7) the Cumberland plateau forest in eastern Tennessee, Kentucky and northern Alabama. The southeastern Georgia-northern Florida region contains county after county with more than 90% of the area in forest. Throughout all of the foregoing regions approximately 80% or more of the total area is forested.

Cotton Production Changes.—The most fundamental change in southern land use was the decline in acreage planted to cotton. Acreage in cotton between 1944 and 1950 was between 20,000,000 and 24,000,000 ac., about 44% less than in 1924–25. If production had declined as much as did acreage, the consequences could have been disastrous, but such was not the case. In the 1925–50 period eastern Texas-Oklahoma yields per acre increased about 25%, and regions east of the Mississippi averaged more than 50% increases. Raw cotton prices rose steadily from 1930 onward because of the AA:A. (Agricultural Adjustment Administration) price-parity formula for cotton and the demand created by World War II. By the late 1940s and early 1950s the south was producing as much cotton as it had formerly on little more than half the old acreage, and it was receiving more henome from the crop than during the 1920s. Increases in yields offset acreage declines, but the tremendous acreage decrease destroyed the former cotton belt.

In place of the cotton belt there arose seven cotton regions which, together, accounted for less than 10% of the area in the south, but produced almost two-thirds of the southern cotton crop. These regions are: the inner coastal plains in Georgia and the Carolinas; the Georgia Carolina Piedmont; the Tennessee river valley in northern Alabama; the alluvial Mississippi valley; the black wax prairies of Texas; the south Texas coastal plains; and the high plains of western Texas and

Oklahoma,

By the 1950s cotton no longer held the dominant position that it traditionally had as a southern income source. In 1930 it had accounted for about 50% of southern cash farm income; in 1944-50 it supplied about only 45% despite substantially higher prices. The basic factor involved in this change was the shift to production of livestock and other crops on acreage which higher yields had freed from cotton. Resultant diversification contributed greatly to a steady rise in agricultural income.

Cotton did not dominate the landscape in any of the seven cotton regions; in more than half of their area cotton occupied less than 15% of the total acreage during the period 1944–50. The one-crop system no longer existed. Occupance systems developed in the regions between 1944 and 1950 concentrated on cotton, the high unit-value product, plus activities which fitted both conservational rotation systems and optimum use of machinery. Beef cattle fitted these requirements well and became important in every cotton region. Each region was also noted for a second crop specialty; on the Piedmont small grains were major crops, the inner coastal plains led in tobacco and peanuts, while the Mississippi valley became a major soybean producer.

Mechanizatión of Farms.—The cotton regions became leaders in southern farm mechanization. The 1946-95 ractor increase amounted to 455:557 (1950 number of tractors: 502,858). In Arkansas, tractor numbers increased approximately 300% between 1940 and 1950, in Mississipil 400%, in Georgia 1,000%. As the number increased, the number of work animals, especially mules, underwent a tremendous decline. Infusion of machines was associated with (1) increases in pasturage, formerly devoted to supporting mules, available to support cattle and calves; (2) introduction of accessory machines, such as combines and hay balers, to utilize machine power efficiently, and adjustments in field crops to utilize the accessory machines; (3) decline in hoe-and-mule cotton farming, diversification of field crops, and reduced emphasis upon cotton; (4) decreases in rural-farm population; and (5) reappearance of many large landholdings as centrally-managed units with numerous plantationlike aspects (neoplantations). These changes were particularly pronounced after World War II.

After 1930 the majority of landowners were forced to mechanization by labour shortages. Industrial and urban growth proceeded in the south at rates greater than those for the country as a whole. Farm

workers migrated to cities and factories voluntarily in response to relatively higher urban-factory wages

Complete mechanization of cotton production became possible By the 1950s about half the cotton produced on the west Texas high plains was machine-harvested. One- or two-row picker-harvestes were available for use in humid areas; volume production of these machines began in 1948. Some machines were cheap enough for use on small cotton farms in eastern segments of the south. Pre-emergence herbicides applied by tractor-drawn machines during planting, plus postemergence herbicides to control weeds and grass in young cotton, meant that heretofore essential but laborious hand hoeing, weeding and "chopping" of the crop could be eliminated Thus hoc-culture cotton pioducion appeared doomed Mechanization was far from completed on the region's farms. By 1950 about three-fourths of them still depended primarily on animal power and more than 90% had neither hay baler, cotton harvester, corn picker nor combine.

Aspects of Diversification.—The south is important as a pro-

Aspects of Diversification.—The south is important as a producer of many agricultural products besides cotton, and both variety and volume of other products increased greatly between 1940 and 1950

The great majority of American tobacco is produced in southern Georgia and northern Florida, the inner coastal plans of the Garollans and south-central Virgnia (flue-cured cigarette tobacco areas), southern Maryland, central and western Kentucky, central Tennessee, and the Appalachian hill-lands in eastern Tennessee southwestern Virgnia (principally burley tobacco areas). Locations of these production regions were fixed by acreage-quota regulations under price-parity supports within A.A.A. legislation during the 1930s.

Peanuts are the third most important regional cash crop. The area including southwestern Georgia, northern Florida and southeastern Alabama ordmarily produced more than half the crop, followed by the Virginia-North Carolina coastal plains and the northern Texas black was prairies. Both edible and olinut varieties are produced; in the Georgia-Alabama area, hog feeding on peanuts has become widespread. Peanut producers benefit from Drice-parity supports under A.A.A. lesislation

Albama area, hog feeding on peanuts has become widespread. Peanut producers benefit from price-parity supports under A.A. legislation The northern half of the alluvial Mississippi valley became the nation's second largest soybean producing area (for vegetable oils) between 1940 and 1950. Acreage devoted to soybeans exceeded that planted to cotton, and production averaged about 13,500,000 bu. Rice production by machines predominates in east-central Arkansas, and the southwestern Louisiana-eastern Feas outer coastal blains.

pianted to cotton, and production averaged about 13,500,000 bit. Kansas, and the southwestern Louisiana-eastern Texas outer coastal plains. In 7040 and 7050 the ten top states in percentage gains in cattle population were all in the south, with Alabama, Georgia and North Carolina leading. Exclusive of Virginia and Kentucky, beef cattle increased from 11,000,000 in 1935 to about 16,000,000 in 1950, when they produced 400% more cash return than in 1925. Practically all plainslands areas expanded beef production during the 1940s; there was no distinctive regional concentration. Four major poultry producing areas developed after 1945, the Guadeloupe-San Marcos valley in eastern Texas; the upper Chattahoochee valley in Georgia, northwestern Arkansas; and northwestern Virginia. Broller chicken and meat production predominated in the first three areas; the Virginia district has been a major egg producer as well. Northern Georgia led nationally in broller output in 1951-52.

# INDUSTRIAL REGIONS

Factors Favouring Rapid Industrialization.—In large pat, urbanization was a result of major industrial and services expansions. The causes which underlay these expansions included higher consumer incomes in the region as the consequence of increased agricultural productivity and prices (the net effect of which was to create new malkets for most manufactured goods); expansion of established industries the south in response to both a larger regional market and an increasing national population; expansion of both private and public power facilities (especially electrical power) which attracted numerous industries because of low costs and availability; development of new randerials because of low costs and availability; development of new randerials processing techniques (such as newsprint manufacture from resinous southern pine) whereby underdeveloped raw materials were used for commercial use; expansion of the chemicals industries, many of whose raw materials were any present; attractive local industrial water supplies; relatively lower ad valorum and corporate income taxes than in most northern areas; plentiful labour supply (much of it not inherently skilled in manufactural processes and not unionized) and somewhat lower labour wage rates than prevailed in northern areas. Finally, the impetus provided manufacturing by World War II was enormous since both new industries and huge government supply contacts were located in the south to meet wartime exigencies. Fears that the wartime industrial expansion would collapse, harming the region's economic structure greatly when peace came, proved to be groundless.

the wartine industrial expansion would collapse, harming the region's economic structure greatly when peace came, proved to be groundless. The south of the 1930s was a rural-agrarian exporter of a few staple crops and raw materials. It was a market area for industrial and farm products most of which it did not produce itself. During the 1940s the region began to supply itself and to export some products to other areas. The remarkable progress in manufacturing was, significantly, the consequence of new developments in chemicals, mineral fuels (especially petroleum), electrical goods, metal products, and paper and apperboard industries. Older industries that also grew included textiles, wood, furniture and tobacco. The general diversification of industrial types and their widespread dispersal during the 1940s assured a

healthier economy than heretofore.

Between 1939 and 1947 the regional industrial labour force increased 50%, wages paid 10se 274% and value added by manufacture increased 244%; these were considerably greater increments than for the rest of the nation. North Carolina, Texas, Georgia and South Carolina, in that order, led in industrial employment. The textile industry, the regional manufacturing backbone, declined from 35% to 27% in proportion of total workers largely because of marked increases in employment in other industries. Textile and other low-wage industries did not expand as rapidly as did high-wage industries whose total employment was relatively small in 1939. The chemical industries, and outstanding high-wage group, undewent major expansions in the Texas-Louisiana gulf coastal area and consequently Texas threatened, in 1947, to displace North Carolina as the leading state in industrial in 1947, to displace North Carolina as the leading state in industrial employment.

In 1947 the south contained three important industrial regions the Piedmont-Appalachian area based on textiles; the Birmingham, Alahama area based on steel; and the Texas-Louisiana coastal area based

on chemicals and petroleum.

Piedmont-Appalachian Area.—Around 1875 cotton textile mills began to migrate in numbers from New England to the south,

Piedmont-Appalachian Area.—Around 1875 cotton textile mills began to migrate in numbers from New England to the south largedy'n response to lower southern wage rates, nearness to raw materials and lower taxes By 1900 the south contained 30% of the textile industry's spundles, in 1925 the region surpassed New England and by 1947 contained 77% of all US. active spindles, accounting for 84% of spindle hours operated, and consuming 87% of all US. raw cotton consumption About 70% of all US. active spindles, accounting for 84% of spindle hours operated, and consuming 87% of all US. raw cotton consumption About 70% of all looms were in the south at mid-20th century. After 1940 southern mills produced higher proportions of finer, lighter goods than formerly; the bulk of 1940-50 output was—as it had been traditionally—coarser woven goods such as sheeting, ginghams, print cloth, cotton drill, duck and denims.

Most of the rapid expansion in synthetic textiles production occurred in the south. U.S. production rose from 130,000,000 to 1,150,000,000 lb of rayon annually between 1927 and 1947, and by the latter date about 75% of the national output in six large plants. Rayon manufacture requires proximity to acids, caustics, coal and large quantities of water of great purity. Isolated plant sites, adjacent to good labour supplies, and adequately serviced by both rail and road transport are highly desirable. The extent to which the Piedmont-Appalachian area was able to supply this combination of requirements surpassed almost all other areas. Scanty data available on nylon production indicated that about 50% of the 1944 rational output was produced in the south.

All textile industries, including synthetics, ranked first in numbers of production workers a mong industries in South and North Carolina, Georgia, Virginia, Alabama and Tennessee. Textiles employed more than half the production workers in the first three states. In the first four states listed above, textile mills are located primarily in Piedmont works site is along

four states listed above, textile mills are located primarily in Piedmont towns, secondarily in cities along the fall line. In Alabama and Tennessee the Appalachian ridge and valley cities are the primary textile

nessee the Appalachian ridge and valley cities are the primary textile centres. Manufacturing employment totalled about 2,00,000 in 1947 in the south; textiles accounted for more than one-fourth of it. When textile, tobacco, furniture, lumber and paper manufactures in the Piedmont-Appalachian area were combined, they accounted for approximately 40% of southern manufacturing employment.

Tobacco manufacturing, a long-established Piedmont-Appalachian industry, employed about 62,000 workers in 1947 to produce about 72% (\$463,000,000) of the national total value added by tobacco processing. North Carolina, Kentucky and Virginia led the region in producing more than 90% of the nation's cigarettes and 30% of its cigars. The furniture industry, concentrated especially on the North Carolina Piedmont, in eastern Tennessee and in Piedmont Virginia, nearly doubled its industrial personnel in the south to a total of 75,000 nearly doubled its industrial personnel in the south to a total of 75,000 in 1947, which amounted to 25% of national furniture manufacturing employees. The south produced about 21% of the nation's furniture and related fixtures, by value, mostly in Piedmont factories.

employees. The south produced about 21% of the nation's furniture and related fixtures, by value, mostly in Piedmont factories.

The Birmingham Area.—Situated near the southern end of one of the great limestone-floored valleys of the Appalachian ridge and valley, Birmingham, Ala., is the south's Pittsburgh. Few locales are better fitted by natural advantages for iron output since all basic materials for primary production occur abundantly within less than 20 mi, of the city. The floor of the valley provides dolomitic limestone for fluxing virtually beside the blast furnaces; coal comes from the bituminous Warrior coal basin immediately northwest of the city. Southeast of the city Red mountain, a ridge extending northeastward for many miles, consists principally of Clinton (Silurian) sediments of high iron content. Several deposits of commercial quality outcrop on the western flanks of Red mountain, the largest of which—Big Seam—is 20 mi. long and contains solitic haematites averaging about 36% iron. Mining proceeds in shafts extending up to 6,000 ft. downslope. Other seams, notably the Woodstock, supply softer ore from irregular limonite deposits found in clays and gravels and extracted in open pits. Estimated local ore reserves amount to nearly 2,000,000,000 tons. During the 1940 or provided of the services of the national output.

In addition to pig iron, the Birmingham mills produce forgings, casteriated between the content of the produce of wire wester wire.

In addition to pig iron, the Birmingham mills produce forgings, castings, rails, structural steel, plate, extended soft steels such as rods, wire,

nails, bolts and rough sheets, and pipes of many types. Although steel mill employment increased about 50% in the area during World War II, it levelled off at about prewar levels during 1946-47 Consequently, the area did not keep pace with the rest of the south in industrial expansion

Gulf Coastal Chemicals Area.—This region encompasses the coastal plains in Texas, Louisiana and Mississippi. Between 1939 and 1947, production workers in chemical industries in Texas and Louisiana increased from 10,700 to 27,400, and all factory jobs increased 60% between 1929 and 1947 The population was not a highly industrialized between 1929 and 1947 The population was not a highly industrialized ne since in 1947 manufacturing employment amounted to 3,3% compared with a national percentage of 7.9 Petroleum and chemicals industries are noted for peculiarly low ratios of employees to capital investment and high wages per employee Between 1939 and 1947 slightly more than \$73,50.00,000 invested in new plants alone in this area, by about 75 chemical companies, represented about 27% of the mational investment in such plants during a period when U.S. chemical productive capacity virtually doubled The Gulf coast area was attractive to these companies because of the unusual sensitivity of the chemical industry to availability of raw materials. Petroleum, natural 2828, sall, see water, suiphur, wood nuln, grain sorchums, cane sugar. gas, salt, sea water, sulphur, wood pulp, grain sorghums, cane sugar, molasses and cane bagasse were the primary raw materials available Of these, greatest development was based upon petroleum and natural gas for production of such synthetic organics as ethylene, propylene and butylene The vast majority of all industries used petroleum or natural gas as a power source.

Between 1701 and 1751 Texas alone accounted for about one-third of the total crude oil production in the US and 21% of world output the greatest production came from the east Texas Gulf coastal field, The greatest production came from the east Texas Gull coastal field, which continues into Louisana, southern Arkansas, southern Missisippi and southwestern Alabama Large oilfields also occur in northern and western Texas, and the Texas panhandle area around Amarillo contained in 1950 the nation's largest producing natural gas deposits Crude oil production for 1951 in Texas amounted to 1,010,128,000 bbl. and natural gas output to 3,862,400,000,000 cu.ft. The crude oil output amounted to about 45% of the national total. Texas, Louisiana and Mississispi contained about 56% of the nation's proven crude oil reserves (1951), of which 47% was situated in Texas alone. Thirty-four per cent of the national refining capacity (1950) was in Louisiana and Texas, clustered principally in four areas: Houston-Texas City and Beaumont-Port Arthur, Tex., and Baton Rouge and Lake Charles, La. Corpus Christi, Tex., and New Orleans, La., were important secondary centres. The nation's two largest refuneries were situated at Baton Rouge and Baytown (near Houston).

The area's large refining capacity proved attractive to chemical

Baton Rouge and baytown (near nouscon).

The area's large refining capacity proved attractive to chemical companies concerned with synthesizing organics from refinery gases (formerly wasted), natural gas and crude oil residues. These materials are used as chemical building blocks for production of industrial alcohols, solvents, plastics, detergents, synthetic rubbers, high-octane gaso-line ingredients and certain synthetic fibres. Some of these materials were produced as end-products in the area; after initial synthesizing, chemicals essential to others were shipped from the area to processing

and finishing plants elsewhere.

In 1950 the Gulf coast produced one-fifth of the nation's electrolytic In 1950 the Gulf coast produced one-fifth of the nation's electiclytic caustic soda for use in paper mills, oil refineries and other chemical plants; the Dow Chemical company plants at Freeport-Velasco, Tex, were the leading producers. Butadiene, primary raw material of GR-S type synthetic rubber, was in production at Baton Rouge and Lake Charles, La., and Port Neches, Baytown and Houston, Tex, from gases supplied in large volume by the catalytic "cracking" petroleum process. Butane was produced from natural gas at Borger, Tex. Copolymen rubber plants, operated by established rubber companies, were situated adjacent to butadiene units in each of the foregoing centres. Streep the ether primary ingredient in GR-S rubber was were stuated adjacent to buttadene units in each of the foregoing centres. Styrene, the other primary ingredient in GR-S rubber was produced at Velasco and Texas City, Tex., from natural gas.

Anhydrous ammonia for fertilizers was in production (1950) in wartime-constructed plants at Sterlington and Lake Charles, La., and

wartime-construction at Yazoo City, Miss. These plants use natural gas, water and air as raw materials. The Houston area contained 27 chemical plants reraw materials. The Houston area contained 27 chemical plants responsible for production of alkalies, chlorine, glycerin, sulphuric acid, ammonium sulphate, sodium silicate, industrial alcohols and plastic resins. These plants and their products—the most diverse combination of chemical productions found in any Gulf coast centre—are in addition to the area's refineries. The du Pont corporation plant at Orange, Tex., produced nylon salts, methanol, formaldahyde and polythene from 60,000,000 cutf. to fautural gas delivered daily from a nearby gas field. Dow Chemical company plants at Freeport-Velasco, Tex., produced magnesium, bromine, caustic soda, vinyl chloride, glycols and other industrial chemicals from sea water, brine and natural gas. To insure an adequate natural gas supply for fuel as well as raw material. insure an adequate natural gas supply for fuel as well as raw material, the company controlled about 100,000 ac. of off and gas leases near by: Several Gulf coastal chemical centres developed into port cities/of im-

Several Guit coastal chemical centres developed into port cities of importance. Most of the Texas ports are man-made. Houston is linked to the Guif of Mexico by the Houston Ship channel, an artificial channel 58 mi. long and 34 ft. deep, whose construction was started during World War I. In 1948 Houston handled cargoes totalling more than 40,000,000 tons and rivalled New York city in volume shipped. Another artificial channel, the Sabine-Neches waterway, links Beaumont, Port

Arthur, Orange and Neches to the Gulf via a 6r mi dredged canal The volume handled by the Sabine-Neches ports rivalled that of Houston in 1948. New Orleans challenged Baltimore, Md, between 1945 and 1948 as the nation's second largest port in terms of value of cargoes, but had yet to displace the Chesapeake Bay centre. New Orleans trade expansion was based upon vigorous campaigns to capture shipments formerly handled by eastern ports and to expand traffic with Latin American nations Outshipments characterized all ports in 1948 and consisted primarily of regionally produced imperishable bulk goods such as wheat, cotton, crude oil and refinery products, sulphur, rock phosphate and bulk chemicals. Petroleum shipments provided the vast majority of cargoes from all Gulf ports except Houston and New Orleans, and predominated even in these centres. Inshipments constituted a small fraction of cargo tonnage and consisted principally of bautate unloaded at Mobile, Ala, and New Orleans, and tin ore unloaded at Texas City and Galveston, Tex.

Bibliography — Materials, concerning ante-bellum conditions are

iraction of cargo tonnage and consisted principally of bauxite unloaded at Mobile, Alia, and New Orleans, and tin ore unloaded at Texas City and Galveston, Tex.

Bibliocraphy — Materials concerning ante-hellum conditions are found in Ralph H Brown, Historical Geography of the United States, biblio (New York, 1948); J D B DeBow, Industrial Resources of the Southern and Western States (1853); L C Gray and E. K. Thompson, History of Agriculture in Southern United States to 1860. (Washington, D C., 1933); U B. Phillips, "Plantation and Frontier Documents' in Documentary History of American Industrial Society, vol it (1910); Justin Winsor, Narrative and Critical History of America, vol.—viii (1894). On climatic conditions, see US. Department of Agriculture, Climate and Man: Yearbook of Agriculture, biblio. (1941); Robert De Courcy Ward, The Climates of the United States (Boston, 1925). On landforms and physiography, consult W. W Atwood, Physiography of Provinces of North America (Boston, 1940); N. M. Fenneman, Physiography of Eastern United States (New York, 1938). On southern soils, consult US. Department of Agriculture Soils and Men: Yearbook of Agriculture (1938); H. H Bennett, The Soils and Agriculture of the Southern States (New York, 1921). On population, see US. Bureau of Census, Census of Population, 1870–1970; US. Department of Commerce, Bureau of Foreign and Domestic Commerce, "Regional Shifts in Population, Production and Markets," Economic Series (1943); H. W. Odum, Southern Regions of the United States (Chapel Hill, N.C., 1936); Gunnar Myrdal, The American Dilemma (New York, 1944); T. Lynn Smith, Population Problems (1949). On reconstruction, plantation fragmentation, tenancy, 1se of share-gropping and growth of the Democratic party, see especially E. M. Coulter, The South During Reconstruction in Georgia (New York, 1947); E. Hobert Weaver, Mississippi Farmers, 1850–1860 (Nashville, 1942); Herbert Weaver, Mississippi Farmers, 1850–1860 (Nashville, 1942); Herbert Weaver, Mississippi Farmers, 1850–1860 (N

Council, (1947-1953); F. J. Well and D. G. Miley, McChainzaudin of the Cotton Harvest, Journal of Farm Economics, vol. 27 (1945). On southern industry, see especially Calvin B. Hoover and B. U. Ratchford, Economic Resources and Policies of the South, biblio. (New York, 1951); Ben F. Lemert, Cotton Textile Industry of the Southern Appalachian Piedmont (1933); R. P. Brooks, Industrialization of the South (Athens, Ga., 1920); Harriet L. Herring, Southern Industry and Regional Development (Chapel Hill, N.C., 1941); National Resources Planning Board, Regional Development, IN. C., 1941); National Resources Planning Board, Regional Development, National Resources South (Washington, D.C., 1949); Independent Petroleum Association of America, The Oth Producing Industry (1922); J. W. Newton, "The Saline-Neches Area of Texas: an Industrial Survey," Texas Geographical Wagazine, vol. 13 (1949); J. J. Parsons, "Recent Industrial Development in the Gull South," Geographical Review, vol. 40 (1950); W. H. Shearon, Jr., "Chlorine and Alkail Production in the Southwest," Chemical and Engineering News, vol. 26 (1948); Vearbook American Bureau of Metal Statistics (1948). On general human and economic geography of the south, see A. E. Parkins, The South (New York,

1938); and R. B. Vance, Human Geography of the South (Chapel Hill,

SOUTH AFRICA, UNION OF. Comprising the southern part of southern Africa, which extends from the south coast of the continent to the Congo-Zambezi watershed, the Union of South Africa has an area of 472,494 sq mi. The four provinces of the Union and their areas are: Cape of Good Hope (Cape province). formerly Cape colony, 277,113 sq mi.; Natal (including Zululand), 35,284 sq.mi.; Transvaal, 110,450 sq.mi.; and Orange Free State, 49,647 sq.mi. Bordering it to the northeast is Portuguese East Africa (Mozambique); to the north, Southern Rhodesia, Bechuanaland and South-West Africa, the last-named being mandated to the Union after World War I and now administered as a part of the Union. Basutoland lies within the borders of the Union and Swazaland forms an enclave in the eastern Transvaal, but both are British territories administered by the British high commissioner and do not form part of the Union The shores are washed by the Atlantic and Indian oceans, the conventional division between the two being the meridian of 20° E.

### PHYSIOGRAPHY

Geography.-Physiographically the two primary divisions of the Union are the plateau and the marginal area which lies between the plateau edge and the coast. The plateau altitudes increase generally from about 2,000 ft. in the Limpopo trough and 3,000 ft. in the western interior to more than 11,000 ft. in the Basuto highlands, areas over about 4,000 ft. in height being known generally as high yeld and those between about 2,000 and 4,000 ft as middle veld; in the marginal areas land below about 2,000 ft. is generally known as low veld. The marginal areas normally consist of a zone of plateau slopes and a coastal zone, but in the Cape province the marginal area is split up by the folded mountains into an inner basin, between the folds and the plateau edge, known as the Great Karroo (2,000-3,000 ft. above sea level); a series of river basins within the folded area, known as the Little Karroo (1,000-1,500 ft ); and a coastal foreland between the folded mountains and the coast (sea level to 800 ft.). Between the coastal foreland and the Little Karroo stretches the Langeberg range (3,500-6,000 ft ) and between the Little Karroo and the Great Karroo the Swartberg line of ranges (5,000-7,000 ft.), the highest peak in the range being Seven Weeks Poort mountain, 7,627 ft,

The edge of the plateau is the most prominent and most continuous orographic feature in the country and is known as the Great Escarpment. It reaches its maximum altitude in the Natal Drakensberg, the highest point surveyed being Thadentsonyane (11,-425 ft.); several other points, such as Champagne Castle (11,075 ft.), Giant's Castle (10,868 ft.) and the Mont aux Sources (10,-822 ft.), are almost as high. The great height of the escarpment in this area is attributable to the strength of the Stormberg basalt, which lies at the top of the Karroo system and here attains a thickness of more than 4,000 ft. Southwestward the Great Escarpment loses height with the thinning out and final disappearance of the basalt, its highest point outside the basalt being the Compass Berg (8,215 ft.), an inclined sill of dolerite in the Sneeuwberge, north of Graaff-Reinet. Points in the Nieuwveld range, farther west, exceed 6,000 ft.; in the western part of the Cape province the highest points on the escarpment are about 5,000 ft. above sea level. To the north of Natal the highest part of the Great Escarpment is formed by the westward-dipping Black Reef quartzite, whose eastward-facing scarp is known as the Transvaal Drakensberg. The highest point in this area is Mt. Anderson (7,498 ft.), but the highest point in the Transvaal lies a little to the west in the Steenkamosberge, where Die Berg is 7,651 ft.

There are several physiographic subdivisions in the plateau. The plateau high veld stretches from the Witwatersrand in the north to the Great Escarpment in the south. The Cape middle veld extends from about Kimberley to the western edge of the plateau. To the north of the Witwatersrand lies the Transvaal Plateau basin (including the Central Bushveld basin) and the Limpopo trough, which is the lowest of all the plateau regions. The Kalahari basin lies between the eastern periphery of the plateau (high veld and Transvaal Plateau basin) and the western periphery formed mainly by the South-West Africa highlands.

Geology .- Geologically the Union consists of formations extending in time from the Archaean to Recent, the oldest rocks being those of the basal or fundamental complex, which include the older granite-gneiss formations and the most ancient metamorphosed sediments of the continent, known as the primitive formations. These are succeeded by the Pre-Cambrian systems of which the most important are the Witwatersrand system, the Ventersdorp and the Transvaal system, all of which have been greatly disturbed by earth movements and by igneous intrusions. of these the most important is the bushveld igneous complex of the central Transvaal, the largest lopolith in the world. Overlying the Pre-Cambrian are the post-Cambrian and pre-Karroo formations, including the Waterberg, Nama and Cape systems, the first two affected by faulting and by crustal flexing The Cape system is strongly folded, the high antichnal ridges of the Table Mountain sandstone being the most prominent features of the "Cape folded belt" in the south and southwest of the Cape province Overlying the Cape system the Karioo system consists of about 25,000 ft. of sediments, mostly sandstones and shales, injected with much dolerite Except in the extreme south and the east the Karroo beds have not been disturbed by folding and they are almost horizontal. Forming slightly more than half the surface of the Union the Karroo system determines to a greater extent than any other formation the surface features of the country. Because of the horizontality of the beds, the alternation of sandstone and shale and the widespread outcrops of dolerite, the type of surface associated with the Karroo formation is tabular, wide expanses of plain being broken by frequent occurrences of tafelberge (mesas), tafelkops (buttes) and spitskoppies (with pointed summits) Post-Karroo formations, covering comparatively small coastal areas and synclinal valleys in the Cape folded area, include Cretaceous and Tertiary marine beds, fluviatile conglomerates and the widespread Cretaceous to Recent conglomerates, limestones, sandstones and sands of the Kalahari basin, only the extreme southern end of which falls within the Union. (I H. Wn)

Climate.—The climate of South Africa is warm, temperate and dry except in the mountains and the coastlands of Natal and Cape province. The main controlling factors are the subtropical situation and the altitude of the plateau. Except in the southwestern and southern Cape province the rain falls in summer, often in heavy convectional showers occasionally accompanied by hail. In the region of winter rainfall in the southwestern Cape, however, the rains are associated with travelling barometric depressions of the westerly wind belt. In a country which is so large and in which altitude ranges from sea level to more than 10,000 ft., large variations of climate are to be expected. But the most striking is the decrease in rainfall from east to west; the western half of the country is semiarid passing gradually into desert which is found

near the mouth of the Orange river.

The warmest and wettest region is the subtropical coastland of Natal below 2,000 ft. in height, extending from Kosi bay southward to the Cape province. The rainfall is 45-50 in. in northern Natal but decreases to 33 in. at Port Elizabeth. The wettest month is March, at the end of summer. In summer the coastal region is uncomfortably warm; the mean January temperature is about 75° F. and the range between day and night is about 12° F. Relative humidity falls to about 65% in the afternoon. But in the winter the climate is close to the ideal for human comfort; at Durban the mean July temperature is 65° F. and the daily range 16° F. The coast is windy, and while the regular and strong sea breezes in Natal give some relief from the summer heat the persistent winds farther south are a disagreeable feature of the climate. East London, with a mean velocity for the year of 15 m.p.h., is one of the windiest places in South Africa.

Westward, on the eastern slopes of the plateau, climates vary with altitude and exposure. Exposed mountain slopes are misty and wet, while the sheltered valleys (e.g., the Pongola, Umfolozi, Tugela and Great Kei) are much drier. Valleys and depressions are liable to extreme temperatures—hot in summer and cold in winter. Mean summer maxima in the Tugela and Buffalo valleys exceed 90° F. and the range from summer maxima to winter minima is about 50° F. In Natal and the Cape severe frosts are fre-

quent, at Nottingham Road (4,700 ft.) in July the minimum temperature falls below 27° F. on three nights out of five But in the Transvaal the plateau slopes have milder winters and the freedom from severe frosts makes these areas important producers of winter clops In summer, however, this region, which merges into the low veld adjoining Mozambique, is uncomfortably hot At Komatipoort the mean January maximum is 92° F. and the mean July maximum 70° F.

The main climatic features of the plateau are low rainfall, plenty of sunshine and large seasonal changes in weather. Summer is warm and rainy and winter is cool and almost rainless. At Johannesburg the mean rainfall is 33 in, the wettest month being January, with 6 in , and the driest July with 0 5 in. The highest rainfall occurs in the mountains of the eastern escarpment-e.g., Woodbush, Forest, 68 in .- but over most of the Transvaal and Orange Free State the rainfall is between 20 and 30 in. (at Pretoria 31 in., Pietersburg 18 in , Bloemfontein 21 in., Standerton 30 in.). The 20-in isohyet (line of equal rainfall) lies close to the 26th meridian, and the semiand part of the plateau, including the western Orange Free State and the central and western part of Cape province, lies to the west of this isohyet The high veld is moderately cool; Johannesburg (5,750 ft.) has a mean January maximum temperature of 80° F, and the temperature seldom rises above 85° F. Fortunately the occasional high temperatures are associated with very low relative humidity and the heat is not unbearable. Frosts occur between April and September and severe frosts occasionally from June to August. (Mean July minimum at Johannesburg, 38° F) The western part of the plateau is lower and in summer hotter than the high veld. (At Kimberley the mean January maximum is 91° F.) Afternoon temperatures are usually close to 90° F. and temperatures above 95° F. can be expected oc-casionally from October to February. The hot season ends in casionally from October to February. March and from then till October the climate is pleasant and comfortable. The days are warm and dry and the dry atmosphere accounts partly for the large diurnal range of temperature (at Kimberley the mean July maximum is 66° F. and the minimum 37° F.). This pleasant winter weather is interrupted once or twice a month by outbreaks of cold air in strong southerly winds, which sweep across the plateau. The cold air has a high lapse rate and so, while the temperature in the coastal regions over which it passes may not be exceptionally low, the plateau may suffer from severe frost. The lowest temperatures on record are: Standerton (5.004 ft.) 9° F., Middelburg (4,746 ft.) 11° F. and Bloemfontein (4,678 ft ) 12° F.

From the northwest coast of the Cape province desert spreads inland in the valley of the Orange river and Namaqualand. The coastal strip cooled by the Benguela current is quite distinct climatically: mean temperatures vary little throughout the year (Port Nolloth, mean January maximum 67° F. mean July maximum 64° F.), and the low cloud and fog characteristic of coldwater coasts is nearly always there-a uniform layer of stratus cloud from which drizzle is falling covering the whole sky a few hundred feet above the ground. It forms at night and usually is dispersed by the sea breeze before noon. In this coastal desert the highest temperatures occur in the winter in short hot spells when "Berg" winds blow seawards from the interior. Similar in some respects to the foehn and Chinook, the berg winds are formed by subsidence in the atmosphere. Though they affect all parts of the South African coast they are remarkable on the west coast because of the great difference between the temperature of the berg wind and the normal temperature.

Climatically the southwestern and southern Cape province are distinct from the rest of the country. Winter is the rainy season and in the southwestern Cape the summer is dry. But the southern Cape gets summer rains too and is the only part of the Union with an all-season rainfall. In the southwestern Cape the mountains are responsible for variations in both temperature and rainfall. Near Cape Town the mean rainfall is 25 in. Rainfall decreases northward, Saldanha bay, about 100 mi. from Cape Town, receiving about 10 in. At Cape Town the mean January temperature is 70° F. and the mean July temperature 55° F., the mean daily ranges being 20° F. and 15° F. Both winter and summer

are characterized by strong winds—in winter the strong northwesters which often bring rain, and in summer the "Cape southeaster" which sometimes blows with gale force for two or three days at a time. (S. P. Jn.)

Vegetation.—Five vegetational types can be recognized in the Union: (1) forest, (2) savannah, (3) grassland, (4) sclerophyll

and (5) semidesert and desert.

Natural forest occurs where there is the perennial availability of adequate soil and atmospheric moisture. In few parts of the Union do such conditions obtain, and where they do the effects of fire and human exploitation have reduced the areas, so that at present only about 0.25% of the country is covered by natural forest. Three main types can be recognized: temperate, subtropical and montane. The largest area of temperate forest lies between the south coast, to the west and east of Knysna, and the Langeberg orographic line (the Outeniqua mountains). This area, which is generally known as the Knysna forest, contains almost entirely evergreens, the tallest and economically most important trees being the yellowwoods, Podocarpus spp., which are sometimes 150 ft. high. Other valuable trees include the stinkwood (Ocotea bullata), the sneezewood (Ptaeroxylon obliquum), the black ironwood (Olea laurifolia), the white ironwood (Toddalea lanceolata), the Cape beech (Myrsine melanophloeos), the assagar (Curtisia faginea) and many others.

Much smaller areas of temperate forest occur on the southern slopes of the Winterberg-Hogsback-Amatola escarpment and in the interior of Natal. Subtropical forest occupies a narrow coastal belt stretching from the eastern Cape province through Natal and Zululand into Mozambique. The altitudinal limit is about 800 fit, the most common trees in the dense bush and evergreen forest being of the genera Albizzia, Protorhus, Sclerocarya, Trichilia and Ficus. Formerly the Cape box (Buxus maconani), the Cape mangany (Trichilia emetica) and the Cape ebony (Heywoodia luceus) flourished in this forest zone but they have almost all been cut down for timber. Palms such as the wild date palm (Phoenix reckinata), the ilala palm (Hyphaene crimta) and the wine palm

(Raphia vinifera) are found in this zone.

The montane forest occurs on some of the east-facing escarpments of Natal and the eastern Transvaal. The largest areas are the woodbush, to the east of Pietersburg, and the Entabeni forest, on the southern slopes of the Soutpansberge, to the east of Louis Trichardt. The heavy rainfall and frequent mists brought in by the easterly winds are responsible for these occurrences.

2. The savannah occupies the eastern and northern parts of the Transvaal, extending westward into the Kalahari basin and in a narrow belt southward as far as Port Elizabeth, with outliers in the Little Karroo. Of the mixed type, the savannah in places has a close association of trees almost resembling a forest; elsewhere it opens out to parkland and in places to tree steppe. In the eastern part of the Union the most common trees are acacias, with aloes and euphorbias in the drier areas. The most common grasses are of the genera Themeda, Panicum, Rhynchelytrum, Setaria, Pennisetum and Chloris. In the northern Transvaal the baobab (Adansonia digitata) is associated with the acacias and in the middle Limpopo valley the dominant tree is the mopane (Colophospermum mopane).

In the central bushveld basin of the Transvaal the mixed character of the savannah is most marked, for both evergreen and deciduous types are represented, including the genera Faurea, Burkea, Protea, Terminalia, Combretum, Rhamnus, Rhus and many others. In the southwestern Transvaal and northwestern Orange Free State the Kalhanti thorn veld is dominant, the most characteristic tree being Acacia girafae, with which are associated A. karroo, A. detimens, A. dulcis and many other acacias. Other common trees include Burkea africana, Terminalia sericea and Bosia albitrunca, and the grasses include the short and tall Bushman grasses, Aristida ciliata and A. uniplunis, with Dantonia suffrescens on the dune crests.

3. The grasslands lie mainly in the summer rainfall area to the east of the 15-in. isohyet and so occupy almost all the eastern portion of the plateau high yeld, the high yeld and middle yeld of Natal and the eastern Cape province. From the pastoral point

of view three types of grassland can be recognized. In the west a "sweet" veld type predominates in which the grasses remain palatable and nutritious throughout the year. In the east the grasses are mainly of the "sour" type, nutritious during the first two or three months of growth and thereafter becoming unpalatable and indigestible to animals. In an intermediate position lies a mixed type of veld in which both sweet and sour grasses mingle. On the plateau the most common species are of the genera Themeda and Cymbopogon, with Hyparrhenia, Tristachya, Trichopteryx, Digitaria and many others represented. Below the escarpment, in the Natal and Transkeian high veld, the main grasses are of the genera Hyparrhenia, Sporobolus, Setaria, Tristachya and Themeda.

- 4. The sclerophyll covers most of the southwestern Cape province, where the climate is of the Mediterranean type, with winter rain and summer drought. The sclerophyll bush occurs between sea level and about 3,000 ft. where the rainfall is between about 20 and 30 in. Large bushes, mostly shrubs five to eight feet high belonging to the Proteaceae, are generally interspersed with small woody plants and geophytes including an abundance of those of the Restionaceae; in other areas an intermediate layer occurs consisting of small shrubs of the Compositae, Ericaceae, Rustaceae and many others.
- In the more humid areas the wet schlerophyll bush is more luxuriant, consisting mainly of a dense growth of bushes up to ten feet in height, in which the most common genera are Berselia and Erica. On the mountains at altitudes of more than 3,000 ft. mountain bush is composed of smaller bushes which often assume a prostrate habit as a protection against the wind. Along the border of the semidesert zone another type can be recognized—the dry schlerophyll bush, a more open association than in the wetter areas, the low bushes having small, dry, flat leaves; succulents are often found mingled with the bushes. There is a general absence of trees in the sclerophyll area except in the kloofs and ravines of the high mountain ranges.
- Semidesert and desert vegetal types occur where the rainfall is less than about 15 in, in the summer rainfall area and about 10 in. in the winter rainfall area. The most common vegetal form is the desert shrub, which is of the woody type in the moister areas and of the succulent type in the drier. In the driest parts of the Karroo, where the annual rainfall is about five inches, the most common forms are low succulent bushes rarely more than eight inches high together with tiny shrubs with ericoid leaves and many species of Mesembryanthemum. In the western Karroo the two most common bushes are the kraalbos (Galenia africana) and the yellow milk bush (Euphorbia mauritanica), while numerous geophytes burst into activity during the short wet season. Farther east the succulents are taller and include bushes of Euphorbia, Cotyledon, Aloe, Crassula, Mesembryanthemum and Portulacaria. In the eastern Cape province Aloe ferox is abundant, as are three or four species of Euphorbia, including the noorsdoorn (E. coerulescens), an important stock feed in times of drought.

The second type of desert shrub, the woody bush, is the Karroo bush proper, of which a taller mountain type can be recognized and a smaller type which covers most of the flat country. The smaller shrubs are perennial woody bushes about 3 to 12 in. high, with very small leaves and relatively large spreading roots. The most common are various species of Pentzia, such as the gansies (P. wirgata, P. incara, P. globosa), the sweet resin bush (Euryops multifidus), the bitter karroo (Chrysocoma tennifolia), the gannas (Salsola spp.) and the saltbushes (Atriplex spp.).

After rain annual grasses spring up, often almost concealing the bushes, but they die in times of drought. The karroo bushes, however, can survive droughts of nine or ten months' duration, after which seedlings spring up when the next rains occur.

In the desert areas of the northwest coastal zone where the rainfall is less than about five inches, a zone of succulents just behind the coast is made possible by the frequency of mists. The desert zone is continued into the South-West African namib and up the Orange river valley into Little Bushmanland. In the rocky areas of Little Namaqualand tall succulents occur such as the elephant's trunk or halfman (Packypodium namaquamum), the

kokerboom (Aloe dichotoma), the spekboom or fat tree (Ceraria namaquensis), the poison tree (Euphorbia virosa), the Bushman's candle (Sorcocaulon burmanii) and many others. (J. H. WN.)

Fauna.-Zoologically South Africa belongs to the Ethiopian region and is characterized by the absence of bears and deer and by the presence of a great variety of antelopes, which range in size from the diminutive blue duiker to the eland. Some of the more strictly tropical forms are unrepresented, such as the gorilla, chimpanzee and many of the parrots. Some animals, as for example the lion, crocodile and some antelopes, have a continuous distribution from the Sudan, along the East African corridor between the great equatorial forests and the coast belt down to South Africa. On the other hand the country may be regarded as a distinct subregion of the Ethiopian area because of a number of forms which are peculiar to it. Among these are the springbok, black wildebeest, the long-tailed sugar bird, which appears to have a distribution closely related to that of the Proteaceae, and a great variety of insects, adapted to the Cape flora. Since the white man entered the country with his rifle, his enclosures and his domestic animals, the numbers of the larger native animals have been enormously reduced. A few species such as the quagga have become extinct. Several species of buck survive only in a semidomesticated state on some of the large farms or in game reserves. The white rhinoceros, which occurs about the sources of the Nile and which used to be common in the area between the Zambezi and the Orange rivers, is now represented only by a few individuals in the Umfolozi game reserve of Zululand. The elephant still survives in the Knysna forest, the Addo bush and the Kruger National park and in Bechuanaland, and a herd of mountain zebra is preserved in Cape province.

Of the rodents there are about 150 species, including squirrels, hares and porcupines. Two species of Insectivora—the golden mole and the elephant shrew—are peculiar to South Africa. The Nomarthra and Tubulidentata include the scaly anteater and the aardvark, or ant bear, the structure of whose teeth (molars) has on analogy among the mammals. Several species of whales are caught in South African waters. The primates are not well represented, but monkeys are found in the forests and baboons are comnon in nearly all the mountainous areas. Of the Carnivora the leopard is still fairly secure in some of the mountain kloofs; lions are confined to the northern Transvaal and the Kruger National park. Several of the smaller Felidae—wildcat, lynx, spotted serval, etc.—are moderately numerous. Hyenas are becoming scarce, but the Canidae are still well represented by the black-backed and striped jackal and the wild, or Cape, hunting dog.

Over a thousand species of birds are known, including migrants such as the European swallow, red-backed shrike, white stork, curlew, etc. Parrots and hornbills are found from the tropics to Damaraland on the west, and on the east through Natal to the Knysna forests. The jackass penguin, which breeds in large numbers on the islands of the south and west coasts, represents an antarctic element. Eagles, kites, falcons, harriers, hawks and owls occur. The secretary bird, with its long legs and terrestrial habit, is related to the eagles and hawks and is protected because of its reputation as a snake killer. It is peculiar to South Africa. Among the birds which are shot for sport or food are the francolins (locally known as pheasants and partridges), guinea fowls, sand grouse, ducks and geese. The ostrich still exists in the wild condition in unenclosed parts of the country. The common European starling is rapidly spreading about Cape Town and in the coastal parts of Natal; the Indian mina is well established and is pushing away some of the native species.

The reptiles include more than 350 species. The crocodile does not occur south of the Kunene and Tugela rivers. Tortoises and especially lizards are numerous. Snakes are represented by 125 species. Among these are the puff and night adders, cobra, python and the swift and deadly mamba (Dendraspis angusticeps).

There are 200 species of fresh-water fish. By far the commonest are representatives of the carp family, known in South Africa as barbel. The tiger fish (Hydrocyon lineaties) is the finest indigenous sporting fish and occurs in the Komati and Crocodile rivers. There is only one native species of eel; it is confined to the rivers

flowing into the Indian ocean. Brown, rainbow and Loch Leven trout have been acclimatized and many rivers in the cooler parts of the country are well stocked. In Natal they do well above 4,000 ft. South Africa has many varieties of scorpions and spiders. Of insects, it is estimated that there are at least 40,000 species. Those of the northeastern and eastern districts have affinities with central Africa. Mention can only be made of the mantis, or Hottentot god, the white ants or termites, which are often destructive of timber and trees; of the bees, including honey bees, which are common; of several types of mosquitoes, including the anopheline mosquito; and the tsetse fly (Glossim).

(R. U.S.)

Bibliography.—J. Hutchinson, A Botanist in Southern Africa (London, 1946); Austin Roberts, The Birds of South Africa (London, 1940) and The Mammals of South Africa (Cape Town, 1951); J. Stevenson-Hamilton, Wild Life in South Africa (London, 1947).

#### HISTORY

Portuguese Pioneers .- Whether or not the Phoenicians sailed around Africa as claimed by Herodotus, southern Africa was unknown to the Greeks and the Romans and to Europeans before the 15th century. Then, largely as a result of the patronage of Prince Henry the Navigator (1394-1460), Portuguese mariners steadily pushed down the West African coast until in 1488 Bartholomeu Diaz de Novaes rounded the Cape of Good Hope and in 1498 Vasco da Gama, in a flagship of 120 tons, 80 ft. long, reached the objective, India. Thereafter the Portuguese gained maritime supremacy in the Indian ocean and used it to exploit the Asiatic spice trade and, less effectively, the East African gold trade. But, though they colonized Angola and Mozambique, they made no settlements as far south as what is now the Union of South Africa, regarding its resources as negligible and its inhabitants as too primitive for commercial or evangelical effort. Throughout the 16th century, therefore, South African waters were often Praversed by Portuguese fleets, but the only civilized people who spent much time ashore there were the survivors of the many ships that were wrecked on the coast.

# DUTCH FOUNDATIONS

The Trading Companies.—By the end of the 16th century Dutch and English seamen had also begun to trade with Asia by the Cape route. They found it desirable to pause for refreshment, the death rate on the long voyage being often as high as 50%; so during the first half of the 17th century they usually stopped at St. Helena, the Cape or Mauritius. In 1615 the English tried vainly to form a settlement at the Cape with ten felons reprieved from the hangman's nose, and five years later two English captains made the empty gesture of annexing all Africa for King James; but it was St. Helena that eventually became the main port of call for the English company.

Meanwhile the Dutch East India company outstripped all rivals and obtained a virtual monopoly of the East Indian spice trade. For several decades Dutch ships made a practice of putting into Table bay to take in fresh water, to barter meat from the Hottentots and to find the latest information about the affairs of Europe or Asia in dispatches they left one another under inscribed stones. Then in 1647 Leendert Janssen was shipwrecked in Table bay with the crew of the "Noord Haerlem," and after his return to the Netherlands he presented a report advising the company to found a permanent refreshment station at the Cape. Largely because the Anglo-Dutch war of 1652-64 was imminent, the directors eventually agreed; three ships were to take out materials for building, seeds and implements, and 90 men were to build a fort and develop a vegetable garden.

Jan van Riebeeck.—To command the expedition the directors chose Jan van Riebeeck. or Riebeek, a doctor by training, who had already had six years of commercial experience with the company. He landed at the Cape on April 7, 1652, and remained ten years, during which time droughts, floods and pests, indiscipline among his subordinates and thefts by the Hottentots often brought the settlement to the brink of disaster. Burit survived; a timber-and-sod fort was built, the coast line was charted, the interior was explored, and a belt of land extending about eight

miles from Table bay to Wynberg was brought under cultiva-

However, the Cape did not become the simple outpost which the directors had had in mind At that time Hottentots, pastoral nomads loosely organized in small tribes, occupied most of the coastal regions of South Africa as far east as Natal. The Cape peninsula had been used by two such tribes, who regarded the Dutch as intruders in their domain, especially when it became apparent that they were not birds of passage but were building fortifications and extending their area of cultivation. The Dutch bartered with the Hottentots for sheep and cattle and from time to time the Hottentots stole them back again. Van Riebeeck calculated whether he was strong enough to use force, but when the directors cautioned him to do no such thing he fell back on the idea of confining the settlement within a palisade this early stage in South African history it was not possible to keep the races completely apart, because the Dutch continued to barter with the natives. Van Riebeeck also initiated two experiments which had far-reaching consequences. At first all the work of the station was done by the company's servants, but in 1654 a few slaves were imported and more came in 1658 and thereafter. The second experiment started in 1657 when the company, hoping it would save money if corn were grown and stock bred by unpaid freemen instead of by paid employees, freed nine men from their contracts and gave them 30-ac. farms along the Liesbeeck valley at Rondebosch, where they were to produce corn and stock and sell them to the company at the company's prices. So Van Riebeeck left behind him an embryonic colony of settlement which used slave labour and was confronted with a "native problem."

Immigration and Expansion .- In 1662 the Cape contained only about 250 white persons, of whom nearly half were company servants, and in the next few years there was little increase. But during the governorships of Simon van der Stel (1679-99) and his son W. A. van der Stel (1699-1707) the company made its one serious effort to encourage immigration. In 1707 a census showed a white population, other than company servants, of 1,779 men, women and children, owning 1,107 slaves. This was a slow rate of progress compared with that of the English colonies in North America. Nevertheless, the Afrikaner people of today are descended for the most part from those who were enumerated in 1707. These were company servants who had taken their discharge at the Cape and people who were sent out to settle. Most of them were of Dutch and German stock. There was also a small but significant group of rather fewer than 200 French Huguenots who, after the revocation of the Edict of Nantes in 1685, went to Holland and then were sent to the Cape. As a matter of policy the company scattered the Huguenots among the other settlers, and within little more than a generation they became fully assimilated, discarding the French language and even pronouncing their names in the Dutch manner. The area of settlement expanded with the population-to Stellenbosch beyond the sandy Cape flats (1679) and then to the Berg river valley. To meet the needs of local administration a general purposes official (landdrost) was appointed to Stellenbosch in 1685; sitting with four local freemen (heemraden), he was given jurisdiction in minor civil cases. Nearly all the company servants, however, lived in Cape Town, where the governor and his chief subordinates formed a council of policy which issued regulations for the colony, subject to the overriding authority of the governor general and council of the Indies in Batavia and the directors in the Netherlands.

From the first the freemen had fretted at many of the regulations, which imposed restrictions and taxes on internal trade; for example, the rights to deal in much local produce, including cattle, were auctioned annually to contractors, as well as the rights to retail imported goods. Furthermore, by the end of the century the Cape was producing more wine, brandy and corn than was consumed locally and by passing ships, and there was little opporunity for export.

What was particularly galling to the freemen was the tendency of the officials to farm and trade on their own account, using their uthority to make sure that their own produce did not remain nsold. This led to an outcry against the governor, W. A. van der

Stel, who embarked on large-scale farming operations and cornered the market so successfully that some malcontents, including the Huguenot diarist Adas Tas. sent a petition to the directors, who recalled Van der Stel in 1707. But the underlying cause of the discontent—the commercial policy of the company—was not remediad

The Evolution of the Afrikaner People.-The company had no vision of a New Netherlands in South Africa and sponsored no immigration schemes after the time of the Van der Stels. Nevertheless, during the 18th century a New Netherlands of a sort was arising from the materials present. The white population grew. mainly by natural increase, to about 15,000 in 1795, by which time they regarded South Africa as their only home and spoke a language, Afrikaans, which deviated from the language of the Netherlands. Those who lived in Cape Town-the only port and the only real town in the colony-were mostly traders and innkeepers. In the southwestern part of the colony, near Cape Town, were the corn and wine farmers, or boeren, some of them proprietors of large estates run by slave and Hottentot labour Beyond them were the trekboeren, about half the total white population. The trekboeren were seminomadic, many of them completely nomadic, pastoral farmers. Most of the land they occupied was unsuitable for cultivation; moreover, the market for agricultural produce was glutted and slaves did the skilled work There was, therefore, nothing to keep the inof the colony crease of the white population in the southwestern Cape and much to encourage them to disperse and become self-sufficient pastoral farmers. The way was paved by W. A. van der Stel, who, unlike his father, allowed freemen to concentrate on stock farming, Within a few years it became possible for any freeman to take occupation of 6,000 ac. or more of land and treat it as his property, paying the company a small annual licence. The result was a continuous expansion of the frontiers of white settlement. In the north the trekboeren were slowed up by aridity and finally stopped near the Buffels river about 1760. In the east they advanced along either side of the and Great Karroo until in the 1770s the two streams of pioneers began to mingle beyond it in the vicinity of what became Graaff-Reinet, about 400 mi. from Cape Town. Thus a few thousand white persons scattered over an area about twice as large as England. Their simple needs were met by their stock and by hunting and by travelling traders who bought their sheep and cattle for the Cape Town market and sold them a few imported goods. The company did little for them beyond establishing courts of landdrosten and heemraden at Swellendam (1745) and Graaff-Reinet (1785). From time to time officials expressed concern that the isolation of the trekboeren was causing them to degenerate. But although all the trekboeren were extreme individualists and some were ruffians, most of them contrived to preserve a sound domestic morality, a smattering of literacy and a respect for their religion, a rather strait Calvinism.

Slaves, Hottentots and Bushmen.—During the 18th century the slaves, the Hottentots and some of the Bushmen (q,v) were beginning to interbreed with one another and with Europeans to produce the community now known as the Cape coloured people. Although few slaves were imported, the slave population outstripped the white to number nearly 17,000 in 1795. Negroid types from the west and east coasts of Africa predominated, with Malays from the East Indies forming an important minority. There was a considerable amount of extramarital miscegenation between white men and slave women. Most of the slaves were the property of the agricultural farmers, for whom they formed the main labour supply. Others were owned by the company and the Cape Town burghers, a few by the trebboeren. The treatment of the slaves, which had at first been fairly mild, tended to deteriorate, and the 1754 slave code was a stiff one.

The nearest approach to a Hottentot war had taken place in the 1670s. It was smallpox that took the heaviest toll of the Hottentots, especially a shattering epidemic in 1713. After that, as the trekboeren advanced into their territories, the surviving Hottentots lost their land and their cattle, their only means of an independent existence. Many were reduced to a status not unlike serfdom. forming the main labour supply of the trekboer, whose

simple demands they were able to satisfy. Others withdrew beyond the frontiers of white settlement to maintain a more or less Independent existence until the next century.

There was a certain amount of miscegenation between white men and Hottentot women, although intermarriages had been unlawful since 1685. The offspring were usually disowned by their fathers and became known, bluntly, as Bastards; some entered into service, others retreated before the advancing trekboeren, leading trekboer lives themselves.

The small Bushmen were still more primitive than the Hottentots. Before white settlement began they had been driven into the more arid and mountainous parts of South Africa by the Hottentot and African tribes. But, though every man's hand was against them, they contrived to make hit-and-run raids to get sheep and cattle for food, and, if cornered, they were able to kill human beings with their poisoned arrows. As the trekboeren in turn-began to enter Bushman country and to suffer from their raids they organized Boer commandos to hunt them. Toward the end of the 18th century several Bushmen bands made a prolonged stand, operating from mountain fastnesses along the northern fringes of the area of white settlement; but the commandos gradually cleared them out, killing 2,500 Bushmen and capturing 650 in the decade ending in 1795. Those captured were children who were taken into service.

Their experience with slaves, Hottentots and Bushmen had important and enduring effects on the racial attitudes of the Afrikaner people. Most of the nonwhites they came into contact with were at so low a cultural level that the Afrikaners tended to think of themselves as innately superior. Their response was not merely hostile, however, because they all—Capetonians, agriculturalists and trekboeren—came to depend on the use of nonwhite servants.

African Opposition and Economic Discontent.-Before the last quarter of the 18th century the trekboeren had not been seriously impeded by human obstacles. Then, however, they came up against formidable opposition. There were two main groups of African (Bantu-speaking) tribes in southeastern Africa: the Nguni group, who inhabited the well-watered coastal strip between the mountains and the Indian ocean; and the Sotho group, on the plateau. These Africans were more numerous and more advanced than the Hottentots; they were organized into larger tribes and, though they too were primarily pastoralists and hunters, they also practised a rudimentary type of agriculture. While the trekboeren were moving eastward in search of new pastures, some of the Nguni tribes were moving westward toward them from Natal for the same purpose. By 1700 the Xosa tribe in the van had reached the Great Kei river; by 1750, the Keiskama. Boer hunters made contact with the Xosas and bartered ivory and cattle from them. The company vainly tried to prevent such contacts and delay the convergence of the Boers and the Xosas by issuing proclamations prohibiting barter and defining limits beyond which the Boers were not to go. When the governor, J. van Plettenburg, toured the frontier in 1778 he found that the leading Boers were already intermingled with the leading Africans in the vicinity of the Fish river.

A long series of frontier "wars" followed-basically struggles for possession of the land. The first fighting took place in 1779-81 and was sufficient to show the Boers that they faced tough opposition. They therefore appealed to the company for aid; although a landdrost, M. Woeke, was appointed to Graaff-Reinet in 1785, no troops were sent. Woeke's life was soon made intolerable by the Boers, and in 1793 he was superseded by H. C. D. Maynier. Further fighting broke out in that year and again the result was inconclusive. The Boers were disgruntled. For nearly a century they had been left by the company to make their own terms with man and nature, and when at length they had asked for help all they received was a government official who not only failed to defeat the Xosas but also allowed Hottentots to come to his court with complaints against them. In 1795, on the eve of the British conquest of the Cape, they drove out Maynier and declared Graaff-Reinet to be a republic. But the name "republic" was a euphemism: in fact there was anarchy at Graaff-Reinet. Similar events took place at Swellendam, where another "republic"

came into being.

Meanwhile there was trouble in the southwestern part of the colony also. The company had maintained rigorous commercial restrictions, together with a system of government that gave the colonists practically no voice in the determination of policy. The trekboeren had managed to escape most of the effects, but the restrictions had always borne heavily on the agricultural farmer who had produce to sell and on the Cape Town man who lived by trade. In the 1770s, which were lean years, the discontent came to a head with the organization of the Cape Patriots movement, which had some connections with the anti-Orange Patriot party in the Netherlands (see Holland). A petition was drawn up criticizing many of the officials and asking for full burgher representation on the council of policy and the right to trade freely throughout the company's possessions. When it was laid before the directors in Amsterdam, their only response was to dismiss the official who was most roundly criticized—the fiscal, W. Boers.

In 1784 a second petition was taken above the heads of the directors to the states-general of the Netherlands. This time the colonists were given equal representation with officials on the court of justice, but not on the council of policy, and the right to trade with the company's possessions—a right that was nullified by the conditions that were attached. By then, however, the disaffection had subsided because the American War of Independence had brought a large French garrison to Cape Town to help the Dutch to defend it against the British, and the garrison provided an abnormally large market for Cape produce and brisk business for the traders and innkeepers. In the early 1790s bad times came again as the company, trying desperately to stave off bankruptcy, made a final effort to make the colony pay its way. The garrison was reduced, public works were suspended and-the last strawnew taxes were imposed. So, when the British invading force arrived in 1795, it found depression in the west and rebellion in the east. The company had never done much for the white colonists and still less for the nonwhite races.

## SOUTH AFRICA DIVIDES (1795-1870)

The British Conquest .- The Cape was captured by a British naval and military force in Sept. 1795, nominally on behalf of the prince of Orange, who had taken refuge in England from the Dutch republicans. In their struggle with France the British considered it essential not to let the Cape fall into enemy hands, and until the peace of Amiens a hold was kept on it for strategic reasons. The British tried to conciliate the Afrikaners, and by abolishing the restrictions on internal trade and maintaining a large garrison they caused an economic revival in the southwestern part of the colony. On the eastern frontier, on the other hand, the British were no more successful than their predecessors. Although the republics of Swellendam and Graaff-Reinet soon submitted to the new government, anarchy developed in Graaff-Reinet again in 1799, after the arrest of a prominent trekboer, A. van Jaarsveld, on a charge of forgery. Not only the Xosas but also many of the Hottentot servants of the Boers made the most of the opportunity created by the divisions among the whites and caused havoc as far west as Knysna. The British general F. Dundas patched up a truce; but H. C. D. Maynier, appointed resident commissioner of the two eastern districts, failed to satisfy the trekboeren, who rebelled again in 1801, when once again their Hottentot servants joined with Xosa tribesmen to harry the farms over a wide area.

The eastern districts were therefore in turmoil when in 1803 the Cape was handed back under the treaty of Amiens. By this time the company was dead and the Dutch government—the Batavian republic organized by the French in 1795 after their conquest of the country—succeeded to its charge. J. A. de Mist, the commissioner general, and Gen. J. W. Janssens, the governor, tried to restore the morale of the Boers and showed a considerable understanding of the problems of the country; but these men did not stay long enough to consolidate their reforms, for in 1806 the British sent out another force to recapture the Cape from Napoleon's Dutch allies. Janssens lacked the means to put up much resistance and once more the colony passed into the hands of the

British, whose title was confirmed in 1814 as part of the general peace settlement

British Policy, 1806-36 .- Until 1823 British policy was cautious and conservative. Although the governor had autocratic powers, the Afrikaners were used to that. Moreover, their Roman-Dutch law was retained and local administration remained as of old in the hands of landdrosten and heemraden, most of them Afrikaners. These were comparatively prosperous years. The southwestern farmers profited from their access to British markets, where their wine sold well thanks to a substantial tariff preference. Elsewhere, however, extensive pastoral farming remained the norm. Nevertheless, the British did introduce some changes in these years. They appointed more landdrosten. In 1809 they promulgated a code for the treatment of Hottentot servants, who were to be employed only under written contracts registered at a landdrost's office and were given legal protection against ill treatment; on the other hand, they were not to be allowed to leave their employer's farm without a pass signed by the employer. From 1811 onward high court judges, who had previously sat only in Cape Town, made annual circuits to hear cases in all the dis-

Mild though these reforms were, they caused trouble. There was much grumbling in 1812 when the judges on circuit in the easte n districts tried a number of Afrikaners on charges of ill treating their Hottentot servants. Three years later a trekboer, F. C. Bezuidenhout, opened fire on a party that had come to arrest him for repeatedly ignoring his landdrost's orders to answer a similar charge; in the skirmish Bezuidenhout was killed, whereupon his brother proceeded to organize opposition to the government; but the Slagtersnek rebellion soon ended when about 60 rebels were rounded up and tried, and five ringleaders were hanged.

The British also brought superior force to bear against the Xosas on the eastern frontier and thus started the process of the conquest of the African tribes. In 1811 British regular troops and Boer commandos drove the Xosas back to the eastern side of the Fish river, and in 1819 to the eastern side of the Keiskama.

In 1820, 5,000 British settlers were brought out and placed on 100-ac. lots in the Zuurveld, on the western side of the Fish, at a cost of £50,000 to the British government. The 1820 settlers did not, however, form the human barrier that was intended, because the land was not suited to agriculture; within a few years most of them had abandoned their lots and become townsmen in Port Elizabeth and Grahamstown. Others became traders among the African tribes to the east. Those who stayed on the land eventually made good by producing wool for export to England, especially when large farms came onto the market at the time of the Great Trek. This was the first subsidized immigration scheme since the 17th century, and the 1820 settlers were the first white immigrants who were not assimilated by the Afrikaner people.

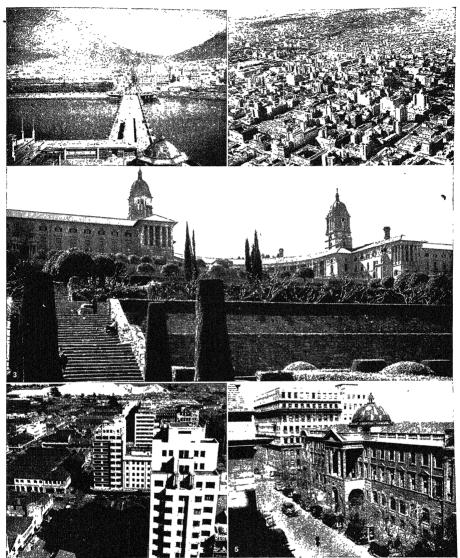
When they had got their bearings the 1820 settlers were dismayed to find that the legal system of the colony was alien to them, the judges were officials without any particular legal training and Lord Charles Somerset, the governor from 1814 to 1826, was an autocrat who made it impossible for them to publish a newspaper. Their agitation for British liberties and institutions evoked some response. The Charter of Justice of 1827 created a supreme court of qualified judges with security of tenure, abolished the heemraden and introduced English rules of procedure and evidence, including the jury system, while it left untouched the Roman-Dutch substance of the law. In 1834 an executive council of officials and a legislative council of officials and nominated nonofficials were established. By that time the freedom of the press had been won, English had become the official language of the courts, and British teachers had been imported to start village schools in which English was the medium of instruction,

During these years South Africa was attracting the attention of the British humanitarians or evangelicals who were striving to free the nonwhite races in the colonies from their legal disabilities. They were supplied with severe criticisms of South African conditions by John Philip. South African superintendent of the London Missionary society, which had established a number of mission stations up and down the country. Philip reached the conclusion that the Hottentot code of 1800, with its stringent pass regulations, was unjust; in 1826 he returned to England to appeal to the government and the British public, and in 1828 the house of commons passed a resolution for the emancipation of the Hottentots. Seeing the trend of affairs, Gen. R. Bourke, the acting governor, had already passed an ordinance, no. 50 of 1828, which abolished the pass system and gave "free persons of colour" complete liberty of movement Meanwhile, with their eyes focussed primarily on the British West Indies, the British government had been insisting on improvements in the treatment of slaves; and in 1833 the reformed parliament passed the emancipation act under which all slaves in the colonies became free after a period of apprenticeship, and £20,000,000 was voted as compensation to their owners. When their period of apprenticeship ended in 1838 the former slaves in the Cape colony stepped into the position of other "free persons of colour." Thereafter the emancipated slaves and Hottentots-the Cape coloured people-became a rural and urban working class in the Cape colony.

Meanwhile the frontier had flared up again. Unrest had developed among the border African tribes for various reasons, including the frequency of military raids on their villages made in reprisal for the theft of stock from white farmers. In 1834 Gen. Sir Benjamin D'Urban arrived as governor with instructions to devise a more equitable policy, but he did nothing about it before. at the end of that year, large bodies of Africans had invaded the colony and done serious damage. D'Urban then reasserted British military superiority and annexed the land up to the Great Kei river, from which most of the Africans were to be expelled (May 1835). But he found it impossible to enforce the expulsion, and the colonial secretary, Lord Glenelg, disapproved; consequently, in 1836 the territory was disannexed and an attempt was made to pacify the tribes by making treaties with their chiefs. By that time, however, the frontier was no longer a clear line of division between the races; white traders and missionaries were working among the tribes to the east of it, and Africans were working on white farms to the west.

Afrikaner Reaction and the Great Trek .-- For several generations the trekboeren had been left more or less to their own devices. Now, under an alien government actuated by liberal ideals which they did not comprehend, many of their institutions were being transformed, they were short of labour, they found it difficult to comply with the regulations and get the compensation money for their slaves, their property was being pilfered by wandering Hottentots, and they suffered further losses during the 1834 African invasion. Behind all these things they saw the hand of missionaries, who, they considered, misrepresented them in England. The reversal of D'Urban's frontier policy of May 1835 was the last straw that made many of them decide to throw off British dust and find a new home where they could, in the words of Piet Retief, their ablest leader, "preserve proper relations between master and servant." Later, Anna Steenkamp recorded that the British had placed their slaves "on an equal footing with Christians, contrary to the laws of God and the natural distinctions of race and religion, so that it was intolerable for any decent Christian to bow down beneath such a yoke; wherefore we withdrew in order thus to preserve our doctrines in purity." Imbued with this spirit the voortrekkers, about 12,000 Afrikaners, men, women and children, left the colony with their sheep, their cattle, their ox wagons and their coloured servants between 1835 and 1843.

In the previous two decades there had been widespread destruction and dislocation among the African tribes, caused by the Zulus under Chaka (Tshaka) and their offshoot, the Matabele, under Moselekatse. By the time of the Great Trek two areas seemed suitable for white settlement-Natal, south of the Tugela river. and the high veld, on either side of the Vaal. But appearances were deceptive, for these two areas were kept denuded by Zulu and Matabele impis or warriors. The first voortrekkers made for the high veld, where they were attacked by the Matabele, whom they routed in 1837. Most of them then decided to settle in Natal. Piet Retief went to the kraal of Dingaan, Chaka's successor, to negotiate for a cession of land; and there, in Feb. 1838, he and

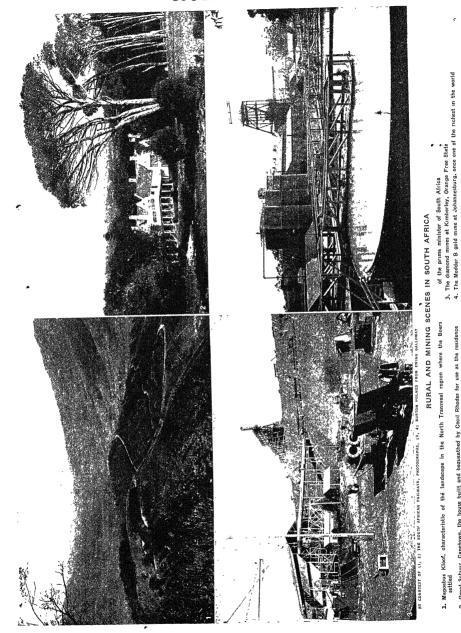


5) ILSE STEINHOFF PIX FROM PHOTOGRAPHS, (1, 3) BURTON HOLMES FROM EWING

## CAPE TOWN, JOHANNESBURG AND PRETORIA

- Cape Town and Table mountain. The mist on the mountain is usually referred to as the "Tablecloth".

  Air view of Johannesburg, the principal commercial city in the Union of South Africa, situated among the rich goldfields on the slope of Witwatersrand
- 3. Administrative buildings at Pretoria, seat of the Union government.
- Cape Town is the seat of the legislature
- 4. Skyscrapers of Johannesburg and the gold mines of Witwatersrans in the distance
- 5. Johannesburg's Bourse, where the price is set for gold mined in the Johannesburg reef  $\quad \bullet$



2. Groot Schuur, Capetown, the house built and bequeathed by Cecil Rhodes for use as the residence

70 Boers and 30 coloured servants were treacherously massacred, while another 300 Boers, mainly women and children, and 200 coloured servants, were killed in upper Natal. On Dec. 16, 1838, however, Andries Pretorius gained a decisive victory over the Zulus at Blood river Most of the voortrekkers then proceeded to stake out farms in Natal. Border troubles ensued, and when in 1840 a commando made a sortie to the south against the kraals of a chief named Ncapaai, his neighbour Faku, who had a treaty with the British, appealed for aid. Previously the British had been undecided what to do about the voortrekkers; the Cape of Good Hope Punishment act of 1836 had made them liable, as British subjects, to trial in British courts for crimes committed south of latitude 25° S., but little had been done to make it effective. Now, however, anxious lest the activities of Natal commandos would lead to disturbances on the Cape frontier, the governor, Sir George Napier, sent a small force to Natal which, after some fighting, became British territory in 1843. Most of the voortrekkers who had settled in Natal then inspanned their oxen again and trekked back to the high veld, north of the Vaal river, where they proved to be immune from further British attention for a generation.

Between the Orange and the Vaal, however, the British were drawn in for a while. There was a racial medley in that region: Griquas (Hottentot-European half-castes), who had been living on the northern side of the Orange river for several decades; Africans, survivors of the Matabele devastation of the high veld, who had been rallied by Moshesh near the Caledon river; and Afrikaners, both trekboeren, who had no particular grudge against the British, and voortrekkers, who had. The British had made a treaty with the West Griqua chief, Andries Waterboer, in 1834, and in 1843 they made treaties with the East Griqua chief, Adam Kok III, and with Moshesh, hoping to use them to keep the peace along the Orange river. Trouble followed when Kok, in accordance with his treaty, tried to hand an Afrikaner over to the Cape authorities for trial under the Punishment act. The Afrikaners took up arms and were dispersed by troops from the Cape at Zwartkoppies (1845). Two years later Gen. Sir Harry Smith became governor of the Cape colony and British high commissioner in South Africa. An optimist, he believed that the South African imbroglio would be pacified if the area of British authority was extended. Accordingly, after overcoming further African resistance on the eastern frontier of the Cape, he annexed the land up to the Great Kei river as the province of British Kaffraria (1847) and the land between the Orange and the Vaal as the Orange River sovereignty (1848). The colonial secretary, Earl Grey, accepted these annexations most grudgingly. Humanitarian influence was waning in Britain and the main concern of the colonial office was to cut down expenses. Therefore, when further fighting broke out on the eastern frontier and similar difficulties developed in the sovereignty with Moshesh, the British government decided to reduce its commitments in South Africa by recognizing the independence of the voortrekkers. This was done in two stages. In 1852 the commissioners W. Hogge and C. M. Owen granted the Transvaalers "the right to manage their own affairs without any interference on the part of the British government" in a convention signed at the Sand river; and in 1854 Sir George Clerk made similar arrangements with the Afrikaners of the Vaal-Orange area at Bloemfontein. South Africa was thus divided into two camps: Afrikaner republics and British colonies.

The Afrikaner Republics.—At the time of the Bloemfontein convention there were about 15,000 white persons engaged in pastoral farming in what then became the Orange Free State. They soon agreed on a rigid constitution, which vested legislative power in an elected volksraad, executive power in an elected president—the voters being the white male adults—and local administration in landdrosten and heemraden on the old Cape model. The East Griqua question was settled in 1860 when Adam Kok sold out his remaining land rights in the Free State and trekked with his people to found a new East Griqualand nearer the coast. The Basuto question was more difficult. The British had abandoned the sovereignty because they shirked the expense of controlling the brisk rivalry between the Afrikaners and the Basuto for the

Caledon river valley, which included some of the best arable land in southern Africa. When fighting broke out in 1858 the Basuto outmanoeuvred the Free Staters, who were glad to accept the mediation of high commissioner Sir George Grey (First Convention of Aliwal North). The Free Staters, conscious of their weakness, then tried to unite with the Transvaal, but were stopped by Grey, who threatened to withdraw the recognition of their independence and advised them to federate with the Cape colony; yet when they expressed a desire to do so, the British government refused. Further fighting started in 1864; this time the Free Staters were more successful and were able to dictate stringent terms, by which Moshesh lost most of his arable land (treaty of Thaba Bosigo, 1866). But the peace was not kept and Moshesh asked to be taken under British protection. This was done in 1868 and the next year the frontier line between the Free State and Basutoland was agreed upon (Second Convention of Aliwal North). The intervention of the British preserved for the Basuto people more land than had been left to them in 1866; but it gave serious offense to the Free Staters, depriving them of the fluits of their victory Thereafter the Free State, its frontiers pacified, and absolved from the responsibility of administering a large number of Africans, became what Tames Bryce once described as a model republic, under the wise leadership of J. H. Brand, president from 1864 to 1888. The Cape colony took over Basutsland in 1871, but later got into difficulties in trying to force the Basuto to forfeit their arms and was glad to hand it back to Great Britain in 1884.

Meanwhile the voortrekkers north of the Vaal river, numbering perhaps 22,000 at the time of the Sand river convention, preserved their old trekboer mode of life. It was not until 1858 that most of them overcame their factional disputes and united to form the South African republic under the presidency of M. W. Pretorius, son of the victor of Blood river. Their constitution, which created institutions similar to those in the Free State, frankly stated that "The people desire to permit no equality between coloured people and the white inhabitants, either in church or state." Otherwise it was an ambiguous document and from the first the volksraad ignored any restraint but that of force. In 1863 there was further factional fighting; and Boer expansion frequently led to disputes with African tribes, the weaker of which were broken up, the remnants becoming squatters and servants under white landowners.

The British Colonies After the Great Trek .-- Not more than a quarter of the Afrikaners had left the Cape colony. Those who remained gradually became accustomed to the more equal order and in the course of time a liberal tradition developed in the colony, in contrast with the illiberal tradition of the republics. When the colony received representative government in 1853, the only franchise qualifications were low economic ones, irrespective of race or colour; but most of the coloured people were unable to qualify and the vast majority of the electorate were white men. By that time the loss of population had been offset by further British immigration; and the decline in wine farming caused by the removal of British tariff preferences was remedied by an increase in the production of wool for export. In British Kaffraria the high commissioner, Sir George Grey, tried to achieve quick results from a policy of civilizing the Africans by encouraging trade, mission schools, medical services and public works, by bringing in white settlers and by using white magistrates to undermine the authority of the chiefs.

There was a reaction in 1857, when the Africans destroyed their own stock and crops in the superstitious belief that the white man would then vanish from the country. The result was catastrophic: thousands starved to death and emaciated survivors poured into the colony in search of work. In 1865 British Kaifaria was incorporated in the Cape colony, Soon afterward the British government urged the colony to assume full responsibility for its own affairs, and in 1872 a responsible government bill was carried and J. C. Molteno became first prime minister.

British immigrants had settled in Natal, so that its white population became predominantly British and crept up to 9,000 in 1856, when representative institutions were established, and to

50,000 in 1803, when responsible government was obtained. Mixed farming was practised inland and sugar was grown in the subtropical coastal belt. One result of the defeat of Dingaan was an influx of Africans from Zululand into Natal, many of them returning to the region from which they had formerly been evicted by Chaka. Thus the African population rose steeply from about 20,000 in 1840 to nearly 500,000 in 1803. They were handled by Theophilus Shepstone, the son of a missionary who had come to South Africa with the 1820 settlers. He placed most of the Africans in a number of reserves or locations, comprising about one-seventh of the total area of the colony. Their tribal laws and customs were maintained and they were able to preserve their tribal economy for another generation, when they began to suffer from land shortage. Africans subject to tribal law were not eligible for the franchise, but in 1864-65 laws were passed which enabled Africans to apply to be exempted from tribal law and, seven years later, for the franchise. However, the regulations were such that few became exempted and hardly any became

The colonists were critical of Shepstone's policy, mainly because it did not make the Africans work for them. The coastal sugar planters, in particular, were short of labour and it was to help them that Natal began to import Indian labourers in 1860. By £666, 6,000 had arrived, and as their five-year contracts expired most of them chose to stay in Natal, as they were entitled to do. In 1872 the Indian government prohibited further immigration because some of the Indians had complained of ill treatment; but the migration was resumed on a large scale, with a heavy government subsidy, in 1874, and by the end of the century the Indians outnumbered the whites.

## THROUGH WAR TO UNION (1870-1910)

Diamonds and Gold.-After 1870 the South African economy was rapidly transformed. Previously South Africa had been an economic backwater, with most of its inhabitants, whites and nonwhites, engaged in inefficient near-subsistence farming; and it had lacked the means to attract the capital and the skilled personnel to create the facilities of a modern country. In 1867 alluvial diamonds were found along the Orange and the Vaal rivers; in 1870 the dry diamond diggings began to be worked at Kimberley; and in 1886 the gold rush to the Witwatersrand began to eclipse all previous gold rushes. The effects were remarkable. The sum of South Africa's imports and exports rose from £49,000,000 in the decade 1861-70 to £128,000,000 in 1871-80, £179,000,000 in 1881-90, £357,000,000 in 1891-1900 and £700,000,000 in 1901-10. In the last of these decades gold (59%) and diamonds (19%) accounted for 78% of South Africa's exports; and by 1910 £121,-000,000 had been invested in the Witwatersrand gold-mining industry and dividends totalling £77,000,000 had been paid by it. Immigration raised the white population from about 328,000 in 1875 to 1,117,000 in 1904. Railway construction was even more striking: in 1870 there were only 69 mi. of railway track in all South Africa; by 1886 there were 1,800 mi. and the line from Cape Town had reached Kimberley; by 1895 there were 3,600 mi. and Johannesburg was connected with five ports—Cape Town, Port Elizabeth, East London, Durban and Lourenço Marques. Thus South Africa at last entered the world economy and acquired a special place in it as the source of about a third of the world's annual supply of gold and more than half its diamonds.

The control of these great industries became concentrated in a few hands. The digger phase on the diamond fields was short-lived; companies forced out individuals and then the companies amalgamated until in 1890 De Beers Consolidated Mines controlled the entire South African diamond industry. The digger phase on the gold fields was even shorter, but there the process of concentration never reached quite the same finality; companies became organized into groups or corporations, and the groups became associated in the chamber of mines for certain purposes only, notably for the recruitment of African labour. Thus great financial power came to be exercised by a few men, above all by Cecil Rhodes (1853-1902), who went to South Africa for his health in 1870 and became the most successful of all the mining

financiers, controlling both De Beers and the Consolidated Gold Fields, one of the strongest gold corporations

The skilled work in the mining industries was done by whites, mainly immigrants at first, who drew high wages. The unskilled work was done by low-pand Africans who came to the mines from all over southern Africa, especially from Portuguese East Africa, to work for limited periods during which they lived in closed compounds, separated from the ordinary life of the community In 1898, for example, the Witwatersrand gold-mining industry employed 9,476 whites at an average monthly wage of £2 95. Previously many Africans at an average monthly wage of £2 95. Previously many Africans had been employed as farm labourers in return for squatting rights or low wages. Now the agrarian pattern of race relationships was being adapted to the mining industries, which, having a voracious appetite for labour, were giving a distinct impetus to the long-drawn-out process of the disintegration of tribalism.

Annexation of the Diamond Fields .- The discovery of diamonds led to a serious controversy. The Transvaal claimed part of the diamondiferous area and the Orange Free State claimed the rest of it, while David Arnot, a white attorney, claimed it all on behalf of his client Nicholas Waterboer, the chief of the West Griquas. Arnot managed to persuade the British colonial office that the Griquas had the best case; therefore when a new high commissioner, Sir Henry Barkly, reached South Africa in Jan. 1871 he had instructions to take a strong line. Barkly persuaded M. W. Pretorius, the Transvaal president, to submit his case to arbitration by R. W. Keate, the governor of Natal. When Keate discovered that Pretorius had unwittingly placed great reliance on a forged document, he decided against him. Although this award did not directly affect the Free State claims, which were the strongest, Barkly, failing to understand their merits, annexed to the crown the entire area claimed for Waterboer in the same month (Oct. 1871). Five years later a land court decision exposed the fallacies in Waterboer's claim to sovereignty over the diamond fields; whereupon J. H. Brand, the Free State president. went to London and exacted £90,000 compensation from the imperial government. In 1880 Griqualand West was incorporated in the Cape colony.

Annexation and Retrocession of the Transvaal.—When in 1874 Benjamin Disraeli formed a ministry, Lord Carnarvon, his colonial secretary, hoped that the South African states and colonies might unite in a self-governing federation under the British crown. The following year he summoned a conference to discuss the project in London, but it was a failure: the Free State, smarting under the recent annexations, would have nothing to do with the project; nor would the Cape, whose ministers' dignity had been ruffled by the conduct of the historian J. A. Froude, who had toured the colony on behalf of Carnarvon urging federation. Federation from the south having failed, Carnarvon turned his attention to the north and found that the South African republic was ripe for plucking.

That republic, unlike the Free State, had never acquired stability. Pretorius was bundled out of the presidency after the annexation of Griqualand West, and the Transvaalers chose as his successor the Rev. T. F. Burgers, a Cape colonial predikant. But in Burgers they had more than they had reckoned for; he was critical of Transvaal backwardness and proposed to remedy it by social, educational and religious reforms. He also borrowed money, intending to build a railway to Delagoa bay to free the Transvaal from its dependence upon British trade routes; but not a single track of the railway was laid, whereas the loan strained the meagre resources of the republic and alarmed the Cape and Natal merchants whose interests it threatened. When in 1876 Burgers personally waged an unsuccessful campaign against the Bapedi tribe in the northern Transvaal, he was totally discredited. The Afrikaners, including Paul Kruger, were plotting against him, and the traders were conniving with the Cape and Natal mer-chants to bring in the British. Carnarvon heard their cries and commissioned the newly knighted Theophilus Shepstone to annex the Transvaal. Entering the republic in Jan. 1877 with 25 police and a staff of seven Shepstone annexed it in April in a proclamation which promised "the fullest legislative privileges compatible" with the circumstances of the country and the intelligence of the people"

But British rule in the Transvaal was neither efficient nor tactful and the elected legislature did not materialize. Then the Zulu war revealed the weakness of British arms: the Zulus, their martial spirit revived by Cetywayo, routed a large British force at Isandhlwana in 1879 before they were vanquished in the following year. By that time the Transvaalers, who had passively acquiesced in the annexation, were moving toward open rebellion under the leadership of Paul Kruger, M. W. Pretorius and P. J. Joubert, and in 1881 they, too, wiped out a British force at Ma-W E Gladstone's ministry, which assumed office in 1880 but failed to reform the Transvaal administration in time to avert the rebellion, now gave the Transvaalers a qualified independence (Pretoria convention, 1881). Three years later they allowed the republic full internal autonomy, while maintaining British control over its relations with foreign states, other than the Free State (London convention, 1884). Carnarvon's project had completely miscarried, and his permissive act for the unification of South Africa (1877) was stillborn.

The Rhodes-Hofmeyr Alliance.-In the Cape, which remained the most civilized of the South African states, the advent of responsible government and the series of British annexations prompted a group of Afrikaners to form a political organization, the Afrikaner Bond, in 1879. At first the Bond's program was crudely sectional, but three years later J. H. Hofmeyr (1845-1909) gained control and turned it in the direction of Anglo-Afrikaner co-operation, with a British South African federation, which should include the republics, as the ultimate goal. Meanwhile Cecil Rhodes had entered the Cape parliament and, as his vision of British expansion in Africa was reconcilable with Hofmeyr's, he was able to form a ministry with Bond support in 1890. Moreover, although the Cape had mishandled Basutoland, a more promising native policy was developing in the Transkeian territories up to the Natal border, which were gradually annexed between 1872 and 1894. Nearly all the land was left in African possession. African tribal law was recognized, and a corps of able and sympathetic administrators was created. But these annexations raised serious political questions because they caused the African population of the colony to increase threefold and far outstrip the white population. The Cape parliament accordingly granted the territories a modicum of political representation, while making it clear that occupation of land on tribal or communal tenure did not constitute a qualification for the franchise (1887), raised the economic qualifications slightly and added a simple educational test (1892) and encouraged the Africans to adopt individual land tenure and to elect local administrative councils (1894). The native policy of the Cape was thus based on the principle that the Africans should gradually change from the tribal to the western mode of life, and that those who had made the change should have the same civil and political rights as white men. By 1895, therefore, the Rhodes-Hofmeyr alliance was bidding fair to heal Anglo-Afrikaner quarrels and to maintain a promising basis for relations between the whites and the nonwhites in the Cape colony.

British Clash With the Transvaal .- Meanwhile the scramble for Africa was taking place, and in 1884 Germany took over South-West Africa and Transvaalers began to encroach westward toward it, setting up the republics of Stellaland and Goshen. This expansion, which seemed likely to cut off the British from access to central Africa via the Cape, was checked, largely on the insistence of Cecil Rhodes, in 1885, when Great Britain after a display of force proclaimed a protectorate over northern Bechuanaland and annexed southern Bechuanaland as a crown colony. Transvaal efforts to keep their north clear of the British were also foiled by Rhodes, who secured a prospecting concession from the Matabele chief Lobengula in 1888, obtained a royal charter incorporating the British South Africa company to exploit the concession in 1889, and dispatched a pioneer expedition to occupy what became known as Rhodesia in 1890 (see RHODESIA: History). Finally, the Transvaalers tried to push eastward to get

a port on the Indian ocean, but, although they incorporated fresh territory including Swaziland, they did not reach the coast, as Britain annexed Zululand in 1887, and Tongaland, the last gap, in 1895. The Afrikaner republics were thus encircled by the colonies of Great Britain and its oldest ally, Portugal—hemmed in a kraal, as Paul Kruger complained Southern Bechuanaland was taken in by the Cape colony in 1895; Zululand and Tongaland by Natal in 1897; but northern Bechuanaland remained a British protectorate like Basutoland.

In 1883 Paul Kruger (1825-1904) was elected president of the Transvaal. His character had been moulded in the hard school of the Great Trek and of commando fighting against Afrikaner factions and African tribes; and recently he had led the opposition to President Burgers and the British. His policy was to regain complete independence for the republic and to preserve Afrikaner control of it. In 1885 he was constrained to suggest a customs union with the Cape, whose government rejected the offer. Soon afterward his financial difficulties were solved by the gold discoveries, and he proceeded to use the mining industry as a milch cow, imposing heavy taxation and granting monopolies of essential materials, such as dynamite. Nevertheless, the growth of such an industry in the heart of his republic posed serious problems. The Afrikaners became outnumbered by the newcomers who poured in from all parts of the world, most of them Pritish subjects. To give these Uitlanders an effective vote seemed like suicide; to withhold such a vote was bound to cause trouble with the British. Kruger never hesitated. he progressively raised the franchise qualifications until by 1894 no Uitlander could vote in presidential elections, and only those who were 40 years old and had lived 14 years in the Transvaal, during 12 of which they had been subject to an oath of allegiance, could vote in volksraad elections. In short, on the one hand the government was corrupt and fleeced the Uitlanders and denied them political rights; on the other hand the Uitlanders continued to swarm into the republic where many of them prospered exceedingly. Such a situation required patience. Although Kruger was re-elected for a third term in 1893, his majority over the more moderate Jouhert was small and a change seemed likely in 1898.

But Rhodes was not patient. Finding that Kruger stood between him and a British South African federation, he planned to overthrow him. Kruger nearly played into Rhodes's hands in 1895 when, contrary to the London convention, he tried to injure Cape trade with the Transvaal and the Cape railways that were competing with the Delagoa bay line by making the rates over the Transvaal sector of the Cape line prohibitive and by closing the Vaal drifts to prevent the carriage of goods by wagon. But he gave way when the colonial secretary, Joseph Chamberlain, agreed to support the Cape ministry's protests, by force if necessary.

The Jameson Raid.—Rhodes then pushed ahead with his conspiracy: the Uitlanders were to rise, an armed force under L. S. Jameson was to come to their assistance, and the high commissioner was to hurry to Pretoria to "restore order." It is probable that Chamberlain knew of Rhodes's plans when he provided suitable jumping-off place for Jameson's force by ceding to the British South Africa company a strip of land along the Transvaal border of the Bechuanaland protectorate, but that he later withdrew his support when he learned that the Uitlander rising would not take place to give the invasion an air of respectability. Therefore, when Jameson, contrary to Rhodes's last-minute instructions rode into the Transvaal from Pitsani near Mafeking on Dec. 29, 1895, he was disowned by the colonial secretary and the high commissioner. Four days later he surrendered to Transvaal commandos at Doornkop.

The Outbreak of the South African War.—The raid fiasco cleared the decks for the South African War. Rhodes had to resign the premiership of the Cape colony, where, in 1898, W. P. Schreiner became head of a ministry which relied upon the support of the Bondsmen, who had been made deeply suspicious of British designs. In the Orange Free State, which had opposed, the Transvaal over the drifts crisis, M. T. Steyn was elected president and formed a military alliance with the Transvaal. While Steyn

and the Bond were not uncritical of the Kruger regime, Kruger's Anglophobia seemed to have been vindicated in the Transvaal, where he won the 1898 presidential election by a large majority. In England, on the other hand, a parliamentary committee failed to probe Chamberlain's dealings with the raiders, the kaiser's telegram congratulating Kruger turned Jameson and Rhodes into popular heroes, and the press paid much attention to *Uitlander* grievances.

As the tension mounted, Chamberlain, taking the high ground of British paramountcy in South Africa, claimed to be competent not merely to control the foreign relations of the Transvaal (a right expressly granted by the London convention) but also to intervene on behalf of the Uitlanders (which was not). Once the principle of intervention was asserted, there were grounds enough for exercising it. The tendency of the volksraad to give sweeping powers to the president was exemplified in the judges' crisis: in 1807 Chief Justice J. G. Kotzé delivered a judgment which meant that the greater part of the laws of the Transvaal had been enacted unconstitutionally and were null and void, whereupon the volksraad deprived the courts of the testing power and gave Kruger the power to dismiss any judge who disagreed; and the next year Kruger dismissed Kotzé. In 1808 an Anglo-German agreement removed the likelihood of German intervention in the event of a South African war, and Chamberlain and the high commissioner, Sir Alfred Milner, proceeded to apply the screw. The central issue was the Transvaal franchise. In June 1899, in conference at Bloemfontein, Milner proposed a simple five years' franchise, Kruger refused and the negotiations collapsed. The last chance of peace was lost in August when J. C. Smuts (1870-1950), Kruger's young state attorney, offered a five years' franchise and Chamberlain rejected the conditions which were attached to the offer. Milner had long since made up his mind that war was "inevitable," and in September Chamberlain arranged for 10,000 British troops to be sent to augment the meagre British forces in South Africa. The republicans, who had been arming furiously for several years, replied by issuing an ultimatum which expired on Oct. 12, 1899. For events of the war, see South African War.

Reconstruction and Union.-After the treaty of Vereeniging of May 31, 1902, Milner, high commissioner and governor of the crown colonies-the Transvaal and the Orange River colonyconcentrated on their material reconstruction from the ravages of war. The gold mines resumed large-scale operations, and the Afrikaners were returned to their land from the prison and concentration camps and supplied with food, stock, seed and implements, no less than £10,000,000 being spent by Great Britain on their rehabilitation. Milner also prepared the ground for political union by bringing all the colonies into a South African customs union and by amalgamating the railways of the Transvaal and the Orange River colony. All this work was well done by Milner and his band of exceptionally able young men, who were dubbed the "kindergarten." But the opportunity was not used to emancipate the nonwhite inhabitants of the crown colonies from their legal disabilities, which remained much as they had been during the republican regime. Nor did Milner gain the confidence of the Afrikaners: they disliked him as "the man who made the war," who openly supported the anti-Bond agitation for the suspension of the Cape constitution in 1902, who imposed an English educational system on the crown colonies and who was responsible for bringing Chinese labourers to the Witwatersrand gold mines in 1904. For the importation of Chinese labourers there were, indeed, strong economic reasons, because the supply of African mine labour had temporarily fallen off; but the decision played a large part in the rout of the British Unionist party at the polls in 1005-06.

The change of government in Britain was followed by a radical change in the distribution of power in South Africa. Sir Henry Campbell-Bannerman's Liberal ministry, anxious to make amends to the Afrikaners for a war which had been brought about by their predecessors, decided to give the new colonies responsible government—on an exclusively white franchise, as had been promised at Vereniging. Consequently in March 1907 Louis Botha (1862–1919), former commandant general of the forces of the

South African republic, became premier of the Transvaal, with J. C. Smuts as his right-hand man, and in Dec. 1907 A. Fischer became premier of the Orange River colony. The swing of the pendulum was completed in Feb. 1908, when J. X. Merriman's South African party, consisting largely of the Afrikaner Bond, ousted Jameson's Progressives from office in the Cape colony

The high commissioner, Lord Selborne, who succeeded Milner in 1905, argued the case for union in a memorandum published in July 1907, and, once in power, the three Afrikaner parties took it up enthusiastically, with the support of their oppositions. White public opinion in South Africa moved steadtly in favour of union, partly out of an idealistic feeling that it was best to bury the hatchet and make a new start on a basis of white equality, and partly because the African rebellion in Natal in 1906 led many to think union essential for white security; some, moreover, saw in union the best way of guarding against any further British interference in South African affairs. There were also compelling economic reasons for union: the four colonies were interdependent and yet, without political union, their material interests were odivergent that the customs union seemed bound to collapse.

Accordingly a national convention, comprising 30 members appointed by the four colonial parliaments and 3 nonvoting members from Rhodesia, met in 1908 and 1909 under the chairmanship of Sir Henry de Villiers, chief justice of the Cape. A constitution was drafted and unanimously approved by the convenuon; it was then carried with few dissentients in the parliaments of the Cape colony, the Transvaal and the Orange River colony, and by a large majority of the electorate in a referendum in Natal. Finally, in Aug. 1909, it was enacted by the British parliament, substantially as it had been submitted to the British government by delegates from South Africa. The South Africa act came into force on May 31, 1910, and the four colonies became the provinces of the Union of South Africa.

The constitution is described elsewhere in this article (see Constitution, below), but a few points require comment here. The convention, except for the Natal members, wanted a close union and complete flexibility, and they were largely successful; the principal feature of the South African constitution was the grant of power to parliament to legislate on practically every subject by simple majorities in each house. Nevertheless, on two subjects they did not grant parliament such extensive powers. First, the Afrikaner members wanted special protection for the section which gave Dutch (to which Afrikaans was added in 1925) equal status with English as an official language of the Union. Second, the convention could not agree on a uniform franchise for the Union, the Cape delegates favouring a colour-blind franchise and the others a rigid colour bar. Eventually a compromise was reached whereby the franchise qualifications were to remain as they were in each province and the established franchise rights of the Cape nonwhites were specially protected. Accordingly, the sections on language equality and the Cape nonwhite franchise were to be amended only with the approval of two-thirds of the members of both houses of parliament, assembled in joint session. The act also made it possible for Rhodesia to join the union on terms to be approved by the privy council and for the protectorates of Basutoland, Bechuanaland and Swaziland to join on terms laid down in a schedule, but only with the consent of the imperial government, which had special commitments to their African inhabitants.

# THE UNION OF SOUTH AFRICA

The Race Issue.—The dominating factor in the history of the Union of South Africa has been the exceptionally complex character of the population. In 1910 there were nearly 6,000,000 inhabitants, of whom, 21½% were whites, 67% Africans, 9% coloured people and 2½% Asiatics. After that time, while the total population more than doubled, the racial proportions remained about the same. The whites included an Afrikaner majority, who were mainly rural, and a British minority, who were mainly urban, Between them they owned most of the land and the capital, did most of the skilled work and possessed 93%, of the votes. The Africans were still predominantly tribal rather than western in

culture, but, as a result of their conquest and of white missionary activity and economic enterprise, there was already a distinct frend toward the disintegration of tribalism. Although most Africans still had homes of sorts in the reserves, those were scattered lands which amounted to only one-fourteenth of the area of the country and by no means provided them all with a livelihood; consequently, many Africans went out to earn wages on white farms and in the towns. Moreover about 1,000,000 Africans had long been established as squatters on white farms and a few were already completely urbanized. The Africans were subject to pass laws which restricted their movements outside the reserves, to Masters and Servants laws which made breach of contract a criminal offense in many types of employment, to special taxation and to other special laws. These laws varied from province to province, and in the Cape there were about 7,000 African voters who were exempted from some of them. coloured people were western in culture. Most of them lived in the Cape province, where their status was that of the whites, and about 14,000 were voters, whereas in the other provinces they were subject to discrimination. The Asiatics were mainly the product of the indentured Indian immigration scheme to Natal, where they outnumbered the whites and were subject to special laws, including a £3 tax. They were excluded from the Orange Free State, but about 11,000 had settled in the Transvaal, where, too, they came under special laws.

The policies of South African governments differed on many important issues; but all, being responsible to a predominantly white electorate, stood more or less explicitly for "the maintenance of white supremacy," a task which became increasingly difficult as a result of the rapid tempo of economic development in the Union and the change in the balance of power and the climate of public opinion elsewhere.

The Botha-Smuts Regime, 1910-24.—In 1910 the Afrikaner parties in the colonies merged to form the South African party, which, under Louis Botha and J. C. Smuts, governed the country until 1924. Botha and Smuts had been zealous fighters for republican independence so long as there was a chance of success, but they were realistic enough to accept the inevitable at Vereeniging and imaginative enough to see great prospects for South Africa when the hot mood of British imperialism had spent itself. By 1910 they conceived of the coalescing of the British and Afrikaner elements into a white South African nation which would freely cooperate with the British Commonwealth in peace and in war. The ideal went too far, however, for the more conservative Afrikaners, who were concerned with preserving their group identity, and not far enough for the more self-conscious nonwhites, for whom it implied a permanently inferior status.

The government wished to keep most of the Africans in the reserves to prevent the whites from being swamped, and to use African manpower as the unskilled base of all forms of economic enterprise-objectives which involved certain contradictions. As the Africans became more accustomed to a money economy, some of them were liable, unless checked by law, to compete successfully with the less efficient whites. This was already happening in the gold-mining industry, and laws were passed in 1911 to preserve the racial hierarchy in that industry. Such competition was also happening in some rural areas, where Africans were pooling their resources to buy more land; a Natives Land act was passed in 1913 to limit the areas within which such purchases could be made. Neither of these acts was wholly effective. In 1916 a commission reported that if the policy of territorial segregation was to be carried out the reserves should be substantially increased in size, but little was done about it because the whites were not prepared to make the necessary sacrifices.

The Asiatic question had reached a more crucial phase. Already before union M. K. Gandhi (1869–1948) had organized passive resistance against the Transvaal government, and after union he resumed the struggle against the £3 tax in Natal. As a result the Indian government stopped the importation of indentured Indian labourers in 1911 and the £3 tax was removed in 1914. By that time the pattern of later disputes had developed: the Union government regarded the Indians as temporary visitors and tried to

persuade them to return to India; and most of the Indians regarded themselves as permanent residents and demanded full rights of citizenship.

The conservative Afrikaners had found their leader in J B M. Hertzog (1866-1942). Although he had joined the Botha cabinet in 1910, Hertzog regarded his colleagues' policy as liable to cause the Anglicization of the Afrikaner people, and he publicly advocated a different, "twin-stream" policy, which led to his exclusion from a reconstituted cabinet in 1912 and to the foundation of the Nationalist party. When in 1014 the government unhesitatingly took the part of Great Britain in World War I and parliament voted funds for the conquest of German South-West Africa, a number of former republican generals, some of whom held appointments in the South African defense force, came out in rebellion to avenge Vereeniging. After mastering the rebellion, Botha took command of the South-West African expedition and forced the Germans to capitulate on July 9, 1915. South African volunteer contingents also fought in East Africa and on the western front in Europe, where they distinguished themselves at Delville Wood (July 1916), and many individuals joined British units. Smuts, after serving as commander in chief in East Africa, did notable work in the British war cabinet. In July 1919 he and Botha, on behalf of South Africa, signed the treaty of Versailles and the covenant of the League of Nations, under which South-West Africa became a Union mandate. Back in South Africa Botha died before August was out, and Smuts, succeeding to the premiership, faced the discontents caused by thwarted Afrikaner nationalism, a steep rise in the cost of living and industrial

As early as 1907 Smuts had intervened on the side of the employers in a strike of white workers on the Witwatersrand, and in 1914 he had ended another strike by declaring martial law and illegally deporting nine strike leaders. After the war there was a serious crisis. The Chamber of Mines, faced with rising costs and a fall in the price of gold, decided to organize the industry more rationally by using Africans for semiskilled work. There was a violent reaction by white labour, which Smuts suppressed at a cost of 230 lives, with the result that, although the threat to relax the colour bar was not carried out, the Labour party, representing the aggrieved white workers, made an electoral pact with the Nationalists. In the hope of redressing the political balance, Smuts wooed the Southern Rhodesian electorate to accept incorporation in the Union, but when a referendum was held on the issue in 1922 they preferred to remain separate. Two years later the South African party was heavily defeated at the polls and Hertzog became premier of a Nationalist-Labour coalition.

and herizog's Nationalist Policy, 1924—33.—Hertzog's Nationalist Policy, 1924—33.—Hertzog's Nationalist Policy, 1924—33.—Hertzog's main objectives were to complete the emancipation of South Africa from imperial control and to provide greater protection for the whites from the Africans and for the Afrikaners from the British. He played a notable part in the events leading to the Balfour Declaration (1926) and the Statute of Westminster (1931), which gave statutory definition to the established convention that the British government could not exert authority over a dominion. South Africa's sovereign status was also asserted by the adoption, after a long and bitter controversy, of a distinctive national flag (1927), by the appointment of ambassadors to Rome, Washington and The Hague (1929), and by the separation of the office of governor general, the head of the South African government, from that of high commissioner, the representative of the British government in South Africa (1931).

Economic nationalism was fostered by the foundation of a state-controlled iron and steel works at Pretoria, by increased protection for agriculture and industry, by a reduction in imperial preferences and by a commercial treaty with Germany. White supremacy was bolstered by the provision of sheltered employment for "poor whites" in state enterprises, by a Mines and Works Amendment act (1926), which was more effective than its predecessor in shutting Africans out from skilled mining trades, by a Native Administration act (1927) and a Riotous Assemblies act (1930), which gave the executive wide powers over individuals, and by franchise acts (1930–31), which extended the vote to all

white men and women, while they left the Cape nonwhite vote as before, restricted to men who possessed property and educational qualifications. Hertzog's legislative program was still incomplete when the 1930 world depression undermined the prosperity of the country and the popularity of the government, which continued to cling to the gold standard after Great Britain had abandoned it in 1931. After the government, yielding to pressure from some of its own supporters, left the gold standard in Dec. 1932, there was a fairly rapid economic recovery, but political confusion continued until, in 1933, Hertzog and Smuts formed a coalition government which secured overwhelming support from the electorate.

The Hertzog-Smuts Regime, 1933-39 .- The coalition was based on a great deal of common ground between Hertzog and Smuts. Hertzog no longer feared political co-operation with Smuts's British supporters, believing that the Afrikaners had been raised to the point where they were immune from the danger of Anglicization, and Smuts was reconciled to most of Hertzog's achievements and was prepared to collaborate with him in rounding them off. Consequently, in 1934 the two major parties fused to form the United party; but Hertzog failed to carry with him a small group of Afrikaner irreconcilables, led by D F. Malan, who formed the Purified Nationalist party, while C. F. Stallard at the other extreme dissociated himself from Smuts and formed the Dominion party. By then the constitutional settlement had been completed by the Status act and the Seals act (1934) which secured, so far as words could do, that South Africa was master in its own house. The government then proceeded to complete Hertzog's segregation legislation. A Representation of Natives act (1936) removed the Cape province African voters from the common roll and gave them the right to elect three white members to represent them in the lower house, gave the Africans throughout the Union the right to elect four white senators, and created a Natives' Representative council with advisory powers. A Native Trust and Land act (1936) provided for a considerable increase in the size of the reserves. A Native Laws Amendment act (1937) authorized the executive to prevent more Africans from entering the towns and to compel municipalities to segregate African from white residents. It was Hertzog's hope that the enlarged reserves would become capable of maintaining almost all the African people, so that those who worked for whites could be regarded as temporary visitors from the reserves. But it is notable that he saw the need for consultation with an African council, and that he did not try to discriminate against the coloured people. Moreover, his government expanded the social services not only for the whites but also for the nonwhites; there was, for example, a considerable increase in government grants for education. Nevertheless, Africans, Indians and coloured people were becoming disturbed by the great contrast between their living standards and those of the whites and by an accumulation of laws which caused 500,000 Africans to be convicted of statutory and municipal offenses in a year and many more to come into unpleasant contact with a police force recruited from among the poorer Afrikaners, who were imbued with the strongest race prejudices. As tension began to mount the Nationalists claimed that "white South Africa" would not be safe unless the restrictions on Africans were increased and the coloured people were also segregated from the whites. Though Hertzog strongly disagreed, the Nationalists were able to profit from the celebrations held to mark the centenary of the Great Trek in 1938, when they appealed to all Afrikaners to remain true to the principles of the voortrekkers and of Paul Kruger, placing special emphasis on their race attitudes.

World War II.—The outbreak of World War II caused a crisis in South Africa. Although Hertzog and Smuts had co-operated successfully on many issues, they differed widely on foreign affairs. Hertzog took an indulgent view of Adolf Hitler's, reich, believed that its expansion was no concern of South Africa, and moved in the house of assembly, on Sept. 4, 1939, that South Africa should remain neutral. Smuts, keenly aware of the wider implications of Naziism, maintained that it was the interest and the duty of South Africa to support Great Britain, and he won

the crucial division by 80 votes to 67. On Sept. 5 Smuts formed a ministry with the support of the Labour party, the Dominion party and the majority of the United party, and war was declared on Germany.

The Smuts government concentrated its energies on the war. About 200,000 white men (most of them Afrikaners) and 125,000 nonwhites (mainly Africans and coloured men) joined the forces, and about half of them served with distinction in the Ethiopian, Mediterranean and Madagascan theatres. The nonwhites were not allowed to bear arms but were distributed among the combatant units, for whom they performed vital work as stretcherbearers, labourers, etc. In South Africa industry was efficiently switched to the production of munitions and clothing for military purposes. Smuts himself remained in close contact with Winston Churchill and watched carefully the strategy of the war, often leaving his able lieutenant, J. H. Hofmeyr, Jr. (1894-1948), to carry a lion's share of the burden of administration. South Africa's achievements were impressive, considering the strength of the opposition to the war. Fortunately for the government, the opposition splintered into fragments during the most critical period: J. F. van Rensburg's Ossewabrandwag and Oswald Pirow's New Order, accepting the racial doctrines of the Nazis and their contempt for parliamentary government, patently hoped to profit from a Nazi victory; the Malanites expounded the ideal of an Afrikaner republic in which, as in Kruger's republic, the British would not necessarily have political rights; while the Hertzogites stood firm by their principle of equality between the whites. In the first flush of his disappointment, indeed, Hertzog led his defeated minority from the United party to join hands with Malan and form the Reunited Nationalist party, but the reunion was not a happy one and before the end of 1940 Hertzog had been driven out for his tenderness toward the British. His colleague, N. C. Havenga, subsequently founded the Afrikaner party to maintain his ideals. The general election of 1943 was a victory for Smuts in that his prowar coalition secured a majority of 67 seats in a lower house of 153; but it was also in a sense a victory for Malan's Nationalists, who won all the 43 opposition seats. Thereafter, as the prospect of a Nazi victory faded, the Nationalists consolidated their position as the political instrument of selfconscious Afrikanerdom, absorbing elements from the Ossewabrandwag, the New Order and the Afrikaner party, and drawing support from a variety of cultural and economic organizations, including the Broederbond, a secret group of Afrikaner elite.

As the war drew to a close Smuts drafted the preamble to the United Nations charter signed at San Francisco, Calif., in 1945 and returned to mould postwar South Africa along the lines of a generous demobilization scheme, an expansion in the social services for all races, a planned development of agricultural, mineral and industrial resources, and large-scale white immigration.

The Industrial Revolution in South Africa.-Subsequent events can be understood only in relation to the fact that South Africa was experiencing an industrial revolution as intense as the British industrial revolution of the early 19th century, with the added complication of racial differences between the unskilled workers on the one hand and the skilled workers, the capitalists and the majority of the electorate on the other. The way had already been paved by the rise of the mining industries and by the foundation of many manufacturing industries during World War I and the 1930s; the rate of expansion increased during and after World War II. In the 15 years between 1936 and 1951 the total population increased by 32%. In the 13 years between 1938 and 1951 the output of coal, pig iron, iron ore, copper, electricity and many other commodities doubled. In the same period the revenue and the value of imports and exports quadrupled, while the net national income trebled. Even when a factor of about 10/18 is applied for the change in the value of money, these increases are exceptional.

The gold-mining industry continued to play a central role in the Union's economy, and fears that the supply would soon become exhausted were removed by the opening up of new mines in the Orange Free State, where production began in 1951. Nevertheless, gold production declined after 1941, because a fall in the

value of gold made it unprofitable to mine low-grade ores. Moreover, the expansion of the manufacturing industries diminished the relative importance of the gold industry, which produced only 10% of the national income and 20% of the exports in 1951. The mining industries continued to be organized on racial lines and the manufacturing industries adopted a similar basis; therefore skilled work remained virtually a white monopoly, most of the unskilled work being performed by nonwhites. An unusually wide gap continued to exist between the wage rates of the two

As a result of this expansion nearly three-quarters of the white population were townsmen in the early 1950s, the "poor whites' were absorbed by industry, and the earlier economic distinctions between the Afrikaner and the British inhabitants became blurred. Industry also attracted a vast number of nonwhites: more than 2,000,000 Africans-about a quarter of the total African population-lived in the towns. Into some of these towns the influx was so rapid that housing and other amenities were not adequate. But in spite of low wages and squalid living conditions, the urban Africans earned incomparably higher incomes than the rural Afri-

Malan's Nationalist Party Policy, 1948-53.—As the 1948 election approached, disturbing facts were becoming known in South Africa. For example, although the reserves had been enlarged under the 1936 act, the 1946 census revealed that only 40% of the African population lived there, and in 1948 a commission revealed the extent to which Africans were becoming permanent inhabitants of the towns. These facts did not square with the argument that the Africans had adequate homes in the reserves and could therefore be treated as inferiors elsewhere. Moreover, the growing restlessness of the urban Africans raised the question whether "white supremacy," which had developed in the primitive pastoral economy of the 18th century, could be maintained in the industrial economy of mid-20th century

The Smuts government tried to deal with practical grievances in a conciliatory spirit, while Hofmeyr went further than his colleagues on occasion, feeling toward a policy that would be acceptable to all races. But the Asiatics were protesting vigorously against legislation which prevented them from buying or occupying fresh premises in Durban, and the Indian government attacked South Africa at the United Nations general assembly. Consequently when in 1946 Smuts tried to persuade the U.N. general assembly to allow the Union to incorporate South-West Africa, he met with a rebuff, and the assembly passed the first of a series of resolutions condemning South Africa's racial policies.

The Nationalist leaders, steeped in the voortrekker tradition, expressed horror at the "liberalism" of the United party, declared it would cause the "suicide" of white South Africa, and propounded a theory of apartheid, according to which the races should be separated and each allowed to "develop along its own lines in its own area." Their propaganda, skilfully presented, served its purpose: in May 1948 Malan, with the assistance of N. C. Havenga's small Afrikaner party, was able to form a government which had a majority of five in the lower house.

A spate of legislation followed. Mixed marriages were made illegal; every person was to be classified by race in a population register; South Africa was to be gradually divided into an infinite number of racial zones; African tribalism was to be strengthened; and the Natives' Representative council was abolished. cretionary powers of the executive, already considerable, were increased by the sweeping Suppression of Communism and other acts. A Citizenship act extended the period of residence of British immigrants before they could apply for citizenship and the franchise, and a South-West African Affairs Amendment act gave the whites of that territory six seats in the lower house, which they promptly filled with Nationalists. But a further act to remove the 50,000 coloured voters from the common roll in the Cape province and give them, like the Africans, the right to elect three whites to represent them in the lower house was declared invalid by the supreme court, as being in conflict with the entrenched sections of the South Africa act, since it had not been passed by a two-thirds majority of the members of both houses in joint session; and although under a further act the Nationalist members of parliament, sitting as a "high court," reversed that decision, the supreme court subsequently held that the High Court of Parliament act was also invalid, on the same grounds.

While most of the white people in South Africa supported the objective of much of this legislation, the maintenance of "white supremacy," many disapproved of Nationalist methods and, in particular, of the attempt to override the entrenched sections of the constitution. The Torch Commando-a picturesque but misleading name for a thoroughly constitutional organization-was founded to invigorate the opposition to undemocratic methods of government; and among the British in Natal there was talk of secession from the Union. The United party, led by J. G. N. Strauss after the death of Smuts in 1950, was cautious and divided on the fundamental colour issue. But there was a growing number of white South Africans, Afrikaners as well as British, who realized that the time had long since passed when the races could be genuinely separated, that it was futile and dangerous to try to tighten the screws of the caste system, and that the only hope for harmony and prosperity lay in casting aside race prejudice and dogma and attempting the task of making democracy work, though that entailed the relaxation of the industrial colour bar and the admission of civilized nonwhites to the franchise. More significant, perhaps, was the widening of the gulf between the whited and the nonwhites and the forging of closer links between the leaders of the African, coloured and Asiatic communities. Although an all-embracing antiwhite front was not yet completed, headway was being made in that direction during 1952, when many hundreds of persons deliberately went to jail for "passive resistance to unjust laws." A different type of evidence of the intensity of racial feelings was provided by violent riots by Africans against Indians in Durban in 1949 (with a death toll of 142) and against whites in Kimberley, East London and Port Elizabeth in 1952.

Meanwhile South Africa had been weakening some of its remaining links with the other commonwealth countries and embarrassing Britain by reviving its claim to incorporate Basutoland, Bechuanaland and Swaziland. Although a small South African air force was sent to serve with the U.N. forces in Korea, South Africa incurred much calumny at the annual sessions of the general assembly of the United Nations. As the 1953 election approached, the Nationalist party swallowed the Afrikaner party and asked for a further mandate to enable it "to save white South Africa." The election was held on April 15. The Nationalist party was again returned, with an increased majority of seats in the house of assembly. They held 94 seats, the United party 57 and the Labour party 5. There were also the three seats held by the native representatives. In the old house the Nationalists had held 86 seats, the United party 64 and the Labour party 6. These results meant that, in spite of their success, the Nationalists still lacked the two-thirds majority they needed if they were to remove the Cape coloured voters from the common roll.

BIBLIOGRAPHY.—General historical surveys: G. E. Cory, The Rise of South Africa, 5 vol. (London, 1910-30); G. M. Theal, History and Ethnography of Africa South of the Zambesi From . . . 1505 to . . . 1795, 3 vol., 3rd ed. (London, 1907-10), History of South Africa From 1795. 3 vol., 3rd ed. (London, 1907-10), History of South Africa From 1795-1872, vol. i and ii, 5th ed., vol. iii and iv, 4th ed., vol. v., 3rd ed. (London, 1927, 1919-27), and History of South Africa, 1873-1884, 2 vol. (London, 1921), The Cambridge History of the British Empire, vol. viii (Cambridge, 1936); C. W. de Kiewiet, History of South Africa, Social and Economic (Oxford, 1942); E. A. Walker, History of South Africa, and ed. (London, 1940); A. M. Keppel-Jones, South Africa (London, 1940); A. H. I. van der Walk (ed.), Geskiedeniv sum Suid Afrika, 2 vol. (Cape Town, 1951); J. H. Hofmeyr, South Africa, 2nd ed. by J. P. Cope (London, 1952); E. A. Walker, Historical Atlas of South Africa (Oxford, 1922).

Special subjects R. H. Rand The Union of South Africa (Oxford, 1922).

South Africa (Oxford, 1922).

Special subjects: R. H. Brand, The Union of South Africa (Oxford, 1909); J. du Plessis, A History of Christian Missions in South Africa (London, 1911); W. M. Macmillan, The Cape Colour Question (London, 1929); C. W. de Kiewiet, British Colonial Policy and the South African Republica, 1948-72 (London, 1939); I. Schapera, The Khoisan Peoples of South Africa (Cambridge, 1937); I. Schapera, The Khoisan Peoples of South Africa (London, 1930); I. Schapera (ed.), The Banu-Speaking Tribes of South Africa (London, 1937); R. I. Lovell, The Struggle for South Africa. 187-e-no (Toronto, 1934); R. I. D. MacCrone, Race Attitudes in Africa, 1875-99 (Toronto, 1934); I. D. MacCrone, Race Attitudes in South Africa (London, 1937); Lord Hailey, An African Survey, 2nd ed,

(London, 1945); S. H. Frankel, Capital Investment in Africa (London, 1938); E. A. Walker, The Great Trek, 3rd ed. (London, 1948); P. J. van der Merwe, Die Trekboer in die gestiedenis van die Kaapkolonie (Cape Town, 1938); J. S. Marais, The Cape Coloured People, 1653-1937 (London, 1930) and Maynier and the First Boer Republic (Cape Town, 1944); S. T. van der Horst, Native Labour in South Africa (London, 1942); M. Roberts and A. E. G. Trollip, The South Africa (London, 1942); M. Roberts and A. E. G. Trollip, The South Africa Rope (London, 1948); M. W. Spilhaus, The First South African (Cape Town, 1949); J. van der Poel, The Jameson Raid (Oxford, 1952); L. Marquard, The Peoples and Policies of South Africa (London, 1942). Monographs and articles may be found in the Archives 1952); L. Marquard, The Propies and Profess of South Africa (London, 1952). Monographs and articles may be found in the Archives Vearbook for South African History (Cape Town, 1938—), in the South African Jonnal of Economics (Johannesburg and London, 1933—) and among the publications of the South African Institute of

Race Relations.

) and among the publications of the South Airican Institute of Race Relations.

Biographies: J. H. Hofmeyr and F. W. Reitz, The Life of Jan Hendrik Hofmeyr (Cape Town, 1913); B. Williams, Cecil Rhodes, new ed. (London, 19218); I. D. Colvin, The Life of Jameson, 2 vol (London, 19215); E. A. Walker, Lord de Villiers and His Times (London, 1923); and W. P. Schreiner (London, 1937); H. C. Armstrong, Grey Steel—J. C. Smuts (London, 1937); C. M. van der Heever, General J. B. M. Hertzog (Johannesburg, 1946); J. Rose Innes, Autobiography (London, 1949); E. W. Smith, The Life and Times of Davide Lindley (London, 1949); T. C. Smith, The Life and Times of Davide Lindley (London, 1949); T. C. Smith, Jan Christian Smuts (London, 1952). Collected historical records. J. Bird, The Annals of Natal, 1495-1845, 2 vol. (Pietermaritzburg, 1888); G. M. Theal, Basutoland Recology, 1793-1831, 36 vol. (London, 1897-1905); Records of the Cape Cology, 1793-1831, 36 vol. (London, 1898-1903); H. C. V. Leibbrandt, Précis of the Archives of the Cape of Good Hope, 17 vol. (Cape Town, 1896-1905). G. von W. Eybers (ed.), Select Constitutional Documents Illustrating South African History, 1795-1910 (London, 1918); G. S. Preller, Voortrekkermense. 3 vol. (Cape Town and Bloemfontein, 1918-22); A. P. Newton (ed.), Select Documents Relating to the Unification of South Africa 2 vol. (London, 1924); C. Headiam, The Milner Papers, South Africa 1807-1905; vol. (London, 1918-33). comprise original journals, reports, etc.

Official published in Include the following, all published in Pretoria:

Ine punicarions of the Van Kepteleck Society (Cape 10kn, 1916—9) comprise original journals, reports, etc.

Official publications include the following, all published in Pretoria:

Official Var Book of the Union of South Africa; reports of the South
African Native Affairs Commission (1903—50), the Transval IndigenoCommission (T.G. 13–1968), and Drought Investigation Commission
(U.G. 49–1933), the Economic and Wage Commission (U.G. 14–1930),
the Low Grade Ore Commission (U.G. 16–1932), the Cape Coloured the Low Grade Ore Commission (U.G. 16-1932), the Cape Coloured Population Commission (U.G. 54-1937), the Indian Penetration Commission (U.G. 39-1941) and the Native Laws Commission (U.G. 28-1948); reports of the Social and Economic Planning Council, including those on Social Security (U.G. 14-1944), Farming in South Africa (U.G. 10-1945), The Native Reserves (U.G. 32-1946) and The Economic and Social Conditions of the Racial Groups in South Africa

(U.G. 53-1948).

Bibliographies: The most accessible detailed bibliography is in The Bibliographies: The most accessible detailed bibliography is in 1 me Cambridge History of the British Empire, vol. viii (Cambridge, 1936). See also S. Mendelssohn, South African Bibliography, 2 vol. (London, 1910); G. M. Theal, Catalogue of Books and Pamphets Relating to Africa South of the Zambesi (Cape Town, 1912); I. Schapera, Select Bibliography of South African Native Life and Problems (London, 1941). For one publications, see the Quarterly Bulletin of the South African Public Library (Cape Town, 1946—). (L. M. T.)

POPULATION

Racial Groups and Distribution.—The South African people are divided into four groups-Europeans, natives, Asiatics and coloured. The distribution of these groups is shown in Table I. By Europeans is implied persons of European origin, although no absolute test has been found to detect former slight racial mixture. Of the European groups by far the largest are those of Dutch and British origin. With the Dutch are included comparatively small groups of settlers of French Huguenot and German origin. It is not possible to discriminate between the Dutch and British groups on a somatic basis; home language-Afrikaans or English—gives a rough approximation of the group proportions which are shown in Table V. By "native" is implied a member of the Bantu racial group. Asiatics are almost entirely of Indian origin. Coloured or "mixed" groups are those springing from the mixture of European and non-European groups, or of Bantu, Hottentot, Malay and Bushman mixtures.

The proportion between the four main groups remained fairly constant in the 20th century, as is shown by Table II.

The density of population (all races) varied in 1946 from a minimum of 14.63 per square mile in the Cape province to a maximum of 62.42 in Natal, the mean for the Union being 24.16,

made up of 19.14 non-Europeans and 5.02 Europeans.

The later increase of population was attributable mainly to excess of births over deaths and only slightly to immigration.

Table I -Distribution of Population, 1936-51

Group and date	Cape province	Natal	Orange Free State	Transvaal	Total
European 1936 1946 . 1951*	791,574 870,795 935,674	190,549 236,697 274,468	200,978 202,077 227,587	820,756 1,063,121 1,205,458	2,003,857 2,372,690 2,643,187
Native 1936 . 1946 . 1951 .	2,045,570 2,338,329 2,483,652	1,553,629 1,708,483 1,803,317	553,110 662,930 775,702	2,444,380 3,122,173 3,472,640	6,596,689 7,831,915 8,535,341
Asiatic 1936 1946 . 1951* .	10,508 15,174 17,548	183,661 232,317 299,068	29 11 16	25,493 37,758 48,892	219,601 285,260 365,524
Coloured 1936 . 1946 . 1951*	682,248 829,550 980,456	18,629 24,895 31,550	17,943 14,053 14,902	50,841 59,986 75,415	769,661 928,484 1,102,323
Total 1936 . 1946 1951*	3,529,000 4,053,848 4,417,330	1,946,468 2,202,392 2,408,433	772,060 879,071 1,018,207	3,341,470 4,283,038 4,802,405	9,589,898 11,418,349 12,646,375

\*Preliminary census.

During the 15-year period 1937-51 the total net increase of the European population as a result of immigration over emigration was 60,230; that of the non-European population was 6,550.

Table II.—Percentage Analysis of Racial Groups, 1904-51

Year	European	Native	Asiatic	Coloured	Total Non-European
1904	21.6	67 4	2.4	8 6	78 4
1921 .	21.9	67.8	2.4	7.9	78.1
1946	20.8	68.6	2.5	8.1	79 2
1951	20.9	67 5	3.4	8.2	79 1

A noteworthy trend in the movement of population after the beginning of the 20th century was the disproportionate increase in urban population, as Table III shows.

Table III.—Comparison of Urban and Rural Population, 1904-46

Group and year	Uı	rban	Rural		
Group and year	Number	Percentage	Number	Percentage	
European					
1004	590,926	520	525,880	47 1	
1921	847,508	52 9 55.8	671,980	44.2	
1946	1,719,338	725	653,352	27 5	
Non-European	1				
1004	608,799	15.0	3,450,210	85 0	
1921	888,177	164	4,520,915	85 o 83 6	
1946	2,425,645	26.9	6,593,691	73.I	

Towns.—The principal towns of South Africa grew up as seaports (Cape Town, Durban, Port Elizabeth, East London) or as centres of mineral exploitation (Johannesburg, Kimberley) or as administrative and educational centres (Pretoria, Pietermaritzburg, Bloemfontein, Grahamstown). The largest agglomeration is on the Witwatersrand, where more than 1,500,000 people live in Johannesburg and the eight other reef municipalities. Cape Town with its suburbs comes next with more than 500,000. In 1951 there were eight cities and towns with more than 100,000: the composition of their populations is shown in Table IV. After these 8 come 12 towns with between 30,000 and 100,000 persons and 29 with between 10,000 and 30,000. The remainder are for

TABLE IV .- Population in the Principal Towns, 1951

Town	European	Asiatic	Cape Malay	Other coloured	Native	Total
Johannesburg Cape Town Durban Pretoria Port Elizabeth Germiston Springs Bloemfontein	359,539 247,446 150,826 150,657 78,520 65,978 31,513 48,923	21,576 8,008 160,231 5,801 4,131 1,805 1,011	4,300 46,772 694 363 2,839 113 43 22	33,180 220,061 16,364 5,674 38,103 2,132 925 3,797	461,410 49,351 146,911 120,563 65,015 79,954 85,859 56,385	880,014 571,638 475,026 283,148 188,617 149,982 119,351 109,130

the most part small country towns or villages with populations

generally between 3,000 and 4,000 Europeans and about equal numbers of non-Europeans.

Language.—South Africa has two official languages, English

"Language.—South Africa has two official languages, English and Afrikaans. The latter is derived from the Dutch of the 17th century, which was brought out by the early settlers. The vocabulary is somewhat limited and the structure considerably simplified to meet the ordinary requirements of a rural population and to be intelligible to the Bantu and Hottentots in its service. The distribution of the English- and Afrikaans-speaking groups is shown in Table V.

TABLE V.-Proportions of English and Afrikaans Spoken, 10.16

	Language	Cape province	Natal	Orange Free State	Trans- vaal	Union	Per- centage
-	Afrikaans .	512,022	51,510	175,137	621,035	1,359,704	57 31
	English	337,174	175,501	23,640	397,497	933,812	39 36

Refigion.—Table VI indicates the relative numerical strength of the principal religious organizations in 1946. The Dutch

TABLE VI.—Religious Denominations, 1946
(In percentages)

Group	Dutch church- es			Ro- man Cath- olic	Jewish	Pres- byte- rian	Apos- tolic	Mo- ham- me- dan	Other de- nomi- na- tions	No re- ligion or Bantu reli- gions
European Non-Euro-	54.12	16 15	7 15	5 03	4 36	3 71	2.48	_	5.08	1 92
pean .	6 18	8 19	12 10	4-79	-	r 86	2 22	1.21	20 83	42.62

churches include the Nederduits Gereformeerde Kerk, with a European membership of more than 1,000,000, the Gereformeerde Kerk van Suid-Afrika and the Nederduits Hervormde Kerk, which together have a European membership of slightly more than 200,000. The (Anglican) Church of the Province of South Africa is divided into 15 dioceses; the seat of the archbishop is Cape Town. The Methodist Church is under the jurisdiction of the South African Methodist conference, which organizes seven districts and 305 circuits. The Roman Catholic Church in South Africa is organized under the Apostolic Delegation of Southern Africa. The seat of the apostolic delegate is in Pretoria.

Health.—The health of the European population of the Union compares favourably with that of other countries, the European crude death rate (1945–47) standing at 8.9 per 1,000, as compared with 10.2 in the United States, 10.6 in the Netherlands and 12.3 in England and Wales.

Of the notifiable-diseases, about 5,000 cases of amoebic dysentery occur annually, mainly among the natives of the eastern low veld, and a similar number of enteric or typhoid cases. Diphtheria is now reduced to about 2,000 cases, the greater number being European. The most serious disease is tuberculosis in its various forms, the native and coloured people being particularly susceptible. Leprosy is decreasing; in the institutions are about 2,000 cases; of these fewer than 100 are Europeans. Malaria is endemic in the eastern and northern low veld and is epidemic in some years over much of the Transvaal middle veld, but the DDT campaign against the anopheline mosquito is succeeding in many areas. Bilharziasis is serious in parts of the Transvaal, Natal and the eastern Cape province; in places 50% of the native population is infected. A National Bilharzia committee was formed to deal with the situation. Of the formidable epidemic diseases human plague and smallpox generally cause a few deaths annually; epidemics of typhus have occasionally been serious among the natives but their incidence is decreasing as a result of DDT and health education.

Housing.—In 1920 a Housing act was passed, empowering local authorities to borrow money from the government for the purpose of building houses of limited size or for lending to approved borrowers for building. A Central Housing board was set up to examine plans and to report on them to the administrator of the province concerned. By 1939 a large number of schemes was in operation, but World War II slowed up progress. Under the 1944 Housing Amendment act the Central Housing board was replaced by the National Housing and Planning commission, and an ad-

visory body, the National Housing council, was set up. The commission was given much wider powers than the Central Housing board and could build houses, buy and allocate materials and establish building research and regional planning branches. On Dec I, 1945, the Natal Housing board came into existence to fulfil in that province the functions performed in the rest of the Union by the National Housing and Planning commission. Under a new agreement between the government and the local authorities a new National Housing scheme was set up under which the government was to hear more of the loss on housing schemes than previously.

The pace of drift into the towns, particularly by natives, made the housing problem a difficult one in the Union. It was estimated that 154,000 additional houses were needed for natives in the towns in 1947. During the financial year ended March 1951 the Union spent nearly  $\mathcal{L}(S.A.)$  3,000,000 on native housing, and in June 1952 the minister of health, K. Bremer, said that, in the three years up to June 1951, 18,900 houses had been built for coloured and native people. European housing was also insufficient, and between the beginning of 1948 and April 1951 60,000 housing units were built by the National Housing and Planning commission, local authorities and private agencies.

Conditions of Labour.—In 1922 the first Apprenticeship act made provision for training South African youth in trades for which it had previously been necessary to bring workmen from abroad. The Industrial Conciliation act and the Wage act of 1937, the Shops and Offices act of 1939 and the Factories act of 1947 cover most industrial and commercial occupations and provide for the fixing of minimum wages, hours of work, etc., and also deal with industrial health.

Most skilled work is done by Europeans, though in the Cape there are many skilled coloured workers and Malays, and in Natal Indian businessmen and many Indian journeymen. Most unskilled and semiskilled work is done by native or coloured people, though the drift into the towns has made it necessary for many Europeans to be employed in unskilled and semiskilled work not previously open to them.

There was little unemployment in the Union after World War II.

Table VII.—Registered Unemployed, 1948-52

Date*	Total	White	Asiatic	Coloured
1948 1949 1950 1951	8,477 18,908 10,818 10,137 11,243	3,503 7,430 4,408 3,193 4,411	003 2,847 1,600 1,823 1,209	3,981 8,631 4,801 5,121 5,623

\*Number registered on Dec. 3x in each case

Cost of Living.—After Jan. 1919 figures relating to prices were collected under the authority of the Statistics act. The cost of living rose steeply in the Union after World War II. Table VIII shows how the rise in prices compared with that of other countries.

Table VIII.—Retail Price Index Numbers, 1937-49

1,701											
Year	Australia	Canada	New Zealand	South Africa	United Kingdom	United States					
1937 1940 1943 1946	100 110 120 131 162	100 104 117 122 159	100 112 123 128* 144	100 107 129 139 159	100 119 129 132 111†	100 98 120 136 165					

\*Amended figure. †Base: June 17, 1947=100.

Education.—Education of European children is compulsory between the ages of 7 and 16, but a child who has passed standard VI is permitted to leave school provided he enters a regular occupation. For coloured and native children education is not compulsory, except under special circumstances. The number of schools and pupils (in brackets) for non-Europeans in the Union in 150 was: Asiatics, 227 (56,396); coloured 1,263 (205,949); native, 5,338 (747,026).

There are nine universities in South Africa. The University of South Africa now conducts courses for external students only and is an examining body for external degrees. There are also the Universities of Cape Town, of the Witwatersrand, Johannesburg (the two largest universities, each with between 4,000 and 5,000

students), of Stellenbosch, of Pretoria, of the Free State, of Natal, of Potchefstroom and Rhodes university, Grahamstown. With the last named is affiliated the South African native college, Fort Hare. The total number of students in the nine universities is about 20,000. In 1952 at the Universities of Cape Town and of the Witwatersrand there were 219 and 245 non-European students, respectively, who enjoy academic opportunities in the same classes as European students. At the University of Natal there were 224 non-European students accommodated in a separate college. At Fort Hare there were 399 students of which 350 were natives, 34 coloured and 15 Asiatic. (J. H. WN.)

### CONSTITUTION

By the provisions of an act of the British parliament (South Africa act, 1909), the colonies of the Cape of Good Hope, Natal, the Transvaal and the Orange River colony were united to form the Union of South Africa on May 31, 1910. Upon its formation these four colonies became the provinces of the Union, the Orange River colony being renamed the Orange Free State province. The colonial legislatures were abolished, provincial councils were set up with specified powers, which could be reduced or increased by the Union parliament, and provincial administrators replaced the colonial governors. The constitutional basis of the Union is contained in the South Africa act, 1909, as amended. The Union remained a member of the British Commonwealth, but its sovereign independence is assured by the British Statute of Westminster, 1931, and the South African Status of the Union act, 1934. In 1919 South-West Africa was assigned to the Union as a "C" mandate. Its inhabitants are now South African citizens. It has an administrator and a legislative assembly and is represented in the Union parliament in terms of the South-West African Affairs Amendment act, 1949. (See South-West Africa.)

The Executive and Legislature.—The government is vested in the queen but is normally administered by a governor general, a South African. He acts on the advice of ministers of state whom he appoints as the queen appoints her United Kingdom ministers; that is to say, government is by a cabinet possessing the confidence of a majority in the lower house of parliament. Ministers administering departments may not exceed 14 in number. A minister cannot hold office for more than three months unless he has a seat in parliament; he may sit and speak in either house but can vote only in the house of which he is a member.

Parliament, consisting of a senate and a house of assembly, has "full power to make laws for the peace, order, and good government of the Union." It may legislate on any topic and amend most sections of the South Africa act by bare majorities in each house sitting separately; but to amend the sections providing for the nonwhite franchise in the Cape province and the equal official status of the English and Afrikaans languages throughout the Union, bills must be passed by both houses sitting together and at the third reading must be agreed to by not less than two-thirds of the total number of members of both houses. During 1952 the appellate division of the supreme court gave two unanimous decisions to the effect that this procedure is still necessary.

The senate consists of 48 members. Its legislative powers are co-ordinate with those of the house of assembly, except in regard to the origination and amendment of money bills. A senator must be a South African citizen of white descent, aged 30 and, if an elected senator, must possess immovable property of the clear value of £500. In each province the members of the provincial council and of the house of assembly for that province elect eight senators by proportional representation; and in South-West Africa the members of the legislative assembly and of the house of assembly for that territory similarly elect two senators. Four senators are chosen to represent the Africans in specified areas by a complicated system of indirect election, in which chiefs, local councils and African advisory boards play a part. Five, including one for South-West Africa, are appointed by the governor general because of their special knowledge of "the reasonable wants and wishes of the coloured races"; and five others, including one for South-West Africa, are appointed by the governor general in his discretion. The four senators who represent the Africans serve

for five years and do not vacate their seats on a dissolution.

The house of assembly consists of 159 members, all of whom must be adult South African citizens of white descent. The constituencies are single and are delimited by a judicial commission every five years. One hundred and fifty seats are allotted to the provinces in proportion to their adult white population. By the 1952 delimitation, the Cape province returns 54 members, Natal 15, the Transvaal 68 and the Orange Free State 13. Within each province each of these constituencies contains an approximately equal number of voters, but a variation of 15% below or above the average is allowed for various factors, notably sparsity or density of population. Six seats are allotted to South-West Africa The African voters in the Cape province elect three members who hold their seats for five years and do not vacate them on a dissolution. A general election must take place at least every five years and all polls must be taken on the same day.

Apart from the three representatives of Africans, the house is elected by all the adult white South African citizens without distinction of sex in the four provinces and South-West Africa, and by a number of coloured men in Natal and the Cape province. In 1952 there were 134,761 white and 1,192 coloured voters in Natal and 546,364 white and 49,272 coloured voters in the Cape. These coloured voters have to possess literacy and property qualifications. Only male Africans who possess such qualifications may vote in the elections for the three whites who represent them in the Cape province. The Natives' Representative council which was set up with advisory powers in 1036 was abolished in 1051.

set up with advisory powers in 1936 was abolished in 1951.

The Judiciary.—The judiciary consists of a supreme court with local, provincial and appellate divisions. The judges are appointed by the governor general and are removable by him on receipt of an address from both houses of parliament requesting such removal on the ground of "misbehaviour or incapacity." Appeals lie to the appellate division from the local and provincial divisions of the supreme court and from the high courts of South-West Africa and Southern Rhodesia. Appeals from the supreme court to the privy council in England were abolished in 1950, except for appeals emanating from Southern Rhodesia. There is also an elaborate system of courts for civil cases between Africans. Such courts administer African customary law, with some infiltration of Roman-Dutch common law, and on points of law there is an appeal to the appellate division of the supreme court. The African is, however, subject to the ordinary courts in criminal cases and in disputes with whites.

Provincial Administration.—Provincial councils have the same number of members as the province returns to the house of assembly (but with a minimum of 25). Constituencies are single. The qualifications for electors are the same as for parliament, and any person qualified to vote is qualified to be a member of the council. Coloured men may therefore sit in the Cape provincial council and have in fact done so. The Cape provincial council also includes two members (whites) elected by the Cape African voters. Any member of a provincial council who becomes a member of either house of parliament thereupon ceases to be a member of such provincial council. Each provincial council continues for three years and is not subject to dissolution.

Provincial councils have original legislative authority as defined in the South Africa act and further authority as granted by parliament. Parliament may, however, remove any such powers; and provincial ordinances require the assent of the governor general and must not be repugnant to any act of parliament or the South Africa act. Primary and secondary education, hospitals, roads, municipal and charitable institutions are the principal subjects regulated by provincial ordinances. Formerly the provinces possessed considerable financial powers, but in the course of time they have been subjected to much greater control by the central government.

The head of the executive in each province is an administrator appointed by and responsible to the central government. He holds office for five years and is assisted by an executive committee of four persons elected by the provincial council from among its own members, or otherwise, on the proportional representation principle. The administrator, and any other member of the executive

committee who is not a member of the council, has the right to take part in the proceedings of the council, but has not the right to vote.

Law.—The basis of the common law of the Union is the Roman-Dutch law as it existed in the Netherlands at the end of the 18th century. This was the Roman law as put in its final form by Justinian and as interpreted during subsequent centuries and received into the Netherlands, with a large admixture of Dutch-Germanic custom. The authorities upon the common law in South Africa are the Dutch commentators, the statute law of the Netherlands, the decisions of the Dutch courts and, failing these, the corpus juris civilis itself.

English influence in South Africa led to a modification of the law by legislation and by judicial decisions and there was a considerable inflitration of English law. The law of contracts and of torts and the mercantile law, which in any event are derived from a comman basis, absorbed a fair amount of English law, though they are by no means identical with it. The same may be said of the criminal law. The law relating to shipping, insurance and negotiable instruments is practically identical with the English law, in some provinces because of legislation. The operation of the courts is based on the English system, and the rules of evidence and procedure are practically the same. In criminal cases trial by judge and jury, with the same formalities and safeguards as in England, is still allowed; but it is becoming far more common to have trial by judge and assessors. Minor offenses are dealt with by salaried magistrates. In civil cases there is no trial by jury.

There is, as might be expected, a vast difference between the English and South African systems in the law relating to property, persons and marriage and succession. As regards property, there is a comprehensive system of registration. A central deeds registry is kept and virtually all titles to land, as well as servitudes, mortgages and similar charges upon land, have to be registered against the title deeds. There is absolute freedom of testamentary disposition throughout South Africa. By the Roman-Dutch law, and in the absence of any antenuptial contract to the contrary, there is a complete community of property between husband and wife, subject to the sole control of the husband. The courts have, however, the right to interfere in case of any flagrant abuse of this power. Antenuptial agreements must in all cases be notarially executed and publicly registered. By the common law gifts between husband and wife during marriage are void as against creditors, but in 1953 there was the possibility that this rule might soon be abolished. Divorce is granted to either spouse for malicious desertion or insanity or when the other party is declared a habitual criminal by the courts.

See H. J. May, The South African Constitution, 2nd ed. (Cape Town, 1949); G. Wille, Principles of South African Law, 3rd ed. (Cape Town, 1949). (L. M. T.)

Police.—The whole Union and South-West Africa are policed by the South African police. On Dec. 31, 1951, the force consisted of 9,999 European members and 7,291 non-European. Police headquarters are at Pretoria.

In 1951 the first step was taken in a scheme whereby each native area was to be policed by members of the force belonging to the chief tribe of that area.

Defense.—Under the South African Defence act of 1912 (as amended in 1922 and 1932) every citizen of European descent must register when he is 17, and between the ages of 17 and 25 must undergo training for four years in the Active Citizen force. All citizens not accepted for this training must, when they are 21, enrol in the Rifle Commandos. The liability of non-Europeans to service may be decided by parliament.

The approximate strength of the permanent armed forces in 1952 was 1,000 officers and 9,000 men. The Active Citizen force was approximately 30,000 and the Rifle Commandos included approximately 100,000. (X.)

## ECONOMICS

Economic Development.—Three phases can be recognized in South Africa's economic development: the pioneer period of subsistence agriculture lasted until about 1870; from 1870 to 1914

the mining-agricultural phase succeeded, when gold and diamonds formed the basis of the economy and agriculture expanded to meet the needs of the increasing population; after 1914 this gave way to the mining-manufacturing phase in which mining provided much of the inland market and the overseas exchange for the rapid development of manufacture. Between 1914 and 1949 manufacturing industries passed from eighth to first place among the contributors to the national income, being responsible for more than twice the amount contributed by mining. In this period the number of factories increased from 4,000 to more than 14,000 and the gross value of manufacturing output from £(S.A.) 40,000,000 to £(S.A.) 675,000,000.

#### AGRICULTURE

Stock Raising.—Cattle are most numerous in the eastern part of the country where the summer rainfall exceeds 20 in. and where the natural vegetation is either grass veld or bushveld. The native cattle are probably descendants of the Sanga type, some branches of which are of exceptional hardiness and adaptability to the South African environment. The Afrikaner breed, developed by the Dutch settlers, is slow developing but very hardy and well-adapted to high temperatures. The introduction of European highly bred bulls was successful in the cooler regions but not in the hotter climates, to which these breeds are ill adapted. Most of the eastern areas are tick-infested, the main tick-borne diseases being east coast fever (or African coast fever), heartwater and gall sickness (or anaplasmosis), which are controlled by regular dipping.

Sheep farming is specially suited to the karroo type of vegetation in areas with a rainfall of between 10 and 15 in. and to the short-grass areas of the high veld. The most important type of sheep in the Union is the Merino, of which there were in 1950 about 20,00,000. The export of wool in 1951 amounted to 194,-000,000 bl. valued at £(S.A.) 79,000,000. Nonwoolled sheep, numbering about 5,000,000 in 1950, include native and Afrikane fat-tailed and fat-rumped breeds together with introduced Blackhead Persians, English mutton breeds and a few thousand Dutch Tesels, German Merinos, French Rambouillets and 1le de France. An important later development was the introduction, from South-West Africa, of the Karakul, of which there were about 1,500,000 in the Union in 1951.

Goats are kept in almost all parts of South Africa but the main breeding areas are in the Great and Little Karroos where the Angora produces most of the mohair for export. Between 2,000,-000 and 3,000,000 lb. of mohair are produced annually.

Horse breeding, once a flourishing and prosperous industry in South Africa, declined because of horse sickness and the increasing mechanization of transport. After World War II, however, an increasing interest was taken in the industry and four horse-breeders' associations were formed. Stud services were set up at government institutions, agricultural colleges and experimental stations. The best areas for horse breeding are the western Free State, the higher areas of the northeastern Cape province and the southwestern Cape. Donkeys and mules are bred and used in most parts of the country; the mule suffers from horse sickness, but less than the horse. Ostriches are bred mainly in the Little Karroo. In 1913 about 1,000,000 birds produced about 1,000,000 lb. of feathers, worth £(S.A.) 3,000,000. The following slump in

TABLE IX .- Number of Stock in the Union, 1950

Stock		Cape province	Natal	Orange Free State	Transvaal	Union
Cattle Woolled sheep Nonwoolled sheep Angora goats Other goats Horses*	: :	3,516,168 17,199,547 3,409,157 580,395 2,770,714 148,245	2,442,657 925,065 296,723 2,924 949,339 23,045	1,981,518 5,878,600 923,742 35,378 31,591 100,631	3,572,266 1,957,499 770,488 1,265 813,573 74,673	11,512,609 25,960,711 5,400,110 619,962 4,565,217 346,594
Mules† Donkeys†	: :	71,906 315,621 52,114	8,119	8,225 86,219 304	17,057 293,463	105,307 799,297 52,634

1947 figure. †1946 figure. ‡Europeans only,

feathers resulted in the almost complete abandonment of ostrich breeding, but after about 1945 the industry revived.

Arable Farming.-Two distinct natural regions suited to agriculture can be recognized: the part of the summer rainfall region with more than about 20 in. of rain, and the winter rainfall region with more than about 10 in. Elsewhere cultivation on any considerable scale must be on the basis of irrigation.

In the summer rainfall zone by far the most important crop is maize, which is grown to some extent almost everywhere to the east of the 20-in. isohyet. Topography, rainfall and temperature combine to give greatest importance to the southern Transvaal and the northeastern Free State, an area commonly known as the "maize triangle," with its apexes at Ladybrand in the south and at Lichtenburg and Ermelo. This area produces about 60% of the Union's total maize crop, which varies from about 2,000,000 to 3,000,000 short tons a year. The yield varies from about 200 lb. to the acre in some of the native areas to about 1,000 lb. on European farms in the maize triangle. The introduction of hybrid varieties is expected to increase production by at least 25%.

Wheat is the main cereal in the southwestern Cape, but its production is increasing in the eastern Free State and the southern Transvaal where late summer rains or the availability of water for irrigation make a winter crop possible. The total annual production in the Union fluctuates between about 250,000 and 500,000 short tons. Oats and barley are also grown in the wheat area. The faveurite crop of the native is kaffir corn (sorghum), which does well in the summer rainfall area where the rainfall is too low or too

unreliable for maize.

In the Natal coastal area sugar cane became almost a monoculture. The cane fields extend from Port Shepstone in the south to the Pongola valley in the north, comprising altogether about 800,000 ac., of which about half carries cane in any year and a quarter is reaped. The yield of cane in 1950 and 1951 was about 5,500,000 short tons.

Fruits of various kinds have become increasingly important. The winter and summer rainfall areas form fairly distinct areas of production. In the Mediterranean climate of the southwestern Cape, the vine flourishes in the lower areas and deciduous fruits of many kinds in the higher valleys and basins. In the eastern part of the Union, generally under irrigation, citrus varieties form the main fruit crops, with subtropical fruits such as the papaw, banana, pineapple, avocado, granadilla and litchi in the low-veld areas.

The area under irrigation in South Africa is about 600,000 ac. Eight irrigation schemes are larger than 20,000 ac. and the largest, the Vaal-Hartz scheme, has an actual irrigated area of 55,000 ac .-a potential area of nearly 90,000 ac. Obstacles to irrigation include the great variability in the flow of most of the rivers and the high percentage of silt carried in suspension.

# INDUSTRIES

In the Union manufacturing development was stimulated by the mineral industries of which gold mining is of greatest importance. In 1950 gold to the value of £(S.A.) 145,000,000 accounted for about 75% of the Union's mineral production, the consumption of local "stores" being of the order of 35% of the total production costs. In 1950 coal (£[S.A.] 14,750,000) and diamonds (£[S.A.] 14,500,000) accounted for about 15% of the Union's mineral production, and copper, asbestos and manganese for nearly 7%.

Manufacturing industries were stimulated by the difficulty of obtaining overseas manufactures during World War II. The most important development was in iron and steel manufacture; the government-sponsored South African Iron and Steel Industrial corporation (I.S.C.O.R.) was producing in 1952 about 600,000 tons of steel and 800,000 tons of pig iron at Pretoria, and the new works at Vanderbijlpark, near Vereeniging, were producing at the rate of about 500,000 tons of steel a year with a capacity of double this amount. Other spectacular developments include the growth of textile manufactures. Imports of textiles in the immediate postwar period averaged about £(S.A.) 50,000,000 annually. By 1950 eight cotton mills had come into operation in the Union, employing 3,600 workers of whom 3,400 were native males. It was estimated that by 1953 the Union would be supplying one-third of its cotton piece-goods requirements. Woollen factories include nine worsted plants and four fully integrated firms capable of producing three-quarters of the Union's requirements. About 4,000. ooo lb. of the Union's tops can now be combed in the country, but the greater part of the raw wool must still be exported. In the Good Hope Textile corporation's factory at Zwelitsha, near King William's Town, natives in the Ciskeian native reserves are trained in the weaving, spinning, bleaching, dyeing, printing and finishing processes.

In 1949 of the 17 classes of manufacture in the Union the net outputs for private industries included metal engineering, £(S.A.) 58,000,000; clothing and textiles, £(S.A.) 29,000,000 building, £(SA.) 24,000,000; chemicals, £(S.A.) 19,000,000; printing, £(S.A.) 18,000,000; and vehicle making, £(S.A.) 17,000,000. Stonework, heat, light and power, leather and woodworking follow, the total net value of all private industries being £(S.A) 265,000,-000, the gross value £(S.A.) 610,000,000. The corresponding values for public industries were £(S.A.) 33,000,000 and £(S.A.) 65.000,000.

Of the 562,000 wage earners in manufacturing industries in 1948, 28.8% were Europeans, 54.7% natives, 3.2% Asiatics and 13.2% coloured. The total remuneration of these employees was £(S.A.) 115,000,000. This may be compared with the total number of 455,000 employed in mining, at a remuneration of £(S.A.) 52,000,000.

### TRADE, TRANSPORT AND FINANCE

Trade.—Table X shows the Union's principal imports and exports. The South African customs are of a protective character; based on a "three line" tariff, they provide for minimum, intermediate and maximum duties. Of the conventions and trade treaties concluded before World War II those which were still in force in 1953 and which affected the Union's industrial development were preferential and reciprocal trade agreements with the United Kingdom, Canada, Australia and the British colonies, and temporary commercial agreements on a most-favoured-nation basis with cer-

TABLE X .- Principal Imports and Exports, 1951 (In millions of £ [S A ])

Imports		Exports	
Item	Value	Item	Value
Metals, machinery, vehicles Tortiles, apparel, yarns, fibres, Oils, waxes, resins, paints Books, paper, stationery Foodstuffs Wood, cane, wicker and manu- Leathier, rubber and manufac- tures thereof, Drugs, chemicals, fertilizers Minerals, earthenware, glass- ware.	157.8 131 9 40 9 23.3 19 3 16.0 14 6 14.1	Wool semiprocessed and manufac- tured gold Foodstuffs Diamonds Hides and skins. Oxbebelos Leather, rubber and manufac- tures thereof Fibres, yarns, extiles, apparel Wittle bark and extract Wittle bark and extract Coal Manganese.	74.6 65 2 34 9 25 1 10 2 7 2 6.9 6.0 6.0 6.0 5.0 3.1 3.1

tain European countries and with Egypt and Brazil. During World War II a most-favoured-nation agreement was concluded with Angola. The postwar situation was determined largely by the 1947 General Agreement on Tariffs and Trade (Geneva), which covered 23 countries including the Union. After 1947 the Union entered into a Customs Union (Interim) agreement with Southern Rhodesia (April 1949) which aimed at the ultimate re-establishment of a complete customs union between the two countries. This agreement had the effect of introducing competition in certain of the manufacturing industries of the two countries, where costs are differentially affected by the greater employment of European labour in the Union.

Transport.-The railway system was designed mainly to connect the ports with the inland mining and manufacturing centres. The dominating inland area is the southern Transvaal, including the Witwatersrand and the growing manufacturing localities from Vereeniging in the south to Pretoria in the north. The standard railway gauge is 3 ft. 6 in. In 1951 the state railways owned more than 13,500 mi. of line, carried 63,000,000 tons of goods and 243,-000,000 passengers. In the same year harbours (falling also within

the Railway administration) landed more than 7,500,000 tons of ourgo and shipped 5,000,000 tons. Airways carried 141,000 passengers between inland and coastal centres. Motor services ran on 26,000 mi of roads, carrying 15,000,000 passengers. The electrification of the railways between Durban and the Transvaal border had by 1952 accelerated the traffic to the Rand, and the electrification of the Belleville (Cape Town)-Touws River line, and the cutting of the Hex River Mountains tunnel was expected to accelerate services from the southwest to the interior.

Railway rates, designed to assist inland economic development and the distribution of minerals from inland mining areas, are fixed arbitrarily by the Railway administration. The transport of goods and passengers by road is controlled by the National Transport commission and local Road Transportation boards. One effect of this control is the elimination of the competition of private road transport with railway transport.

Finance.—The monetary unit is the South African pound, which is at par with the pound sterling.

The relative powers of the provinces and the Union over finance were mainly defined in the South Africa act of 1909 and in the Financial Relations act of 1913, modified by later legislation.

TABLE XI —Government Finance, 1938-51 (In millions of £ [S A ])

	Year			 	Revenue	Expenditure	Deficit
	1938				50 6	65 9	153
	1949	٠		٠	167.3	235 3	68 o
	1950				195.7	223.2	27 5
ı	1951				226 3	270.2	-43 9

Source International Financial Statistics (April 1053).

Act no. 38 of 1945 provides that a subsidy shall be paid to each province to the amount of 50% of its net normal expenditure. The provinces control and are financially responsible for education (other than higher and technical education), hospitals, poor relief, roads and bridges, townships, racing and betting and the preservation of game and fish.

preservation of game and use.

Bibliographys.—Official Venr Book of the Union of South Africa, no. 26 (Pretoria, 1950); E. Hellmann (ed.), Handbook on Race Relations in South Africa (London, 1949); S. G. Millin, The People of South Africa (London, 1951); S. Patterson, Colour and Culture in South Africa (London, 1953); N. N. Franklin, Economics in South Africa (Cape Town, 1948); Study Group of South African Institute of International Affairs, Africa South of the Sahara (London, 1951).

(J. H. WK.)

SOUTH AFRICAN LITERATURE. The earliest writings about South Africa date back several centuries, but South African literature is of more recent origin. After a difficult start in its development from the Dutch language, Afrikaans developed a strong literature, and a review of South African literature must be divided into that written in English and that in Afrikaans.

### ENGLISH

Various reviewers have held that English literature in South Africa has followed the main lines of development in the rest of the English-speaking countries. This view must be accepted with reserve; it is true that many early writers were British and that most younger writers left the country to work as part of other traditions, but South African literature proper has, none the less, individual characteristics.

In poetry this individuality is revealed by an indigenous subject matter and the use of imagery and diction that are characteristically South African. The first poet of note was Thomas Pringle (Ephemerides, 1828; African Sketches, 1834). After a considerable lapse there were William Charles Scully (Wreck of the Grosvenor, 1886; Poems, 1892; By Veldt and Kopje, 1907; Voices of Africa, 1944), Francis Carey Slater (Footpaths Thro' the Vela, 1905; The Sunburnt South, 1908; Settlers and Sunbirds, 1919; The Karroo, 1924; Veld Patriarch, 1949), Arthur Shearly Cripps (Lyra Evangelistica, 1909; Pigrimage of Grace, 1912; Lake and War, 1917) and Charles Murray (Hamewith, 1909; A Sough of War, 1917; In the Country Places, 1920). These are poets of the older school and their verse shows no particular talent or individuality other than this "South African" quality. Cullen Goulds-

bury (Rhodesian Rhymes, 1909; Songs out of Exile, 1912; From the Outposts, 1914), a poet and novelist of great promise, died prematurely.

Roy Campbell wrote notable South African poetry in *The Flaming Terrapin* (1924), *The Wayzgoose* (1928), *Adamastor* (1930), *Flowering Reeds* (1933) and many others. William Plomer (*Family Tree*, 1928, and others) also became prominent. Later poets include Frank Prince, R. M. Titlestad, Anthony Delius and Guw Butler.

Anthologies include Treasury of South African Poetry (edited by E. H. Crouch, 1907 and 1909), Centenary Book of South African verse (edited by Francis Carey Slater, 1925 and 1945) and South African Poetry (edited by Roy MacNab and Charles Gulston, 1948).

The South African novel also has characteristics which differentiate it from other novels in English. Few of the important novels are free from a topic peculiar to South Africa. Notable exceptions are Olive Schreiner's Story of an African Farm (1883); Sarah Gertrude Millin's Mary Glenn (1925), Sons of Mrs. Aab (1931) and What Hath a Man? (1938); Ethelreda Lewis' Harp (1924); and Elizabeth Charlotte Webster's Expiring Frog (1946). Olive Schreiner's Story of an African Farm has the distinction of being the first novel of note to come from Africa and, despite some failings, is a work of merit. Her later works, Trooper Pêter Halket of Mashonaland, From Man to Man and Undine, fell below its standard.

The most popular subject for novels is the trials of the "mixed" or coloured people, who have been developed by centuries of miscegenation and are isolated from both Africans and Europeans. Sarah Gertrude Millin (God's Stepchildren, 1924; King of the Bastards, 1950; Burning Man, 1952) became the major writer on this theme, although William Plomer in his short stories I Speak of Africa (1927), Laurens van der Post in In a Provunce (1934) and Perceval Gibbon in Souls in Bondage (1904) wrote with insight. Peter Abrahams, a coloured writer, produced some impressive work (Dark Testament, 1942; Song of the City, 1945; Mine Boy, 1946; Return to Goli, 1953).

The native formed the subject of hundreds of adventure stories and "ethnographical" novels, but the best work was done in books showing the difficulties of the native people in society. Cullen Gouldsbury (God's Outpost, 1907; Tree of Bitter Fruit, 1910), William Plomer (Turbott Wolfe, 1925), Sarah Gertrude Millin (Coming of the Lord, 1928; Herr Witchdoctor, 1941), William Charles Scully (Daniel Vananda, 1923), Alan Paton (Cry, the Beloved Country, 1949) and J. Grenfell Williams and Henry May (I am Black, 1936) produced a unique and sometimes powerful body of work.

Other novels include historical works by Stuart Cloete (Turning Wheels, 1937; Watch for the Dawn, 1939; Hill of Doves, 1941) and Dorothea Fairbridge (That Which Hath Been, 1910); A. A. Smith's Trader Horn (1927–28); Percy Fitzpatrick's charming dog story Jock of the Bushveld (1907); Horace Rose's Golden Glory (1915); and Daphne Muir's Virtuous Woman (1920).

Pauline Smith's Little Karroo (1925) must head any list of South African short stories. William Westrup's Old McBein (1937) and Treek Chain (1929) and Ernest Glanville's Kloof Yarns (1896), Tales From the Veld (1897) and Claw and Fang (1933) are outstanding for their description of animal and veld. Among later books, Herman Charles Bosman's Majeking Road (1947) and Nadine Gordimer's Face to Face (1949) revealed remarkable gifts.

Travel books were the earliest books written about South Africa, and the works of Thomas Baines, John Barrow, William John Burchell and David Livingstone became well known. In the popular travel book by Laurens van der Post, Venture to the Interior (1952), the scene is Nyasaland, but it seems that the writer's understanding of the country has its origin in his native soil. In biography an extensive literature gathered round the names of Cecil Rhodes, L. S. Jameson, Louis Botha and J. C. Smuts, the best work being done by Sir Thomas Fuller, Sarah Certrude Millin, Ian Colvin, Earl Buxton, J. Crafford and H. C. Armstrong. The letters of Lady Anne Barnard (South Africa a Century Ago, 1901)

give a vivid account of the years 1797-1801 at the Cape.

No significant drama in English had been produced in South
Africa by mid-20th century

(J. P. L. S.)

### AFRIKAANS

Afrikaans, one of the youngest members of the Teutonic group, is the language used by the descendants of Dutch, German and French colonists who settled in South Africa after 1652 and before the British occupation in 1806. The 17th-century dialects of the Netherlandish province (South) Holland form the linguistic basis of Afrikaans; but, although the Afrikaans vocabulary is even today almost identical with the original stock, the grammatical struc-ture has been much simplified. The Afrikaans noun has no grammatical gender, has lost all inflectional forms but the singular and plural, uses one form of the verb for all persons, forms its tenses with modal words and has obliterated the difference between the weak and strong declension. Afrikaans structure is, therefore, even more analytical than that of English. This development is mainly a result of an early lack of the conserving influence of schools and literature, new surroundings and occupations and the incorporation of German and French immigrants. There is every reason to believe that Afrikaans reached its modern form not much later than 1750.

Until the second decade of the 20th century Dutch was still used in South Africa for literary and official purposes. Toward the middle of the 19th century Afrikaans was used in letters in some newspapers and in a few propaganda pamphlets. In 1875 a society, Die Genootskap vir Regte Afrikaners, was founded to translet the Bible into Afrikaans and to foster the use of the language officially. The society founded a magazine and newspaper and started a printing press, but of the literary production of the period 1860–1900 only J. L. Cachet's didactic stories Die Sewe Duivels and S. J. du Toit's historical novel Die Koningin van

Skeba are still read.

The South African War saw the end of the society, but it also saw the birth of an entirely new spirit in the movement for the recognition of Afrikaans. The old phonetic orthography was discarded in favour of a spelling more closely related to Dutch; new writers and scholars, better equipped for the task, took the lead; new journals were founded. Die Afrikaanse Akademie was founded in 1909. As a result of all these activities Afrikaans was adopted as a medium of instruction in schools (1914), university professorships in Afrikaans were instituted, and by 1924 all the Afrikaans churches had adopted Afrikaans as their official language. In 1925 Afrikaans was officially recognized by the entire country. The complete Afrikaans version of the Bible was published in 1937. The first volume of the Afrikaans dictionary, begun in 1925, was completed in 1950. After 1935 an everincreasing number of Afrikaans journals, magazines and newspapers was established.

A literature distinctly Afrikaans in colour and sentiment grew out of the experience of the South African War. The first group of poets of real merit whose poems arose from this experience were Eugène N. Marais, Jan F. Celliers (Die Vlatte, 1908; Marijie, 1911), J. D. du Toit (Totius—By die Monument, 1908) and C. L. Leipoldt (Oom Gert Vertel E. A. Gedigte, 1911). Largely because of the national spirit of its poetry Afrikaans came to be recognized as the cultural language of the country within an ex-

tremely short space of time.

Advances in the field of prose were soon made. G. S. Preller and C. J. Langenhoven, both keen supporters of Afrikaans, D. F. Malherbe and Jochem van Bruggen were still largely concentrating on the national experience during the war, but they soon turned their attention to the realistic novel and made a sound contribution toward the beginning of an Afrikaans prose style (Malherbe, Die Meulenaar, 1916; Bruggen, Ampie, a trilogy, 1924—2). A. A. Pieunaar's masterly novelettes on wild life in the African jungle, Uit Ourwoud en Vlakte (1921), belong to this period.

Meanwhile a new generation of poets had arisen who were mainly concerned with the impact of modern science and technology on a mainly agrarian and patriarchal culture and religion. Consequently the stress was shifted from national to personal ex-

perience. Toon van den Heever especially, in his Gedigte (1919), succeeded in embodying his doubt and his rebellion against th; biblical tenets of his people in his poems. Although it is characterized by differences of outlook, style and interests, the poetry of the following is actually part of this period: T. J. Haarhoff, Die Liefde van Catullus (1933); S. J. du Toit, Tussen die Dae (1947); A. G. Visser, Gedigte (1925) and Die Purper Iris (1930).

About 1925 a new group emerged to dominate the literary scene for the next decade. The most marked advance was made in the field of the novel and the short story. The realistic and the social novel was much favoured. The dominating figure from that time was C. M. van den Heever (Op dee Plaas, 1927; Droogte, 1929; Somer, 1935; Laat Vrugte, 1939; Die Held, 1948; and a biography, Generaal J. B. M. Hertzog, 1943). Other prominen authors of the period were C. H. Kühn (Toings, a trilogy, 1934-44; Klaradynstraat, 1947), J. van Melle (En Ek is Nog Hy, 1942). G. C. and S. B. Hobson (Kees van die Kalaharie, 1979; Buks, 1933), Holmer Johanssen (Die Onterfdes, 1944), P. J. Schoeman (Op die Groot Spore, 1942) and G. H. Franz (Moeder Poulin, 1946). Those members of this group who were also pets—Van den Heever (Deining, 1932; Aardse Vlam, 1938) and I. D. du Plessis (Stryd, 1935; Kwatryne, 1941)—might be regarded as the transition to the next generation, the poets of 1935.

In the poetry of this latter group national experience is at last entirely ignored and the poems centre on the feelings of the individual. The old rhyming verse is discarded in favour of modern blank verse. The new form of poetry passed its zenith soon after 1950, but until then it dominated the field. The outstanding members of the group were N. P. van Wyk Louw (Alleenspraak, 1935; Die Dieber Reg, 1939; Raka, 1940), D. J. Opperman (Heilige Beeste, 1945; Negester Oor Nineve, 1947; Engel uit die Klip, 1951) and W. E. G. Louw (Die Ryke Dwaas, 1934). The younger poets differed from the above in their lyrical excellence. They include Uys Krige (Oorlogsgedigte, 1942; Hat Sonder Hawe, 1949), Elizabeth Eybers (Belydenis in die Skemering, 1936; Die Stil Avontuur, 1939), S. J. Fretoria (Vonke, 1943; Inkeer, 1940) and Olga Kirsch (Mure van die Hart, 1948).

There are few Afrikaans plays, but dramatists of a high literary standard include C. L. Leipoldt (Die Hebs, 1923), J. F. W. Gross-kopf (Drie Eenbedryvee, 1936; Die Klépdolk E. A. Kort-Spele, 1941), H. A. Fagan (Die Ouderling, 1934) and Uys Krige. A younger dramatist than these, W. A. de Klerk, came to the fore with his play Die Jaar van die Vuuros; it received the national prize for drama during the Riebeeck centenary of 1952 as well as the prize of the Suid-Afrikaanse Akademie, the award in both cases being shared with G. Beukes's As Ons Eers Getroud Is.

See C. M. van den Heever and P. de V. Pienaar (eds), Kultuurgeskiedenis van die Afrikaner, 3 vol., a symposium with exhaustive lists of books (Cape Town, 1945-50).

SOUTH AFRICAN WAR, 1899-1902. The South African War may be divided into three distinct periods. The first comprises the Boer invasion, ending with the relief of Ladysmith on Feb. 28, 1900. The second ended in Oct. 1900 with the flight of Pres. Paul Kruger. The third consisted of guerrilla warfare on the part of the Boers, met by the blockhouses and punitive columns of the British, which operations were in force until May 31, 1902, when peace was ratified at Pretoria.

Operations in Natal.—The war opened with the investment of Mafeking by a Transvaal force under P. A. Cronje and the envelopment of Kimberley by Free State commandos under C. J. Wessels. But these were minor operations. The main Boer effort was made in Natal, where the forces were commanded by P. J. Joubert, while Lieut. Gen. Sir George White was the British commander in chief. The northern part of Natal presented two faces of a triangle to the two republics, the short base being formed by the Tugela river. Close to the head of the triangle at Dundee and Glencoe was posted a small British force under Maj. Gen. Sir W. Penn-Symons. Against this force there advanced a Boer force under Lukas Meyer from the east and, more slowly, the foremost portion of the main Boer army from the north, while at the same time other Transvaalers descended upon the railway between Glencoe and Ladysmith, and

the Free Staters from the passes of the Drakensberg advanced toward Ladysmith, the British centre of operations at which the reinforcements from India gathered. On Oct. 20, 1899, the Dundee brigade vigorously and successfully attacked Talana hill and drove back Lukas Meyer, but Penn-Symons was mortally wounded, and 226 officers and men were killed and wounded. Half the mounted men lost their way in attempting to pass the enemy's flank and were taken, and the brigade, threatened to its left rear by Joubert's advance and by the force that had seized the railway, escaped only by retreating upon Ladysmith, where it arrived in an exhausted state on Oct. 26. Meanwhile Sir George White had discovered the Boer force on the railway, and, though anxious because of the advance of the Free Staters, on Oct. 21, stimulated by the news of Talana, he sent out a force of all arms under Gen. J. D. P. French to drive the Boers from Elandslaagte and so to clear Penn-Symons' line of retreat. This was accomplished by French and his subordinate, Col. Ian Hamilton, in the action of Elandslaagte on Oct. 21 (British losses, 258). But on Oct. 22 the Free Staters' advance caused the victorious force to be recalled to Ladysmith, and the third action north of that town, Rietfontein (Oct. 24), was only a demonstration to cover the retirement of the Dundee force. By Oct. 29 all the British forces at the front and their reinforcements had fallen in on Ladysmith, which the Transvaalers on the north and east and the Free Staters on the west side began to invest. Before the junction of the two allied wings was complete Sir George White attempted by a general attack to break up their line. The result of this decision was the battle of Lombard's Kop, outside Ladysmith, in which the whole of the available British force was engaged. The engagement was disastrous to the British, who had undertaken far too comprehensive an attack, and the Natal field force was obliged to fall back upon Ladysmith with the loss of 1,500 men, including a large number of prisoners belonging to the left column, who were cut off at Nicholson's Nek and forced to surrender by a mixed force of Transvaalers and Free Staters under Christiaan De Wet. Two days later Ladysmith was isolated, but not before French had escaped south by train, and the naval authorities had been induced to send into the town a naval brigade with large guns, able to answer Joubert's artillery.

Buller's Arrival.-Gen. Sir Redvers Buller, who had been appointed to the supreme command in South Africa as soon as it was perceived that war was imminent-his force being one army corps in three divisions, the divisional generals being Lord Methuen, Sir W. Gatacre and Sir C. F. Clery-arrived in Cape Town, ahead of his troops, on the day following Lombard's Kop. The situation which presented itself was delicate in the extreme. In Natal practically the whole of the available defense force was swallowed up by the steady success of the invasion; on the western frontier two British towns were isolated and besieged; and Boer commandos were on the point of invading Cape colony, where the Dutch population seemed on the verge of rebellion. The army corps was about to arrive, practically as a whole unit, in South Africa; but it was evident that the exigencies of the situation, and the widely divided areas of invasion, would at least defer the execution of the plan which had been formed for an invasion of the Orange Free State from Cape colony. The first duty was to effect the relief of the British forces which had been rendered immobile, and another duty imposed by political circumstances was to relieve Kimberley (where Cecil Rhodes was), while the prospect of rebellion forbade the complete denudation of the central part of the colony. Thus Buller had no choice but to disintegrate the army corps. Clery and some brigades were sent to Natal; Gatacre with less than a brigade, instead of a division, was dispatched to Queenstown, Cape colony; while Lord Methuen, with a division, was sent off to relieve Kimberley. As November wore on, British prospects did not improve. Cape colony was invaded; while in Natal a flying column of Boers, pushing down from the Tugela, for a short time isolated the newly arrived force under Gen. H. Hildyard, which opposed Joubert's advance on Pietermaritzburg at Estcourt. The situation in Natal seemed so serious that on Nov. 22 Buller left Cape Town and sailed for Durban.

Failures of Methuen and Gatacre.-In the meantime Methuen had begun his march to the relief of Kimberley. He encountered resistance at Belmont on Nov. 23, but drove the Boers out of their strong positions. Two days later he won another action at Enslin. Still persevering he moved on to the Modder, where he was seriously opposed by J. H. De La Rey and Cronje, the latter having posted down from Mafeking with 2,000 men and arrived on the previous night. The Boers, who held a river line, kept the British attack at bay all day, but eventually fell back, relinquishing the position after dark, as their right had been turned by Sir Reginald Pole-Carew's brigade. It was a long and wearing fight, in which the British lost 485 killed and wounded, and, what was more serious, Methuen (himself wounded) found that his force had exhausted its forward momentum and that he would have to collect supplies and reinforcements on the Modder before fighting his next battle. The extent of the operations and the gravity of the situation now began to be felt in England; every available man was called up from the reserves, and the war office made what at the time seemed adequate provision for the waste which it was seen would occur. On Nov. 30 the mobilization of a sixth division was ordered, offers of colonial aid were accepted and every facility was provided for local recruiting. On Dec. 10 Gatacre essayed a night march and attack upon the Boer position at Stormberg, and, misled by his guides in unknown ground, Was himself surprised and forced to return with a loss of 719. On the following day Methuen delivered an attack upon Cronje's position between the upper Modder river and the Kimberley road, a line of koppies called Spytfontein and Magersfontein. In a night attack on Magersfontein hill the Highland brigade was caught under heavy fire while still in assembly formation and lost its general, A. J. Wauchope, and 750 men, and in the battle by day which followed, the total losses amounting to about 950. Buller had collected at Chieveley in Natal a mounted brigade and four infantry brigades.

Buller's Failure; Lord Roberts Sent Out .- On Dec. 15 Buller made his effort and failed. Behind the Tugela at Colenso (q,v) were Louis Botha's forces covering the siege of Ladysmith, and, imperfectly acquainted with the lie of the ground, Buller sent a force to turn Botha's left, in conjunction with a frontal attack. But the flank attack became entangled in mass in a loop of the river and suffered heavily, and two batteries that formed part of the frontal attack came into action within a few hundred yards of unsuspected Boer trenches, with the result that ten guns were lost, with about 1,100 men. Buller then suggested to White the surrender of Ladysmith, believing this to be inevitable and desiring to cover White's responsibility in that event with his own authority; but White replied that he did not propose to surrender, and the British cabinet, aware of Buller's despondency, appointed Field Marshal Lord Roberts to the supreme command, with Maj. Gen. Lord Kitchener as his chief of staff. As the formation of a seventh division practically drained Great Britain of trained men, a scheme for the employment of citizen soldiers was formulated, resulting in the dispatch of imperial yeomanry and volunteer contingents, which proved one of the most striking features of the South African campaign. Pending the arrival of Roberts and reinforcements, the situation in South Africa remained at a deadlock: the three besieged towns-Mafeking, Kimberley and Ladysmith-merely held their own. In northern Cape colony, French, with two cavalry brigades, kept at arm's length a superior force of the Boers in the vicinity of Colesberg. On Jan. 6, 1900, the Boers tried to storm Ladysmith. The garrison, though weakened by privation and sickness, made a stubborn resistance, and repulsed the attack at Caesar's Camp and Wagon hill with severe loss to the Boers, itself having 500 casualties.

Roberts arrived in Cape Town on Jan. 10, 1900. His first duty was to create a field army out of units in Cape colony. Buller essayed a second attempt to cross the Tugela, by turning the Boer left. But the upshot of several days' fighting was the retreat of the British. They had penetrated the Boers' right centre by the seizure of Spion Kop (q.v.), but the force there became the target for the concentrated attacks of the Boers, and, after suffering heavily, was withdrawn (Jan. 24, 1000).

By Feb. 1 Roberts had matured his plans; on Feb. 3 he ordered a demonstration against the right of the Boer position at Spytfontein-Magersfontein to cover the withdrawal of French's cavalry from before Colesberg, and the concentration of his army at Modder river, disregarding another setback in Natal to Buller, who had against Roberts' advice made a third attempt to relieve Ladysmith and failed to make good the purchase which he secured across the Tugela (Vaal Krantz).

Roberts' Advance.-Roberts' plan was first to concentrate to his left, taking every measure to induce the Boers to believe that the original scheme of invasion by the centre would now be resumed, and in this purpose he succeeded so well that his field army with the necessary transport for a cross-country march was assembled between the Orange and the Modder without serious mishap. Cronje at the new centre of gravity was not reinforced, all available Boers drawing down toward Colesberg. The concentration effected, Cronje still believed that the relief of Kimberley was the object of the gathering behind the Modder river and therefore held on to his Magersfontein koppie. The relief of Kimberley was indeed urgent, for dissensions between Rhodes and the military authorities had become acute But to this part of the task only the cavalry division assembled under French was assigned. The army itself was to force Cronje into the open and then advance on Bloemfontein from the west. Roberts began his operations on Feb. 11. French started from Ramdam (near Graspan) eastward on that day, intending to make a wide sweep round Cronje's immobile army. Skirmishing with De Wet in the first stages of their ride, the cavalry brigades crossed the Modder at Klipdrift on Feb. 13. Cronje sent only detachments to oppose them, but these detachments were broken through by a sword-inhand charge of the whole division, and Kimberley was relieved on Feb. 15. The infantry, meeting with great difficulties in its crossing of the Riet at Waterval because of the country and its own unwieldy transport, followed 11 to 2 days later. But Cronje had now realized his danger and slipped away westward behind French and in front of the leading infantry at Klipdrift. These were deflected by Kitchener westward to follow up the Boer rearguard, and after some delay the remainder of the infantry, at first fronting northward, swerved westward likewise, while French from Kimberley, with such of his men as he could mount on serviceable horses, headed off Cronje in the northwest. The result, after one premature and costly assault on Cronje's lines had been made by Kitchener, was the surrender of 4,000 Boers at Paardeberg (q.v.) with their leader on Feb. 27, the anniversary of Majuba. At the same moment came in news at last of the relief of Ladysmith.

Relief of Ladysmith .-- It was part of Roberts' purpose to relieve the pressure in Natal by his own operations. Buller began his fourth advance on Feb. 14, and though this was checked the foothold gained was not abandoned, and a fifth and last attempt, Pieter's hill (q.v.), was successful. Ladysmith (q.v.) was relieved on Feb. 28. It had fared worst of all the beleaguered garrisons, and its 22,000 inhabitants were almost at their last gasp when relief came. The casualties from shell fire had been few, but those from sickness were very heavy. Buller's operations, too, had cost at Colenso 1,100 men, at Spion Kop 1,700, at Vaalkrantz 400 and now in the last long-drawn effort 1,600 more-more than 5,000 in all. But the tide of war had changed. The Natal invaders fell back to the mountains which enclosed the north of the colony; Olivier and Schoeman retired from Cape colony; and the presidents of the republics hinted at status quo before the war. These proposals were rejected by Lord Salisbury.

Capture of Bloemfontein.—The surrender of Cronje and the relief of Ladysmith for the time being paralyzed the Boer resistance. Two half-hearted attempts were made early in March, at Poplar Grove and Driefontein, to stem Roberts' advance upon Bloemfontein, President Kruger himself arriving on the scene to give confidence to his burghers. But on March 13, 1900, Roberts' army marched into the Free State capital, this in spite of the fact that much transport collected at Ramdam had been cut off by De Wet.

It was only on March 29 that the new railway communication recommenced to feed the army. In the meantime rebellion had broken out in the Prieska district of Cape colony but was promptly quelled by Kitchener. The enforced halt at Bloemfontein was unfortunate for the British; it not only resulted in a bad outbreak of enteric but also gave the Boers time to recuperate, and by the beginning of April they again took the initiative. death of their commandant general, Piet Joubert, on March 28. seemed to mark a change in the fortunes of the Republican army, De Wet, who had first come into prominence as the captor of Roberts' convoy at Waterval and who was now operating east and southwest of Bloemfontein in order to counteract the influence of Roberts' numerous flying columns which rode hither and thither offering peace to the burgher, added to his laurels by ambushing R. G. Broadwood's mounted brigade and horse artillery at Sannah's Post, just outside Bloemfontein, on March 31. Four days later he reduced a detachment at Reddersburg, and then went south and invested a mixed force at Wepener, which was relieved after ten days by Gen. A. Hunter's Ladysmith division.

Relief of Mafeking .- On May 11 Roberts and his army moved northward upon the Transvaal capital, Pretoria. A flying column on May 17 relieved Mafeking, where Col. R. Baden-Powell had throughout shown an unconventional gaiety. The same day the Natal field force under Buller moved up into the Biggarsberg and occupied Dundee. On May 12 Roberts entered Kroonstad and on May 31 occupied Johannesburg, the Orange Free State having been annexed three days earlier. On May 30 President Kruger had fled with the state archives to Waterval Boven on the Komatipoort line. The gold mines were now securely in the possession of the British, and on June 5 Roberts occupied Pretoria practically without resistance.

Diamond Hill .- The Boers still continued to wage guerrilla warfare with skill and fervour for two years. On June 8 Buller, who had made a long halt after the relief of Ladysmith and reorganized his army and its line of communication, forced his way over Alleman's Nek, and on the following day occupied Laing's Nek, the Natal gate to the Transvaal, while Roberts fought a widespread battle against Botha, De La Rey and J. C. G. Kemp at Diamond hill, 20 mi. E. of Pretoria. The object of this action was to push back the Boers from the neighbourhood of Pretoria, but no sooner was this done than the northwestern Transvaal became active, in spite of Hunter's and Baden-Powell's advance from Mafeking through this district. As the British line of operations now extended eastward from Pretoria, the advance of these Boers to the Magaliesberg threatened their rearward communications, and as Buller had moved far more slowly than the main army there was not as yet an alternative line through Natal. Most serious of all was the pressure between Bloemfontein and the Vaal, where the Free Staters, under De Wet and other commanders, had initiated the guerrilla war as soon as Botha and the Transvaalers retired over the Vaal and ceased to defend them by regular operations. Large forces had been left behind during the advance on Johannesburg for the protection of the railway and the conquered territory, and these had now to be reinforced. Hunter and L. Rundle successfully herded M. Prinsloo with 4,000 Free Staters into the Brandwater basin (July 29)-an achievement which was marred for the British by the escape of De Wet, who soon afterward raided the western Transvaal and again escaped between converging pursuers under Kitchener, Methuen, H. L. Smith-Dorrien, Ian Hamilton and Baden-Powell.

Flight of Kruger.-Before this Roberts had initiated a movement from Pretoria to sweep down to Komatipoort on the Portuguese frontier, in which Buller, advancing across country from the south, was to co-operate. On Sept. 25 Komatipoort was occupied by Roberts' troops. From October British operations were confined to attempts to reduce guerrilla commandos which had taken the field. Kruger left for Europe in a Dutch man-of-war from Lourenço Marques and Buller returned to Britain. The Boer leaders definitely decided upon a guerrilla policy, deliberately dispersed their field army and then swelled and multiplied the innumerable local commandos. On Oct. 25 the ceremony of annexing the Transvaal was performed at Pretoria.

Kitchener Takes Command.—The prevailing opinion was that the war was over, and Roberts left South Africa, handing over the command to Lord Kitchener. Then followed a long pejod of British groping for a means to cope with the development of guerrilla tactics, which for the next six months were at their zenith. The railway communications were constantly damaged, isolated posts and convoys were captured, and the raiders always seemed able to avoid contact with the columns sent in pursuit. De Wet, after escaping from Brandwater basin, was hunted northwestward and crossed into the Transvaal, where, joining the local guerrilla bands, he surrounded an infantry brigade at Frederikstad. But, unable to reduce it, and threatened on all sides, he turned back. On Nov. 6 he was severely handled and his guns and wagons captured at Bothaville. But this misadventure only stimulated him. His emissaries roused the Free Staters west of Bloemfontein, and disaffection broke out in Cape colony to an alarming degree, while, as forerunners of the promised invasion, scattered bodies of Free Staters crossed the Orange river to swell the rebellion. From Bothaville De Wet made for Thaba Nchu, where the Bloemfontein garrison held a cordon of posts. He passed through this and on to Bethulie, capturing Dewetsdorp and 500 men en route. Pursued closely and finding the rivers in flood De Wet hid some of his men under Kritzinger near the Orange and himself doubled back, traversing again the line of posts east of Bloemfontein. Kritzinger, J. B. M. Hertzog and bodies of Cape rebels raided Cape colony as soon as they were able to cross the Orange, and Hertzog penetrated so far that he exchanged shots on the Atlantic coast with a British warship. All that the British forces could do was to localize the raids and to prevent the spread of rebellion. Botha meanwhile held his own in the northern Transvaal, attacked the railway posts on the Middelburg railway and captured Helvetia. De La Rey operated successfully and scathelessly in the western Transvaal, in concert with C. F. Beyers. Kitchener called for more men, and on Dec. 22 the war office announced that 30,000 more mounted men would be dispatched to the seat of war.

Concentration Policy .- With the opening of 1901 Kitchener tried new schemes. He withdrew all his detached garrisons except in the most important centres and set himself to make his railway communications secure. He determined to make the area of operations a waste, and instituted the concentration camps, into which he intended to bring the whole of the noncombatant inhabitants of the two republics.

Although the British sustained no great disasters, the new policy was not prolific in success. The Boers invariably dispersed before superior forces, and the removal of the women and children from the farms to the concentration camps, where the death rate from disease was appallingly high for a time, did not discourage the Boers from continuing the struggle.

On Feb. 10 De Wet, with five guns and 3,000 men, carried out his promised invasion of Cape colony. Passing the Bloemfontein-Thaba Nchu cordon a third time, he crossed the Orange to join Hertzog and rouse the Cape Dutch. But this invasion failed. By judicious use of the railway Kitchener concentrated sufficient troops in the colony to cope with the attempt, and, after being hunted for 18 days, De Wet escaped into the Orange River colony with the loss of all his guns, munitions and half his force. In the northern Transvaal a force under Sir Bindon Blood cleared the country, but could not prevent B. Viljoen from escaping eastward to join Botha. Botha's activity in the southeast caused Kitchener to dispatch thither a large force under French. This swept the country up to the Swaziland border, but Botha escaped. On March 3, after various raids, De La Rey, the lion of the western Transvaal, essayed an attack upon Lichtenburg, in which he was heavily repulsed. Signs of weakness were now apparent, and as a result Botha, acting with the authority of Schalk Burger, the representative of President Kruger, opened negotiations with Kitchener. A meeting took place at Middelburg, Transvaal, on Feb. 28. These negotiations, however, broke down mainly over the treatment to be awarded to Cape rebels.

Blockhouse Policy.-Kitchener now resolved upon chains of blockhouses like those protecting the railways. In April H. C. O. Plumer occupied Pietersburg, the last remaining seat of government open to the Boers. In July Botha applied for permission to communicate with Kruger. This was allowed, but Kruger advised

a continuance of the struggle. In the meantime, the concentration camps were becoming filled to overflowing, and a steady stream of captures was reducing the Boer resistance.

In August a proclamation was promulgated formally threatening the Boer leaders who did not surrender with permanent banishment from South Africa, but this proclamation had very little effect. Desultory fighting continued till the close of the year. Disaffection again became pronounced in Cape colony, and on Oct. 8 the whole colony was placed under martial law. The British began a succession of night marches and raids which practically blotted out the resistance in the eastern Transvaal. The year closed on a low note for the British, however, as De Wet on Christmas Eve captured a large force of veomanry at Tweefontein.

The "Drives."-In 1902 the blockhouse system was finished. But the Boers still had about 25,000 men in the field. The mobile columns, of which there were more than 60 in the field, could be pushed out along whatever blockhouse line they touched. In January, Viljoen was captured in the Lydenburg district. Early in February Lord Kitchener commenced his first drive, and it was so successful that it was evident that the key to the situation had been found. First the country east of the line Bloemfontein-Vereeniging was swept four times over, then the method was employed in the Transvaal, east and west, and finally against the Cape rebels. These British drives wore down the Boers' capacity resist. In April their executives met Kitchener and Alfred (later Viscount) Milner at Pretoria and agreed to convene a meeting of commando delegates to consider peace. The delegates met at Vereeniging on May 15 and deputed Botha, De Wet, De La Rey, Hertzog and I C. Smuts to negotiate for "limited independence." In Pretoria Kitchener and Milner rejected any such basis but, after Kitchener had had a private discussion with Smuts, terms were drawn up and telegraphed to the British government, which approved them with amendments. After long debates the Vereeniging assembly accepted them on May 31 by 54 votes to 6 and the same evening the Boer executives signed them in Pretoria.

Peace of Vereeniging.-The essential points of the peace were: (1) Surrender of all burghers in the field, with all arms and munitions of war; (2) all burghers duly declaring themselves subjects of King Edward VII to be repatriated; (3) no burghers who should surrender to be deprived of either their liberty or property; (4) no proceedings to be taken against burghers for any legitimate acts of war during the period of hostilities; (5) the Dutch language to be taught in public schools on the request of parents and to be allowed in courts of law; (6) rifles to be allowed upon the taking out of licences; (7) the military administration to be superseded by civil administration as soon as possible, the civil administration to lead up to self-government; (8) the question of the native franchise not to be decided until after the introduction of self-government; (9) landed property not to be subjected to any special tax to defray the cost of the war; (10) commissions to be formed to facilitate the repatriation of the burghers, a grant of £3,000,000 being given as compensation for the destruction of farms

In the whole war the British lost 5,774 killed and 22,829 wounded, while the Boers lost about 4,000 killed. At the end of the war there were 32,000 Boers in prison camps and 110,000 in the concentration camps. (L. J.; C. F. A.; X.)

SOUTHALL, a municipal borough in Middlesex, Eng., 10 mi. W. of central London by road. Pop. (1951) 55,900. Area 4 sq.mi. Flint weapons and the skeleton of a mammoth have been found there. In 830 the manor of Norwood was bequeathed by Warberdun to the archbishop of Canterbury. The manor house (1581) is preserved in the form of municipal offices. The urban district of Southall-Norwood was incorporated in 1936, and the borough returns one member to parliament. The chief industries are the manufacture of food products, motor vehicles and chemicals, building, engineering, a foundry and many light industries.

SOUTH AMBOY, a city of New Jersey, U.S., on the Raritan river connected with Perth Amboy by the Victory bridge (1926) and the Thomas A. Edison Memorial bridge (1940). Pop. (1950) 8,422; (1940) 7,802. South Amboy has various industries; it was laid out in 1835, becoming a city in 1908.

SOUTH AMERICA, the southern of the two American continents of the western hemisphere, situated between 34° and 82° W. long. and 13° N. and 55° S. lat. It is roughly triangular in shape and in the northwest is joined to the continent of North America (q.v.) by the Isthmus of Panama. South America is the fourth largest of the continents, having an approximate area of 6.856 975 sq mi. or about 12% of the land surface of the globe. Its estimated population in 1952 was 112,310,000, or 16.4 per square mile. South America lies much farther east in the Atlantic ocean than North America, the meridional line of New York city cutting it so as to leave 95% of the southern continent lying closer to the old world. See also AMERICA.

#### PHYSICAL ASPECTS

The Coasts.-The South American continent rises abruptly from the ocean floor along much of its coast, but the steepness of the continental margin is more marked on the western side than on the eastern. The west coast between 5° and 35° S. lat. displays little development of a continental shelf and drops off sharply to a series of deep submarine trenches parallel to the shore. In the neighbourhood of 26° S. lat. the Richards Deep exceeds 25,000 ft. in depth within 50 mi. of the coast. In general the Pacific coast follows the direction of the Andes. The whole west coast north of the Patagonian archipelago is but little articulated and is completely lacking in good natural harbours. The harbours of Guayaquil and Buenaventura would be exceptions to this rule if it were not that the rivers which empty into them carry so much silt that only constant dredging or carefully engineered dikes to direct the flow and deposit of the silt make them possible for steamers of deep draught.

From 41° S. lat. to Cape Horn the coastal zone is a series of islands, channels and fiords, results of subsidence and glaciation. In the far south glaciation is active at low elevations even today, glaciers coming down to sea level at the heads of the larger fiords and along the coast of Beagle channel.

North of 41° S. lat. the land between the Andes and the sea averages 40-50 mi. in width. Its character varies greatly. southern and central Chile a longitudinal interior valley is bordered on the west by a coast range whose elevation increases toward the north. Northern Chile has a high cliff coast situated in front of a series of interior basins. In Peru the coast range is largely absent. The entire strip from 30° S. lat. to the mouth of the Guayas river is arid, broken by a succession of transverse stream channels, most of them of intermittent flow. North of the mouth of the Guayas river the coastal belt is covered with tropical vegetation.

The east coast is in strong contrast with the west. Between Cape São Roque and Rio Grande do Sul the coast generally follows the sinuous eastern edge of the Brazilian plateau. Along this coast lie some of the world's most beautiful harbours, notably those of Recife, Salvador, Vitória, Rio de Janeiro and Florianópolis. Farther south the estuary of the Rio de la Plata is the most marked indentation of the whole South American coast. It is the outlet for the combined waters of the Paraná and Uruguay river systems. The Patagonian coast is but poorly endowed with natural harbours. Although many embayments occur, their utility is reduced by shallow water, high tidal ranges and coastal cliffs.

The east coast of South America has few islands, and these, except Trinidad, off the coast of Venezuela, and Marajó, at the mouth of the Amazon, are mostly small. Trinidad (area 1,864 sq.mi.) is separated from the continent by the Gulf of Paria. Along its northern edge is a range of mountains with a maximum height of 3,085 ft. which is geologically a continuation of the Cumaná range of Venezuela. On the south side of this island is the famous asphalt lake-the largest-known deposit of its kind. West and north of Trinidad and lying farther off the coast are several small islands of historical interest and considerable commercial importance: Tobago, Margarita, La Tortuga and the Curação group. The main island of the Fernando de Noronha group of volcanic islands, 230 mi. off Cape São Roque, has an area of only seven square miles. Although separated from the mainland by a channel 13,000 ft. deep, it really stands upon the submerged corner

of the continent. The Falkland Islands in lat. 51° S. also stand upon the submerged edge of the continent. Their fauna and flora indicate that they were once a part of the mainland from which they are now separated by shallow water. On the west coast north of the Patagonian archipelago are the Juan Fernández Islands west of Valparaiso, the famous guano islands close to the mainland of Peru, the Galápagos Islands on the equator and the islands of the delta of the Guavas river near Guavaguil

Land Relief .- The continent of South America is composed of the following major surface forms: the cordilleras of the Andes in the west and north, the Guiana, Brazilian and Patagonian uplands in the east and south; and the lowlands which divide the highlands from one another, namely, from north to south, the Orinoco depression, the Amazon basin, the Paraguay basin and the Pampa.

The Andes, one of the greatest mountain systems in the world. are more than 5,000 mi. long and are exceeded in average height only by the Himalaya. The southern Andes are a single chain, but north of 28° 5. lat. they form a complex system. Widening to a broad plateau in Bolivia, they narrow to a series of parallel ranges en echelon in Peru, continue in two parallel ranges in Ecuador and then fan out in Colombia into three distinct ranges, two of which end near the Caribbean shore while the easternmost continues through northern Venezuela into Trinidad. Volcanic cones are present in three separate areas. Drainage features are fairly complex. (For further details see ANDES.)

The Guiana highlands and the Brazilian shield together represent the ancient core area of the South American continent, divided into two unequal sections by the Amazon geosyncline. The crystalline rocks comprising the basement complex are granites, gneisses, schists and quartzites, overlain in some areas by old sandstones. Waterfalls and rapids occur along all the streams passing over the edge of these uplands. Angel fall in the Guiana highlands is the highest uninterrupted waterfall in the world (nearly 3,000 ft.). Paulo Afonso falls on the São Francisco rives in northeastern Brazil were being harnessed in the 1950s for a major hydroelectric installation. The crystalline rocks in areas of high rainfall weather into characteristic domelike shapes, as exemplified by the celebrated Sugar Loaf overlooking the bay at Rio de Janeiro. The highest point in the Guiana highlands is Mt. Roraima (elevation 9,219 ft.), and on the Brazilian shield, Pico da Bandeira (elevation 9,494 ft.). Patagonia is mostly a succession of arid plateaus, characterized by horizontal beds of sandstone and widespread lava caps.

In South America the development of lowlands is far greater in the interior of the continent than near the periphery. Only on the Atlantic coast, about the mouth of the Amazon and near the Río de la Plata, do extensive lowlands occur next to the sea. Typically, the lowland areas are pouch-shaped, with their greatest width inland. The Llanos del Orinoco occupy a structural depression between the northern Andes and the Guiana highlands. Orinoco river does not flow along the central axis of the Llanos but at the base of the Guiana highlands, in part a consequence of the great deposition of alluvium by tributary streams issuing from the rapidly eroding Andes. The Amazon basin has an exceedingly low gradient, Manáus, 800 air miles from the Atlantic, being only 150 ft. above sea level, and Iquitos, 1,700 air miles inland, only 350 ft. In spite of this low gradient, far less of the Amazon lowland is subject to inundation than is commonly supposed, the great bulk of the land lying above the level of highest flood water on the major streams. In its widest section the upper Amazon basin affords access over low divides (about 1,000 ft. elevation) into the Orinoco depression to the north and the Paraguay basin to the south. The Paraguay-Paraná geosyncline begins in the north with the great region of swamp (Pantanais grandes) in western Mato Grosso and with the Gran Chaco of Bolivia, Paraguay and Argentina. Slopes are so gentle that drainage is slow and imperfect. Toward the south the Chaco grades into the Pampa, while the swamps of Mato Grosso find their general counterpart in Argentine Mesopotamia. In depth and fertility the soils of the Pampa are among the best in the world.

Rivers and Lakes.—The most important river systems of

South America-the Amazon, Orinoco and the Paraná-La Plata s stem-have the greater part of their drainage basins in the lowland belt. The chief headwater tributaries of the Amazon and the Orinoco have their sources in the Andean highlands, where they have cut deep valleys The principal sources of the Paraná-La Plata system are in the Brazilian plateau, although the Pilcomayo and Bermejo (right bank tributaries of the Paraguay) rise in the Andes of southern Bolivia and northern Argentina. These three river systems together drain an area of about 3,700,000 sq.mi. During the rainy season all of them overflow their banks and flood large sections of the central lowland belt. The Amazon is the largest river in the world, though not the longest. At the narrows of Obidos, where it is constricted by spurs of highland projecting from north and south, it has a width of 14 mi., a depth of 270 ft. and an average current of 2.7 m.p.h. During flood stages it rises about 25 ft. and the current in the narrows increases to 4.2 m.p.h.. The main stream is navigable for ocean steamers as far as Iquitos, while many of its tributaries are navigable for steam launches almost to the foot of the Andes. In time of high water the main stream of the Orinoco is navigable for 1,000 mi or more.

Other important rivers are the Magdalena in Colombia, the Essequibo in British Guiana and the São Francisco in Brazil. The Magdalena is navigable, in two sections separated by the rapids at Honda, for river steamers as far as Girardot, the river port of Bogotá. The São Francisco, which rises in the highlands of Minas Gerais, is navigable nearly to the falls of Paulo Afonso, 140 mi. from its mouth, and for 850 mi. above the falls.

Most of the lakes of South America are mountain lakes in the Andes or along their base. Of the Andean lakes, Titicaca and Poopó are the largest. (See Andrs.) The glacial lakes along the eastern base of the Andes in southern Argentina and those of the Lianquinue district of southern Chile are described in the articles on the Andes, Argentina, Chile and Patagonia. There are many lakes scattered over the flood plains of the great rivers, but these are mostly phase of river development. Along the east coast there are occasional lakes, such as the Lagôa dos Patos of southern Brazil, of brackish water, produced by depression of the coast and the closing of the mouths of estuaries formed thereby or by barrier beaches thrown up by the sea. Lake Maracaibo is a large, narrow-necked bay, somewhat like that of Rio de Janeiro, rather than a true lake. Its waters, however, are brackish. (H. J. Bn.)

## GEOLOGY

The most extensive old land areas (Pre-Cambrian) of South America are found in the plateaus of Guiana and Brazil, where the ancient crystalline granites and gneisses have been laid bare over large areas. The Brasilides, so-called, are a series of Pre-Cambrian and pre-Devonian folds of which traces are found on the western border of the Brazilian plateau and as far south as the Sierras in the Argentine provinces of Córdoba and La Rioja. These old land areas formed the larger units in a chain of islands of which the old rocks of the Falkland Islands are a part. On their shores were laid down the sedimentary beds of the Cambrian seas. At the close of the Cambrian period these Pre-Cambrian islands with their Cambrian sediments were uplifted, and many united to form continental masses of considerable extent. During the Silurian period, however, seas still covered a large area including the present basin of the Paraguay river and a large part of the present basin of the São Francisco and extending northward between the axis of the Andes and the Mato Grosso highlands and eastward by way of the region now occupied by the lower Amazon valley.

During the Devonian period further uplift and the consequent disappearance of the Silurian seas from the basin of the São Francisco increased the area of the continental mass; but in early Carboniferous times the sea still covered a narrow strip through the lower part of the Amazon valley and part of what is now the Andes south of the equator. During the Permian the basin of the Paraguay and the southeast coast of Brazil were covered with lagoons and swamps in which here and there coal beds were laid down.

Continental Permian deposits have been found at a number of

places in the southern part of the Brazilian plateau, in northern Argentina and in the Falkland Islands. Analogies between Permian fauna and flora of South America and South Africa are accepted as evidence of a Permian continental mass, known as Gondwana, connecting South America with South Africa and India, the western limits of which are formed by the Argentine precordillera between San Juan and Jachal where the Permian layers are strongly folded. These folded Permian layers are continued southeastward by the sierras of the Argentine province of Buenos Aires and are known to geologists as Gondwanides. South of them, between the Negro and Chubut rivers, is the Patagonian massif, which consists, like the Brasilides, of very old rocks and may have been connected with an ancient antarctic continent. Against this massif and between it and the Andes, and antedating the latter. is a series of Cretaceous folds known as Patagonides. At the close of the Devonian there was widespread volcanic activity that covered with lavas large areas in what is now Paraguay and Brazil.

The importance of Jurassic and Ctetaceous marine deposits in the Andes is evidence that, during the Mesozoic period, the region now occupied by the Andes was a great geosyncline occupied by the sea between two continental masses, one of which has since subsided to form the Pacific ocean. This geosyncline connected at the north end with a sea that reached from the region of the present West Indies to the present Mediterranean and persisted through the Mesozoic and into the early part of the Tertiary. The South America-South Africa land mass (Gondwana) continued from the Carboniferous to the Cretaceous and may have persisted into the Tertiary.

There is no evidence on the present coast of Brazil of invasion by the sea between the Devonian and the Cretaceous, while the first invasion of the east coast of Patagonia and, consequently, the formation of the South Atlantic ocean dates from the Upper Cretaceous. The folding of the Andes also began in the Upper Cretaceous and continued into the Tertiary, although how far into the Tertiary is not known.

Great changes took place in the Tertiary period. The continent rose considerably higher than its present elevation, and the continental land mass was, consequently, much larger than at present, including such coastal islands as the Abrolhos Islands on the east coast of Brazil and the Falklands. It is possible, also, that, during this period, South America had land connection with New Zealand and Australia by way of the antarctic continent or through the South Pacific ocean. The formation of the Isthmus of Panamá with the resulting migration of North American faunal species to South America also dates from the Tertiary period; but its formation could not have taken place until the Pliocene, since the analogies between the marine fauna beds of Navidad (Chile). which date to the end of the Miocene, and European fauna of the same date can be explained only by the existence of free communication between Europe and the west coast of South America by way of the Tertiary Mediterranean up to the end of the Miocene. The elevation of the Andes during the Tertiary period was attributable in part to the elevation of the continent as a whole. It was in large part assisted by the folding of the rocks and the outpouring of lavas and the accumulation of other volcanic materials in the neighbourhood of the vents. Nor was this volcanic activity confined to the Andean region. It extended into Venezuela and the islands along the north coast, the Patagonian plains, the highlands of the Paraná basin and as far east as the islands of Fernando de Noronha. Toward the end of the Tertiary period subsidence again occurred and the sea entered the Amazon, Orinoco, Cauca and Magdalena valleys and the Maracaibo basin and again made an island or groups of islands of the Guiana highlands. In recent times volcanic activity has greatly diminished over the continent and has ceased entirely in its eastern and northeastern section.

Throughout the southern part of the continent there is evidence of several periods of glacial development and recession during the Ice Age. Ice covered the whole of the Patagonian plateau as well as the western side of the Andes but the continental glaciation did not extend as far north on the east side of the Andes as on the west. Throughout the Andean zone there is evidence that the

present glaciers are remnants of larger glaciers. There were no glaciers in the eastern or Brazilian section of the continent. (X)

#### CLIMATE

South America, the only southern continent to extend far into temperate latitudes tapers toward the pole, and hence does not experience the extremes of temperature of the northern continents. The winters in temperate latitudes are warmer and the summers cooler than in North America or Asia. The continent is broadest in the equatorial section and has larger areas of hot tropical low-lands and cool tropical uplands than any other continent.

Average annual temperatures in the Amazon basin are about 80° F., and seasonal variations are slight. Quito, near the equator but at an elevation of 9,350 ft., averages about 55° F. in every month. Seasonal temperature ranges increase with latitude and reach their maximum in northwestern Patagonia, where July averages 32° F. colder than January. Winter freezing at low elevations is common in Tierra del Fuego and Patagonia, is by no means rare on the Argentine Pampa or in southern middle Chile, and occurs in southern Brazil at elevations above 1,000-2,000 ft.

The northward-flowing Humboldt (Peru) current and associated upwelling water keep west-coast temperatures cool as far north as the equator. The coast of Argentina is cooled by the Faikland current. Elsewhere around the continent warm water washes the shores: the South Atlantic equatorial current flowing west encounters the bulge of Brazil and divides into the south-flowing Brazil current and a coastal current which flows northwest into the Caribbean; on the northern Pacific coast the equatorial countercurrent sends a warm-water eddy to wash the shores of western Colombia and Ecuador.

The rainfall pattern of the continent is closely connected with the distribution of winds and air masses. Most of tropical South America east of the Andes has prevailing winds from the northeast, east or southeast. These transport moisture from the warm Atlantic ocean and give copious rainfall by convection. Rainfall totals average 90-120 in. a year along the lower Amazon and the coast of the Guianas. The middle Amazon basin has somewhat less rain (60-70 in.), and the upper basin has more than 90 in., possibly exceeding 150 m. in exposed portions of the Andean foothills. The interior of the Brazilian bulge is generally dry and periodically subject to extreme drought. The Llanos del Orinoco and the Guiana highlands have moderate to high rainfall with a strong maximum in summer. Much of northwestern South America has two rainfall maxima associated with the two periods of high sun. The Pacific shores of Colombia and northern Ecuador are extremely rainy, while the Gulf of Guayaquil marks the transition to the dry west-coast conditions of Peru and northern Chile. The Atacama desert is one of the driest areas in the world. South of 33° S. rainfall is adequate west of the Andes, and south of 38° S. it becomes excessive. Cyclonic precipitation is characteristic of middle and southern Chile, associated with the westward movement of storms from the Pacific. Valdivia (lat. 40° S.) averages 105 in. of rain a year, and the fiorded coast farther south receives even more. Argentine Patagonia lies in the rain shadow of the Andes and is mostly steppe and desert. The grasslands of Argentina, Uruguay and southern Brazil have moderate rainfall (25-50 in.) well distributed throughout the year. Eastern Paraguay is moist (50-75 in.), while the Chaco is moderate to dry in rainfall and has a dry winter. (H. I. Bn.)

#### SETTLEMENT

Discovery.—The continent of South America was first visited by Europeans in 1498 when Columbus, on his third voyage, touched near the mouth of the Orinoco. Others soon came after and by 1509 the east coast had been followed as far as the Rio de la Plata. In 1513 Balboa discovered the Pacific ocean at the Isthmus of Panamá; in 1520 Magellan navigated the strait that bears his name; in 1527 Pizarro landed on the coast of Peru at Tumbez, and, in the same year, Cabot ascended the Plata and Paraná rivers as far as the mouth of the Bermejo; in 1533 Cartagena was founded and the native town of Quito peacefully occupied; in 1535 Pizarro founded Lima, and, in the same year Almagro

invaded Chile and Mendoza established a settlement at Buenos. Aires; in 1537 Jiménez de Quesada made his way from Santa Marta up the Magdalena river to Bogotá, the capital of the Chibchas; and in 1541 Valdwua founded Santiago de Chile and Orellana travelled from eastern Ecuador to the Atlantic by the Napo and Amazon rivers. It is claimed that the bay of Ro de Janeiro was discovered by the Portuguese in 1502. Afonso de Sousa visited it in 1531 but went on to São Vicente near Santos

Aboriginal Inhabitants.-In contrast with North America. which had few Indians, South America was peopled by several million aborigines. In the northern mountains were the Chibchas. and along the northern coasts were the Caribs and Arawaks, the latter extending southward. In Brazil and the upper Plata basin the Tupi-Guarani tribes predominated, with a semisedentary culture. The extreme south was sparsely populated by the barbarous Patagonians on the east and the warlike but disciplined Araucanians on the west. Far more numerous than all these tribes taken together, and more advanced in civilization, were the lowland Quichua and highland Aymara Indians who populated the Inca empire, stretching from southern Colombia to central Chile. They were ruled by the small, aristocratic Inca race in a complex paternalistic civilization based on enforced communal labour. They practised crop rotation, maintained highways and bridges, used stone in construction, worked the nonferrous metals and produced excellent pottery and textiles. Even among the Inca peoples, however, there was no form of writing, no wheel or saw, no keystone arch and no working of iron, and elsewhere in South America the Indian cultures were still more rudimentary. There were no domestic animals except for llamas in the high Andes. The dwellings were most commonly of adobe, although tile were not unknown, or in the tropical regions primitive palm huts. The food crops were maize, manioc, potatoes, millet (quinoa), beans and peppers, and the principal fruits were bananas and mangoes. The beverages were cacao and various brewed liquors.

Colonial Settlement, West Coast.—The initial penetration of the Spaniards was into the Inca region. Its primary purpose was to secure precious metals, and after seizing what the Indians possessed the conquerors turned promptly to the mining of additional supplies. Agriculture was necessary, however, to provide food and clothing; and in searching for gold and silver many places were occupied which were suited only for nonmining pursuits. The Spanish monarchs were zealous churchmen, too, and sought from the outset, through priests sent with the expeditions, both to convert and to improve the natives. Thus many settlements were based on farming, and all kinds of European domestic animals were introduced and propagated with diligence.

The principal mining regions were in the high Andes inland from Lima and in south central Bolivia. While gold extraction was widely scattered, with Colombia eventually leading, silver was far more plentiful; and the discovery of the huge "silver mountain" at Potosi in 1545 made that place for many years the largest population centre in the hemisphere. The principal farming areas were atong the Peruvian coast, where sugar, rice and maize were grown on a large scale, and in the "Central vale" of Chile, which was for a time the granary of Spanish South America.

Both mining and agriculture were based on the labour of the Indians, who had already been accustomed by their Inca masters to systematic toil. They were adapted without very great difficulty to Spain's encomienda system, under the direction of the mine owners and plantation operators who received grants from the Spanish crown. By the end of the 16th century, when the process of subjugation had been in good part accomplished, the Andean countries were organized in a wide system of agricultural and mining settlements. The number of Spaniards needed for troops and administration, as well as for mining, farming, industries, construction, roads and trade, was large, and these men at once formed irregular unions with the Indian women, since relatively few families came from Spain. The hybrid or mestizo populations which resulted from this intermingling soon swelled to large proportions, particularly in the lowlands; and the mestizos played an important auxiliary role as overseers and superior employees in all activities.

· As a basis for settlement the mining operations receded somethat in the 17th century, since the best deposits became partially exhausted, and other occupations increased. In the highlands the Merino sheep gave the Indians a large new industry. In Chile, Peru and western Argentina wine grapes and olives were grown. In Ecuador vegetable ivory, balsa wood and after 1700 cinchona were exploited. The numerous edifices and houses of European type were built of brick as well as stone or adobe, with the necessary wood brought from southern Chile. Boatbuilding was active.

Colonial Settlement, East Coast .-- Unlike the Andean west coast countries, the eastern regions of the continent had rather few Indians and for two centuries were not known to contain minerals. Settlement from the beginning was based upon agriculture and natural products. The Spanish occupation in the Plata basin was retarded by the southern Indians, with whom the Spaniards were at first unable to cope. They found in Paraguay, however, a well-watered rolling country peopled by the nonnomadic and nonhostile Guaranis, and Asunción in 1537 became the seat of Spanish operations. From it were founded towns farther down the river and eventually in 1580 the city of Buenos Aires. By the late 18th century the rich humus of east central Argentina was coming into use for grains, and the plains for cattle; while in the north and in Paraguay tropical crops and verba maté were produced. The absence of metals and inorganic combustibles handicapped other development, as did the Spanish prohibition of any trade except with Spain via Peru.

The settlement of Brazil, almost one-half of the continent, was undertaken through 20 captaincies granted to nobles for tropical plantations. Because the Indians were found to be ineffective workers, Negroes were imported in large numbers from Africa. Thus along the northern littoral, despite uneven management and deficient rainfall, the production of sugar, rice, tobacco, indigo and cacao soon became extensive; and dyewoods, cabinet woods and animal skins were also exported. Southward from Rio de Janeiro, and particularly in the cooler tablelands of São Paulo, a more European type of farming came into existence. The hardy pioneer population showed energy in subduing and utilizing the Indians, who were satisfactory workers, thus opening the interior of central Brazil. At the beginning of the 18th century came the discovery of gold, diamonds and a diversity of valuable ores in Minas Gerais, attracting an influx of population and making Brazil the world's main producer of gold for more than 100 years. In the south the settlement was more gradual, but came to be based on cattle and sheep.

Some Indian admixture was acquired by the gaucho herders in southern Argentina, while in Paraguay, southern Brazil and northeastern Argentina there were many unions with the Guaranis. In northern Brazil the preponderating Negro majority interbred freely with both Indians and whites, but segments of the Europeans, which included Dutch and French, kept their homogeneity.

Post-independence Development.-With the independence of the Spanish colonies in the early 19th century the last Spanish restrictions upon trade and local enterprise were swept away. Freedom to export to world markets aided the expansion of agriculture, even though factional strife hampered productivity. Road construction progressed, and after 1850 railways were built from many coastal points into the interior, usually with British and other external assistance. Wheat and hides from Argentina were sold in quantity to Europe. Coffee was introduced into São Paulo, and within a few decades gained for Brazil the pre-eminence in that staple which it thereafter maintained. Cacao became important in Ecuador, Brazil and Venezuela.

Immigration was actively promoted and reached considerable volume in the Atlantic countries. Agriculture on the west coast showed less expansion, because of remoteness and the exiguity of arable land, while mineral industries for a time flagged. In no part of South America did independence bring the breaking up of the vast landed estates, and agriculture in consequence did not have the stimulus of diffused ownership. A compensatory gain in Peru was the exploitation of guano on the Chincha Islands, and in Chile the export of natural nitrate from the Atacama desert. The arrival of manufactures from Europe at lower costs than in

colonial days was not favourable to South American industrial development, especially as motive power, industrial training and local capital were not available. Yet simple industries became widespread: textile mills multiplied greatly, cereals, sugar and leather were processed, and the output of clothing, furniture, footwear, soap, ceramics and beverages was everywhere augmented.

The decades just before World War I brought new developments. Natural rubber was exploited in the Amazon, but exports of nuts, waxes and skins proved more permanent. The Plata region built large packing plants and shipped chilled meat, while quebracho extract was produced in the Paraguay area. Along the Caribbean bananas were cultivated, and the mountain valleys of Colombia developed mild coffees. Chilean nitrate became a bonanza, and Chile began to utilize its coal and iron. Copper and tin mining were revived in the Andes, and manganese from Brazil and bauxite from Guiana entered world trade.

20th-Century Development .- The opening of the Panama canal benefited the west coast, and World War I gave added importance to South American metals. Both tended to shift trade away from Europe to the United States. After the war petroleum extraction was begun in Colombia and Venezuela; and postwar scarcity of manufactures, coupled with mounting nationalistic sentiment, stimulated factory projects for "national" goods. Governments secured large loans from New York city and London and improved roads, harbours and education. Both immigration and the birth rate rose. The universities and press participated in the modernization movement. The world depression of the 1930s reversed these trends as to metal exports and immigrant imports, although a number of Spanish republican refugees arrived with skills and capital. But popular discontent arising from the depression caused agrarian reform to be undertaken in several countries, to the ultimate advantage of agriculture.

World War II resuscitated all exports from South America, despite the German submarine campaign, and strengthened the continent's over-all financial position. Postwar exports levelled off at better than prewar volume, and the continent could afford large purchases of equipment. Many countries created official development corporations to promote hydroelectric power, new lumbering and metallurgical activities and general industrialization; and the indexes of industrial production showed gains of 50% or more as compared with the interbellum decades. There was a striking increase in the petroleum output of Venezuela, and that nation's vast iron ore deposits were opened up. Agriculture and sanitation were improved, with technical co-operation from the U.S. and U.N. Fisheries were expanded especially in Peru, and the crushing of vegetable oils was increased.

Commerce and Population .- The exports of South America by the 1950s were valued at approximately \$5,500,000,000 annually, with Argentina accounting for some 30%, Brazil 25% and Venezuela 22%. In typical post-World War II years, half of Argentina's exports consisted of grains and flaxseed, but meat, hides and wool shipments were large. Brazil furnished more than half the world's coffee and had some importance in cotton and cacao; Venezuela was the third largest mineral oil producer; and Colombia sold one-sixth of the world's coffee. Chile continued to ship mainly copper and nitrate; and Peru, although its minerals were substantial, was primarily a source of cotton and sugar. Uruguay exported wool, meat and hides. No other country had exports valued at more than \$100,000,000 annually, but Bolivia's exports of tin were large and significant. Nontropical food exports went mainly to Europe. For tropical foods, coffee and minerals the United States was the leading destination, with Europe, including England, a fairly close second. Exports among themselves by the republics were not large, except in the case of Peru's outward trade.

During World Wars I and II there was a shortage of merchant tonnage available for South America, and several republics consequently undertook governmental ownership and operation of shipping. Argentina by 1950 had 1,000,000 registered tons and Brazil 700,000 tons, while Chile, Venezuela and Peru also possessed respectable fleets. Coastal traffic was reserved to national vessels: but of the maritime traffic as a whole the major part was still borne by foreign ships, with the United States' share considerably increased since World War II. River traffic remained extensive on the Paraná-Paraguay river system and the Magdalena but relatively slight on the Amazon, which showed little development.

Railway construction, largely completed by 1914, was greatest in the countries having extensive interiors. Argentine railways by the 1950s had 27,000 mi. and Brazilian railways 21,000 mi., while Chile, Peru, Colombia and Uruguay each had 2,000 mi. or more. Argentina, Uruguay and Chile had fully integrated broad-gauge networks, and good progress in integration had been made in Brazil and Peru; but there remained many unconnected railways of diverse gauges. Many governments had taken over the ownership, and often the operation, of the railways from the original British and other foreign entrepreneurs. The railway freight traffic of the continent in 1950 was 25,600,000,000 ton-km., more than twice that of Australia but only five-sevenths that of Africa. Highway construction and improvement had increased rapidly, and Brazil had 160,000 mi. of roads, Argentina 38,000, Chile and Uruguay 25,000 each, Peru 20,000, Bolivia 15,000 and Colombia 12,000. Many of these roads were far from modern, and highway transit between countries, while usually possible, remained slight. In aviation South America had a remarkable development after 1930, as topography renders this mode of transport necessary and economic. Brazil and Colombia led the way, because of their geographic problems, but Argentina, Chile, Peru and Venezuela all established active air lines. There was considerable foreign collaboration in air enterprises.

For the decade ended in 1950 the population growth in South America was at a rate higher than elsewhere in the world. Of the total of 109,000,000 persons in that year, Brazil had 52,000,000, Argentina 18,000,000, Colombia 12,000,000, Peru 8,000,000, Chile 6,000,000 and Venezuela 4,500,000. The aggregate net immigration since independence had been about 9,500,000 persons, of whom some four-fifths had entered Brazil and Argentina, divided about equally. In both countries Italians constituted the largest group, with Portuguese second in Brazil and Spaniards in Argentina. German immigration was substantial in the 19th century and continued thereafter on a small scale. By the 1950s there were 2,000,000 persons of German blood in Brazil, Argentina and Chile, principally in southern Brazil. Immigrants from the eastern Mediterranean and eastern Europe had been numerous and were active in trade. Post-World War II immigration was small, except that of Italians into the Plata region. The immigration had been entirely white, and the proportion of white blood throughout the continent had in other ways also increased. While the Indian and Negro populations in the Andes and north Brazil were not decreasing, their habitats remained limited; and unions between them and the whites had long been unusual. Among the mestizos and mulattoes there had been a steady tendency for natural selection to favour the lighter strains, and most mestizos continued to be regarded as Caucasians having a quantum of Indian blood. The interior regions of South America remained sparsely peopled, since water-power sites, transportation and skills are more available near the coasts. The urban rather than the rural populations had shown the increases, and this meant the rise of middle-class elements.

the increases, and this meant the rise of middle-class elements.

Brillogarayra—C. H. Haring, The Spanish Empire in America (1947); M. H. Williams, The People and Politics of Latin America (1938); W. L. Schutz, Latin America (1930); T. B. Jones, An Introduction to Hispanic American History (1939); A. F. Macdonald, Latin American Politics and Government (1949); J. F. Rippy, Historical Evolution of Latin America (1946); George Wythe, Latin American Economic Development (1946); F. A. Carlson, Georgaphy of Latin America (1952); P. R. Olson and C. A. Hickman, Pan American Economics (1943); United Nations, Economic Survey of Latin America, 1943 (1949); Pan American Union, Selected Economic Data on the Latin American Republics (1948); United Nations Statistical Yearbook, 1951; United Nations Demographic Yearbook, 1951.

(W. Fr.)

## ARCHAEOLOGY

Before their discovery by the Europeans in the 16th century, the inhabitants of the South American continent lacked any form of script and, unlike the Maya and Aztecs of Mexico and Middle America, also had no type of recorded calendar. Consequently,

knowledge of the prehistory of the continent is based on local traditions, accounts written by the first discoverers and especially of a rachaeological field excavations. Since traditions of any significance are generally lacking except for the Incas of Peru, and since historical accounts are limited to the conquest period, the dependence on archaeology is even greater. Although much work had been done by the 1950s, there were still many unexplored regions so that reconstruction of the past was incomplete and uneven.

The earliest inhabitants of South America were nomadic hunters, fishers and gatherers who pushed southward from North America by way of Middle America and the Isthmus of Panamá. There are, to be sure, other possible migration routes including the transpacific, but the evidence for these was yet to be satisfactorily established in the 1950s. Remains of the early nomads had been found in such widely separated areas as highland Ecuador, eastern Brazil and southern Chile near the Strait of Magellan. The remains included skulls, none particularly primitive, and stone and bone implements.

The hunting and gathering pattern survived in southern South America until historic times, but elsewhere the development of more advanced cultures and civilizations was based on farming. Various centres of plant domestication have been suggested, such as the marginal areas of the tropical forest, the high Andes, Middle America and even the old world for such plants as the bottle gourd, sweet potato and perhaps cotton. Wherever the origin, the highest civilizations in South America were based on intensive agriculture, and this was best developed in the Andean mountains and along the Pacific coast, particularly in the central Andes, which includes the mountains and coast of Peru and part of Bolivia.

The gross outline of cultural development in the central Andes has been reasonably well established. The earliest remains, found on the north coast of Peru, represent a population that depended heavily on fishing and gathering of shellfish for its subsistence, but that also cultivated some domesticated plants, including the bottle gourd, squash, beans, chill pepper and cotton. These people had no ceramics but did make baskets, mats, crudely flaked implements and cloth from twined cotton fibres. They lived in small, subterranean houses and cooked their food by placing hot stones in some kind of water containers. Their remains are roughly dated as from 3000 to 1000 B.C. (These dates, as well as others used in this account, are approximations based on the radioactive carbon, or carbon 14, dates published by W. F. Libby in 1952).

Ceramics were introduced at approximately 1000 B.C., together with true weaving and domesticated maize and manioc, which initiated a long formative period during which many new techniques were tried and perfected. Systems of irrigation were established, new metallurgical techniques were invented, and many different shapes of sun-baked clay adobes were tried out in buildings. Religion too grew in importance, particularly in the Chavin culture. The stylized Chavin feline design, the dominant religious symbol, appears on stone carving, textiles, ceramics and other mediums in many parts of the mountains and the coast.

The long formative period was the basis for the distinctive regional cultures which flourished in almost every part of the central Andes from approximately A.D. 400 to 1000. This has been called the Classic period because of the high artistic and technical achievements in ceramics, metallurgy, weaving and architecture Some of the outstanding local cultures are the Mochica (also called Early Chimu) on the north coast of Peru, noted for faithfully modelled and realistically painted ceramics; the Nazca on the south coast, famed for polychrome embroideries and multicoloured clay vessels; Recuay in the northern highlands, with incised statues and small modelled figures on ceramic vessels; and Tiahuanaco in the Bolivian highlands, noted for polished and fitted stone masonry and low-relief carving.

Each of the regional cultures started to expand as it grew stronger, and conflict followed. The Tiahuanaco culture became dominant and achieved the greatest extension. It can be traced throughout much of Bolivia, north Chile and the coast and highlands of Peru. There are indications that this Tiahuanaco expansionist movement was strongly motivated by religion, but it was none the less sufficiently organized to eclipse most of the local

styles which it encountered. Although roughly dated from AD 1000 to 1300, there is no evidence that any true unity, political or religious, was maintained throughout this time period, and as its influence diminished, regional cultures once again reappeared, each now definitely formulated into local political units. At least one of these, the Chimu on the north coast, was well enough organized to be called a kingdom. Its arts and crafts reflected the traditions of the earlier Mochica now mixed with Tiahuanaco. Its population was numerous and was settled in large ceremonial cities, such as Chan Chan, near the contemporary town of Trujillo, Peru, or assigned to live in strategically placed garrisons. The political and religious organization shows many parallels to the Inca empire which followed.

The Inca empire, discovered in full flower by the Spanish conquerors in 1532, was thus the culmination of many years of cultural growth. The Incas contributed their genius for political organization and built up an empire which not only united all the central Andes but also extended north to Colombia and south to Chile and Argentina. For the Inca period the archaeological evidence is supplemented by traditions and by the written accounts from the early conquest years.

Unfortunately the accounts preserved are not in agreement on all points, and it is not easy to reconcile discrepancies. For instance, one of the most important documents relating to Inca civilization is the account of Garcilaso de la Vega, son of a lady of the ruling Inca house by one of the conquerors, who had been brought up in his mother's family and had exceptional opportunities for collecting the ancient traditions. But his natural sympathies led him to stress the virtues of the Inca regime to the point of exaggeration. On the other hand, the "official" history of Pedro Sarmiento de Gamboa was written rather with the idea of showing the Incas as oppressors and the Spaniards as liberators.

In general terms, the history of the rise of the Incas to power would seem to be as follows: Their history begins with a frankly mythological account of a migration from the south to Cuzco, under the leadership of Manco Capac. For years the Incas, living the same life as other Andean tribes, consolidated their power in the Cuzco valley, and then began to make their influence felt among the surrounding tribes. A career of conquest, undertaken partly as a religious crusade, eventually raised the tribe to the position of a ruling caste, whose sovereign was regarded as a god on earth. The history of this dim period is discussed fully in Philip A. Mean's book (see Bibliograbhy).

The first historical Inca (bearing the royal title of Sapa Inca) was Sinchi Roca, by most authorities recorded as the "son" of Manco Capac but, in Fernando Montesinos' list, separated from him by a long series of tribal rulers. His date may be set at about A.D. 1200. The list of Inca rulers in historical times (concerning which the early chroniclers are not quite in agreement) seems to have been as follows:

- Sinchi Roca
   Lloque Yupanqui
   Mayta Capac
   Capac Yupanqui
   Inca Roca
   Yahuar Huacac
- 7. Viracocha8. Pachacutec9. Tupac Yupanqui
- 10. Huayna Capac 11. Huascar 12. Atahualpa (usurper)

According to Means's account, the Inca power began to make itself felt outside the Cuzco valley in a southerly direction (among the Colla peoples) and was consolidated by Sinchi Roca's successor. Mayta Capac continued the policy of expansion toward the south, and the activities of these rulers led to the annexation of a large region, extending as far as Lake Titicaca, in the reign of Capac Yupanqui. The next two reigns appear to have been devoted to the settlement of newly acquired territory, but in the time of Viracocha a crisis arose which decided the fate of the cultured peoples of South America. West and northwest of the Inca domain, the Chanca people, living under similar conditions, had built up a powerful confederation. A clash was inevitable, and the struggle was desperate; but the Inca, supported by their newly acquired tributaries from the Colla, emerged victorious. As a result, a large expanse of territory was added to the Inca sphere, inhabited by cognate peoples, practising similar customs and religious observ-

ances, and therefore amenable to the new conditions. The annexation of the Chanca district opened the way to the coast, the conquest of which, for climatic and religious reasons, was a long and laborious process. The reign of Pachacutec seems to have been devoted to a reorganization of the Inca system in view of its new colonial responsibilities. But under Tupac Yupanqui and Huayna Capac, the two great "conquerors" of the Inca dynasty, Inca domination was imposed throughout the highland region from Tucumán in Argentina to Quito in Ecuador. The conquest of the Ica and Chimu peoples of the coast was a more laborious process.

John H. Rowe's account in 1946 (see Bibliography) confirmed the general sequence of Inca conquest but reduced the time span. According to Rowe, the first seven Inca rulers were obscure war chiefs, and the conquests attributed to them were probably only local raids. It was under Pachacutec, the eighth Inca, that true expansion began in approximately 1438. In this view, the Inca empire was built up in less than 100 years, which may help account for its rapid collapse following the Spanish conquest in 1532.

Architecture.—Extensive and large-scale building for both public and religious purposes was characteristic of all periods in the central Andes. In general, buildings in the rainy highlands were of stone, while on the dry coast the common construction material was clay. The highland site of Chavín, attributed to the early formative period, has symmetrically arranged temple units, some with three interior floors of intricate galleries, rooms and vents. The inner construction is of split slabs and rubble fill, but the outer facing is of dressed stone slabs laid in rows, alternating thick and thin. Low-relief carving and sculptured heads on tenons serve as wall ornament.

The Tiahuanaco masonry in Bolivia is noted for its well-dressed and fitted sandstone and basalt pillars and blocks. The typical facing wall has uprights set at intervals, filled between with smaller blocks. Fitting includes notches, joints and grooves for copper cramps. Monolithic gateways with relief friezes are associated, and stone carved heads and figures are part of the architectural plan. The Incas in their extensive building at Cuzco used various types of masonry, depending on the purpose and function of the construction. The zigzag walls of the triple rampart of the fortress of Sacsahuaman are made of immense slabs, each dressed and ground at the site for fitting. Similar walls in Cuzco employ this same "polygonal" style but with smaller stones. Other walls are built of small, rectangularly dressed blocks. Some constructions, such as the city of Machu Picchu, not far from Cuzco, show combinations of walls of rough stone and those of carefully dressed slabs and blocks. The principles of systematic bonding and accurate fitting were inherited from the Incas' predecessors, and, to take a single example, the apsoidal end of the great temple to the sun at Cuzco (the Coricancha) is a famous masterpiece of the early architecture of the Incas.

Contemporary accounts indicate that the roofs, even of the most important buildings, were constructed of thatching supported by beams. Exterior ornamentation was limited in the main to the breaking of plain surfaces by series of niches, but many, perhaps most, of the surviving stone-built ruins of pre-Inca and Inca times achieve their effect simply by their quality of massiveness and the perfect fitting of the blocks which compose them. Both the quality and the quantity of the masonry representing all the periods in the highlands mark the inhabitants as master masons. Apart from actual buildings, there exist throughout the area literally hundreds of miles of stone terracing, built for agricultural purposes on the slopes of the Andean valleys.

On the rainless coast buildings were constructed in sun-baked clay (adobe). In this region are found enormous structures in the form of stepped pyramids (especially at Moche, in the Trujillo area), often supporting the remains of shrines. All served a funerary purpose, since the early population buried their dead in what was the local "churchyard." Polychrome fresco designs are found on some of the walls.

The art of clay architecture attained a very high level in the Chimu period, and the great ruins of Chan Chan, near Trujillo, include long series of walls ornamented with intricately modelled designs, based mainly on textile art. Later buildings on the coast reflect the Inca conquest The severity of Inca stonework is reproduced in the local material, sun-baked clay.

Worship and Burial.—Detailed accounts of the Inca religious beliefs and practices exist, but for earlier times there are no records. The ceramic designs and temple wall decorations show numerous anthropomorphic figures, indicating that birds, animals and even plants were important in the religious concepts. However, more specific interpretation is limited to the occasional references in the Inca traditions, which state that the Tiahuanaco people worshiped a supreme god, Viracocha, associated with rain and thunder, and that the late period coastal people revered the moon and the sea.

The whole of Peruvian religion, in Inca times, is connected with the word huaca, belonging to the Ouichua dialect spoken by the Inca and employed throughout their empire as the official tongue. There is no one word in English which can convey its meaning. It means "holy" in the fullest sense (and was applied to the highest and most mysterious gods). Tribal gods and clan gods were huaca, and the meaning of the word was extended to include objects which were regarded as uncanny or merely unusual, such as a queerly shaped rock or a man with a harelip. The tribal huaca of the Incas was the sun, and their campaigns of conquest were in a sense crusades, to elevate the tribal god to a paramount position among the neighbouring tribes. They made no attempt to suppress local cults, but planted temples to the sun in conquered provinces and compelled the subject tribes to conform, at least outwardly, to the state religion. Lowest in the order of huaca came the personal and household fetishes, known as conopa on the coast and chanca in the highlands, usually small stones of peculiar shape or colour, or any unfamiliar object. Many of the ruling Incas possessed personal fetishes or "familiars," called huauqui.

Throughout the region the cult of the dead occupied a very important place in religion. Many of the tribal and clan huaca were regarded as ancestors, and a similar sanctity attached to the mortal remains of human forbears. The burial rites afford an interesting parallel with those of Egypt. The Egyptian process of mummification arose from the local climatic conditions. The fact that bodies buried in dry sand did not decay led to the idea that the preservation of the body was a matter of importance, and so to the evolution of special means to arrest corruption. The dry air of the highlands in Peru and Bolivia and of the coast provided a parallel environment and produced similar results. In either region the bodies of the dead became desiccated, and in certain instances the preservative tendencies of the climate were assisted by the evisceration of the corpse before burial. The body was usually arranged in a contracted position (unlike the Egyptian mummy) and, after being wrapped in various folds of textile or netting, deposited in a cave (highlands) or a communal grave or "churchvard" (coast). The "mummies" of the ruling Incas were preserved in the great sun temple at Cuzco, where they were seen by the first Spanish invaders. These mummies were huaca of a high order, and those of important persons were paraded at certain festivals to the dead. The word huaca exists today as applied to the temple ruins and to the aboriginal burial grounds.

Arts and Crafts.—The skill of the ancient Peruvians in stone masonry has already been described in the section on architecture. Although stone carving is associated with some of the highland temples, sculpturing as such was not advanced; the carvings were largely confined to incision and low-relief decoration on flat surfaces. The Incas were particularly skilled in making stone bowls, club heads, axes and other artifacts.

Gold, silver, copper and tin were obtained by panning and pit mining and reduced and refined in furnaces. Some metals were used in the pure state, but alloys of gold and silver, copper and gold, and copper and tin (bronze) were also made. The metals were fashined into utilitarian objects, such as points for digging sticks, pins, knives and axes, or worked into decorations and ornaments, such as breastplates, face masks, ear plugs and necklaces. The Inca (that is, the ruler) dined on gold and silver service and had gardéns in which flowers were imitated in the precious metals. The metals were hammered, cast in open and closed moulds and shaped by cutting and joining. Several methods of soldering were

practised, and the art of gilding copper was also known.

The potter's art was highly advanced, and ceramics furnish the best basis for archaeological distinctions of regional cultures and time periods, since they not only present different styles of decoration but also are well preserved both on the coast and in the highlands. The pottery of the earliest periods, particularly Chavin, is thick, dark monochrome coloured and decorated largely by incision, punch and scratching. The later periods are characterized by panted designs in from one to eight or more colours.

The most distinctive and artistic ceramic styles are found in the Classic period of high technological development. The Mochica ceramics are characterized by their excellent modelling and highly realistic bichrome painting in red on a cream-white base. The vessels were commonly made in moulds, unlike other areas where the coiling technique was generally employed. The so-called "stirrup spout," formed by two arched tubes meeting in a single spout, is typical. The modelling and the painting faithfully portray plants and animals, scenes of hunting and fishing, house types and many other aspects of the culture, including modelled portraits of the important rulers. The Nazca pottery is highly polychrome and portrays elaborate animals and stylized figures on tall goblets. and bell-shaped containers topped by two short spouts connected by a flat bridge. Recuay ceramics in the highlands emphasize variety of shape, small figure modelling and painting in a resist, or negative, technique.

The Tiahuanaco culture, which spread throughout Peru following the Classic period, is characterized by polychrome ceramics, painted in black, white and other colours on a red base. Flaring sided cups and goblets are the most typical shapes, decorated with conventional representations of pumas, condors and running human figures. Following Tiahuanaco, the ceramics become more drab. The Chimu pottery is largely of smoked blackware with emphasis on modelling but of a quality inferior to that of the ancestral Mochica. Ica, or Late Nazca, pottery lost the colour variety and imagination of the Nazca and was reduced to black, white and red painting of small geometric figures largely derived from textile patterns.

Inca pottery is frankly geometric, although utilizing many colours. Typical shapes are tall collared aryballoid jars with wide loop side handles and conical bases; pedestal bowls; and shallow dishes with single curved handles ending in a modelled bird head. This characteristic pottery is found from Ecuador to Argentina and serves as an archaeological confirmation of the historical accounts of the extent of the Inca empire.

Peruvian textiles have been considered as among the finest in the world from the point of view of fineness of thread, variety of techniques and range of colours. Native cotton, wool from the llama, alpaca and vicuña, and an agave bast were the principal fibres. The loom is known as a "girdle-back" type, since the lower bar was attached to a belt which encircled the weaver's back. Shedding was accomplished with a flat weave sword and a simple heddle consisting of a stick attached to alternate warps by means of a looped cord. For the pattern tapestry weaves the weft was inserted by hand with wooden, copper or thorn needles.

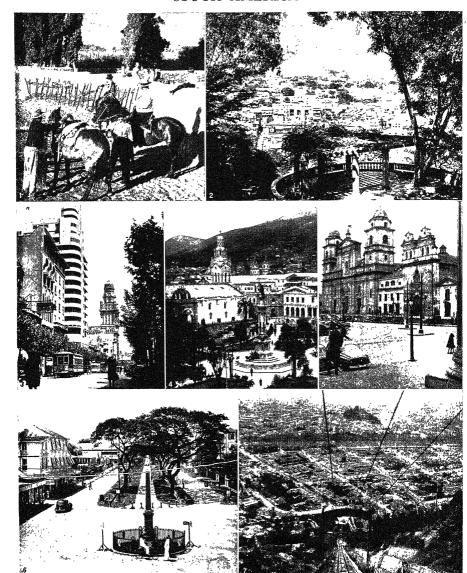
In spite of the simplicity of the loom and the weaving process, virtually every known weaving technique is represented in the ancient Peruvian collections. Plain weaves are decorated with simple warp or weft stripes, ginghams, and with such applied techniques as embroidery, feather mosaic and attached metal or shell bangles. Tapestries are outstanding in fineness of weave, and, although many methods of interlocking colour areas were known, the vertical slits were frequently left open as part of the design (like the oriental kelim). Warp and weft pattern weaves, gauze, brocade, tie dye and ikat dye are not uncommon.

The textiles from the Nazca region (particularly the Paracas site) are characterized by elaborate polychrome embroidered designs, and complex fringes of needle knitting. The Tiahuanaco period specialized in tapestry techniques. In the Late Chimu period a double-faced cloth, with reciprocal patterns, was woven on a simple loom equipped with two heddles and two shed sticks; a process involving two warps and two wefts (for further details see Bibliography, especially the Lila M. O'Neale monograph).



# VIEWS OF SOUTH AMERICA

- 1. Indian mule drivers on a mountain pass near Sorata, Bolivia
- 2. Air view of Botafogo bay, Rio de Janeiro, Brazil 5. Court in the ministry of the 3. The president's palace, often called the "Casa Rosada," in Buenos Aires, Argentina
- 4. The congress building at Asunción, Paraguay
  - 5. Court in the ministry of the interior at Carácas, Venezueia

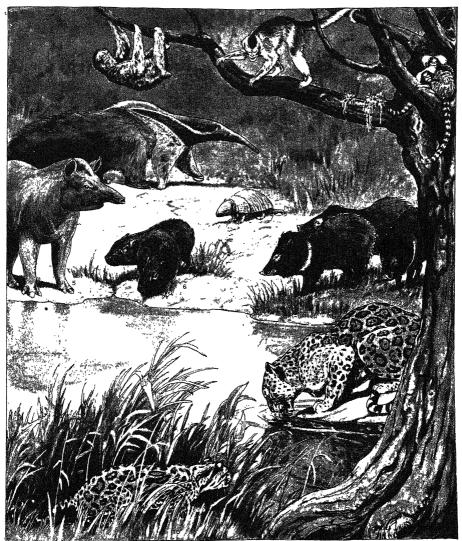


SOUTH AMERICAN SCENES

- 1. A ranch in Chile
- 2. Carácas, Venezuela, as seen from Calvary hill

PHOTOGRAPHS, (1) E. P. HADDON-PIX (2, 3, 7) EWING GALLOWAY, (4, 5) P

- 3. The Avenue 18th of July, main thoroughfare of Montevideo, Uruguay 7. Santiago, Chile, viewed from the funicular on San Cristóbal hill 4. Plaza and cathedral in Quito, Ecuador
- 5. Cathedral at Bogotá, Colombia, fronting the main plaza
- 6. The main street of Georgetown, British Guiana



PAINTED FOR THE ENCYCLOPÆDIA BRITANNICA

# SOUTH AMERICAN MAMMALS, BY CHARLES LIVINGSTON BULL

The mammals native to South America embrace many exceedingly interesting forms though none attain the immense size of various

Old-World and North American animals. The Illustration portrays types of several important groups.

For details see the articles on the animals shown

Al or Three-toed Sloth (Bradypus tridactylus).
 Capuchin Monkey or Sapajou (Cebus capucinus).
 White-eared Marmoset (Hapale

jacchus). 4. Great Anteater (Myrmecophaga jubata). 5. Tapir (Tapirus terrestris). 6. Capybara (Hydrochaerus capybara). 7. Hairy Armadillo (Dasypus villosus). 8. Collared Peccary (Dicotyles tajacu). 9. Jaguar (Felis onca). 10. Ocelot (Felis pardalis) .

Social Life.—The Inca rule was a form of state socialism, based on the idea that the sovereign was the earthly representative of the Inca tribal god, the sun. In the course of expansion, and the meticulous organization of conquered provinces, the Incas, from a tribe, became an official caste, constituting eventually a huge bureaucracy. The inhabitants of the highlands acquired a mentality remarkably responsive to discipline. The expansion of Inca rule was, to the populace, merely a change of overseers.

The socialistic system seems to have dated from the earliest times; under Pachacutec it was adapted to the needs of colonial expansion Eventually the empire was divided into provinces. each under the control of a hereditary curaca (often a local chief, confirmed in his office because of ready acceptance of the new regime), and a hierarchy of officials ranging from subchiefs to subordinate inspectors whose supervision was limited to a few families. Intensive supervision was a condition of the peculiar form of government. All produce, agricultural, pastoral or industrial, was fundamentally state property. Trade was practically nonexistent. Labour manual, operative and official, was state tribute, and some form of labour was exacted from every member of the community. Lands were apportioned for cultivation to the commoners, the church and the state. The produce of the state's land supported the Inca caste, and any excess was distributed according to a regular system. Public granaries were maintained by the state in many parts of the country. This system permitted an equal food supply throughout the empire; the surplus of the maize crop, for instance, in the fertile valleys, provided for the upkeep of a large herdsman population in the sterile uplands and also for the relief of drought.

Craftsmen (weavers, potters and metalworkers), though not entirely exempt from agricultural work and corvée labour (involved in the construction of roads and state buildings), were in the main supported by the agricultural population, which, in its turn, received a proportion of textiles and other manufactured goods. The distribution of raw material as well as manufactured articles was carried out on a regular system; to take one instance, the weavers received a regular allowance of cotton and llama (or. alpaca) wool, from which they were expected to produce a certain amount of woven material. Knowledge of the carefully organized interchange of produce is based mainly on Garcilaso de la Vega's account, which is probably overdrawn, but there is no doubt that the main lines are correct.

The system was perhaps less perfect than appears from his description, yet there is no question of the drastic measures employed by the Incas in the organization of conquered territory. Whole sections of the population were transferred from one part of the empire to another. Such enforced colonists were known as mitimaes, and the practice served a double purpose, political and economic. In the first place it was a safeguard against insurrection; in the second, it provided for the population of uninhabited areas. Under a system of this type a rigid population survey was a matter of first importance, and a careful census was made from time to time, the records preserved on the knotted cords known as quipus (q.v.; and see L. L. Locke, The Ancient Quipu [1923]). It was equally important that there should be no shifting of population, except under state supervision; consequently an individual born to a certain occupation in a certain locality could, in normal circumstances, neither change his trade, move from his village nor even marry outside his local group. The system involved the suppression of personality or enterprise but provided comparative security to the individual.

Behind the state organization lay the community, still imperfectly studied and obviously far older than the imposed Inca regime. Local family groups, which appear somewhat like true clans (known as ayllu), practising the cult of a common huaca, existed within the tribal complex of the Peruvian aborigines.

The administration of the enormous length of mountainous territory governed by the historical Incas necessitated rapidity of communication, and a service of professional runners was maintained; they traversed the country in relays, from rest house to rest house, along the roads which are still traceable from Quito to northern Argentina. In the highlands these tracks are often in

the form of stairways cut in the faces of precipices.

Among the populace marriage was arranged, under supervision, within the local group. But the ruler himself was limited to certain restrictions. He was allowed to maintain a number of concubines, but, according to some authors, his normal consort (coya) was his sister, who alone could bear him a successor. This seems to suggest that rank followed the female line and that Peruvian inheritance was based on a matrilineal system. Here again, chance was on the side of the Spanish invader. Pizarro arrived just at the moment of a grave politico-religious crisis. Huayna Capac had died recently. His legitimate heir, by his sister, was Huascar But a pretender, who asserted that he was the son of the late emperor by a daughter of the chief of the lately added province of Quito, had assembled a force of Ecuadorian mountaineers and, by a coup de man, had captured Huascar.

Pizarro, by means which it is difficult to describe save as sheerly treacherous, seized Atahualpa. Atahualpa gave orders for the execution of Huascar, and these orders were obeyed. The motive power behind the Inca empire therefore ceased to exist. Huascar was dead, and Atahualpa, who by force of arms might have taken his place, was a prisoner. The Inca organization was for the moment like a clock without a mainspring, though the works were otherwise unimpaired. Yet the organization was so complete that when the Spaniards by a lucky random stroke, held in their possession the person of the only possible claimant to the position of divine ruler, they were able to set the wheels going to their own advantage. Naturally there was a certain amount of opposition but Pizarro had little to face in this respect compared with Hernan Cortes. His main difficulties lay in the dissensions which arose among the Spaniards.

Allusion may be made to the system of training which was imposed on boys of prominent Inca families in the capital, Cuzco. Lads of prominent families, destined to the higher posse in administration and the army, were subjected to a severe training of a public-school nature (which the heir to the throne also underment) and submitted to severe tests. The culminating ceremony was a race from the sacred Huanacauri hill to Cuzco, after which candidates who had passed received certain insignia of nobility, including the ear ornaments which distinguished the ruling caste.

Other Cultures of South America.—Archaeological remains elsewhere in South America are less complex than in the Andean region described above. The northwestern provinces of Argentina were the centre of the Calchaquí or Diaguite culture, reflecting influences of Tiahuanaco and Inca civilizations plus certain local modifications. The Tiahuanaco and Inca influences are also in evidence in the cultures of northern Chile. Both the northwest Argentina and the northern Chile regions seem to have had a common cultural stratum, called Atacameña, older in chronological position than the Andean-influenced periods. The frequency of urn burial, particularly of children, in the Calchaquí region is in marked contrast with pre-Spanish Peru, where this mode of burial despot occur.

Archaeological remains from southern Chile and Patagonia confirm the early ethnological observations that simple nomadic hunters occupied this area. The excavations of Junius Bird in 1936-37 indicated that the territory near the Strait of Magellan had long been occupied by such hunters, since the oldest remains found were definitely associated with extinct forms of the horse and ground sloth.

The vast area of the Amazon jungle has furnished but few archaeological sites, but the elaborately ornamented urns and vessels from the island of Marajó in the mouth of the Amazon, and from the site of Santarem at the mouth of the Tapajos river, indicate fairly advanced cultures. These remains have been tentatively identified with an early Arawak people, and it seems probable that an antiquity comparable with the early Andean periods will some day be assigned to them.

The Northern Andes.—Ecuador and part of Colombia were conquered by the Incas shortly before the Spanish conquest. Quito, in Ecuador, had risen almost to the rank of a second capital of the Inca empire. To say the least, remains of Inca buildings and ceramics are abundant. Archaeological remains antedatings and ceramics are abundant.

ing the Inca conquest show that the cultures were well advanced. In Ecuador the mythological history speaks of the Caras of the coast advancing to the highlands, where they amalgamated with

the Quitu tribe and subsequently with the Puruhá.

In Colombia the site of San Agustin is outstanding for the number and variety of large stone statues. Elsewhere regional ceramic types can be isolated which show influences from the central Andes and from Central America. Particularly characteristic is a style of ceramic decoration known as "negative" painting, a technique of reservation of patterns in the ground by means of wax painting or some analogous process.

BIBLIOGRAPHY.—Detailed summaries of South American archaeology together with comprehensive references to published sources may be found throughout the six volumes edited by J. H. Steward, Handbook of South American Indians, Bureau of American Ethnology, bulletin 143 (1946–50). Vol. ii of the Handbook also contains an article on the Incas by J. H. Rowe. T. A. Joyce, South American Archaeology (1912), covers the whole continent. General coverage as well as detailed treatment of the central Andes is found in W. C. Bennett and J. B. Bird, Andean Culture History (1949). A comprehensive treatment of Andean archaeology and history, as well as an excellent bibliography of early Spanish sources, may be found in P. A. Means, Ancient Civilizations of the Andes (1931). The bulk of archaeological literature has been published in the form of monographs and articles. Some of the important journals are: Journal de la Société des Américanistes de Paris; Revista del Musco Nacional (Lima); Journal of the Royal Anthropological Institute; American Antiquity. Current bibliography is reported annually in the Handbook of Latin American Studies. The Reports of the International Congress of Americanists contain many pertinent contributions. Carbon 14 dating techniques are described by W. F. Libby, Radiocarbon Dating (1942); L. L. Locke, The Ancient Quipu (1932), analyzes the Inca knotted string records; and special textile studies are found in M. D. C. Crawford, American Museum of Natural History, Anthropological Papers, vol. xii, Lila M. O'Neale, Field Museum of Natural History, 1937) and Raoul d'Harcourt, Les textiles anciens du Pérou et leurs techniques (1934). Detailed mention of the many monographs is not possible here, but the field reports of such authors as the following may be found in the bibliographical sources cited above: W. C. Bennett, J. B. Bird, S. Debendedti, H. U. Doering, I. Jijón y Caamaño, A. Kidder II, A. L. Kroeber, R. Larco (M. D., C. Tallo, W. Uhle, L. E. Valcárcel and G. R. Willey.

## **ETHNOLOGY**

South American types of culture, which extend throughout most of Central America and the Antilles, have been divided by different authors into a varying number of areas. The present description uses the fourfold classification of the *Handbook of South American Indians:* (1) Andean civilizations; (2) circum-Caribbean peoples; (3) tropical forest tribes; and (4) marginal, hunting and gathering or prefarming tribes.

The development and differentiation of South American cultures into these four principal types and innumerable subtypes was largely autochthonous. The biological characteristics of the Indians of North and South America are very similar, and there is little doubt that South America was originally populated by migrations from North America via Mexico and Central America. Evidence of transpacific influence in native American culture is slight and cannot account for the principal cultural developments of the latter. Carbon 14 dates show that man had reached southern Chile by about 7000 B.C., when the extinct ground sloth still survived. A similar antiquity of man in North America is proved by carbon 14 dates. Both continents, however, may well have been inhabited much earlier. The diversity of South American Indian languages also proves a long separation of the groups not only from one another but from their Middle American and North American relatives.

Racial Type.—Variation in head form, stature, and other features has been regarded by some scholars as evidence of admixture of Australian, Negroid and other old world races with the basic Mongoloid race, but this theory has been questioned because substantial transpacific migrations are improbable.

Linguistic Groups.—J. Alden Mason's linguistic classification in the Handbook of South American Indians lists 66 major independent groups and 22 other groups which are unclassifiable on the basis of present information. Future analysis will undoubtedly greatly reduce this number, but the position of many extinct

groups can never be known. No South American languages have been proved to be related to any old world languages, nor, with the exception of certain Central American dialects, to any North American languages.

Central American stocks of Mexican and North American affiliation are Subtiaba and Maribichicoa, belonging to Hokan-Siouan; Nahuatl and Aztec, belonging to Utaztecan; Lecan, Jicaquean and Payan, all possibly belonging to Macro-Penutian; and several dialects of Macro-Otomaguean.

The following languages are limited to South America. The phyla, each of which includes several stocks, are Macro-Chibchan, Macro-Ge, Macro-Guaicuruan and Macro-Tupi-Guaranian. The lesser families or stocks are:

Alacalufan Araucanian Arawakan Ataguitan Auakean Bororoan Cahuapanan Calianan Canichanan Carajan Cariban Caririan Catukinan Cayuvavan Chapacuran Charruan Chiquitoan Chonan (Tehuelche-Ona) Comechingon-Savavironan

Cucuran Fulnioan Guahiban Guaitacan Guatoan Huarpean Itonaman Lecan Lule-Vilelan Macuan Mascoian Mosetenan Moviman Muran Nambicuaran Opavean Otian

Shocoan
Shucuruan
Taririuan
Teremembean
Timotean
Trumaian
Tucanoan
Warrauan
Yanganan
Yunca-Puruhan
Yuracarean
Yurumanguian
Zamucoan

Puelchean (Het)

Puinavean Quichua-Aymaran Saliva-Macu-Piaroan

Shirianan

The Central Andes.—The Indians of Peru and Bolivia achieved the highest native civilization of South America. Their archaeological remains, which are dated with fair accuracy by carbon 14, show prehistoric development in some detail.

Pancararuan

Prior to 3000 B.C., the Andes were sparsely populated by hunters, gatherers and fishermen. The first farmers lived in small, independent villages, growing Canavalab beans, gourds and cotton and making bark cloth, pottery and twined or finger-woven fabrics. Genetics show that the cotton had a south Asian ancestor, which is certain proof of transpacific influence.

Between 1000 B.C. and the time of Christ, the Andean people began to cultivate several indigenous American plant domesticates (mais-quash, Phaseolus beans, peanuts and perhaps manioc), and they domesticated the llama as a source of wool and meat and as a beast of burden. They wove textiles on true looms and invented metallurgy, first in gold and later in copper. Expansion of agricultural production required intervillage co-operation in construction of irrigation works. Religious temples built upon mounds were perhaps the centres of theocratic states, but these states were also militaristic as evidenced by weapons and certain burials which contain warrior-priests

During the millennium after Christ, generally known as the era of regional florescence, a series of localized, theocratic-millitaristic states developed throughout the central Andes. The largest mounds and temples were built, and the finest work in metallurgy, ceramics, weav-

ng, painting, sculpture and other arts was produced.

About a.b. 1000 most of the central Andes may have been brought under a single empire centring at Tiahuanaco in Bolivia, after which local states regained independence until the conquest by the Quichuaspeaking Incas began in the middle of the 15th century. When the Spaniands arrived in 1532, the Incas controlled the Andes from southern Colombia to northern Chile. The empire was highly centralized under the absolute authority of the Inca, the divine ruler and son of the sun-god. Rulers of formerly independent states were kept in power but became subservient to the Inca royal family. Local forms of religion—household and village shrines and state temples—were made secondary to the imperial sun temple, which was served by a large priesthood and to which convents of virgins were dedicated.

Inca (q.v.) society was rigidly class structured. Under the Inca, who was so exalted that he might marry only his sister, were the nobles, which included the royal family and local rulers. Below these were the common people who tilled special plots of land for the sun temple, for the state and for themselves; who provided soldiers for the conscript armies; and who supplied special artisans and servants for the nobility. The commoners were rigidly controlled and had little chance to improve their status.

to improve their status.

Inca economy was based upon irrigation agriculture. Canals watered miles of terraced mountainsides as well as valleys. There were more than 50 domesticated plants including potatoes and quinoa, the high-allitude staples; maize, beans, pumpkins and others in the middle and low altitudes; and sweet potatoes, pineapples and many fruits in the lowlands. Starchy vegetables and fruits were fermented to make

chicha, a beer. Coca and tobacco were cultivated, but these drugs had religious uses.

had religious uses.

The Incas were builders, producers and organizers rather than intellectuals and aesthetes. They built huge mounds, palaces, temples, cities and irrigation works and linked their empire with roads and suspension bridges. They produced superb textiles and ceramics, ceremonial and art objects of gold, silver and copper, and weapons of bionze in quantity and in standardized forms. They organized an empire of more than 6,00,000 people. But they never achieved writing, calendrical systems or aesthetic skills such as those of Meao-America. They never here wirm the wheel more sales in the standardized forms. They never knew iron, the wheel, porcelling glass and many other old world accomplishments. Whatever influence came from the old world—penhaps cotton, calabashes, bark cloth, the blow gun and a few others—were isolated items and did not constitute a basic part of native civilization.

civilization. The Circum-Caribbean Culture.—This culture was distributed through Central America and Colombia, especially among Chibchanspeaking peoples, in Ecuador, among the Timoteans (q v) in western Venezuela and among the Arawakans (q v) in the Greater Antilles. The culture was adapted principally to the highlands Some lowland articulates of this type, but others had a tropical forest culture, constituting enclaves within the cucum-Caribbean area.

This culture resembled that of the tropical forests in its palisaded villages, thatched houses, household furniture and farming pattern (but many tropical fruits were grown in addition to root crops). It was distinctive in its state organization and its possession of many traits derived partly from Meso-America and partly from the Andes: metal-lurgy in gold, copper and several alloys, working of precious stones, monumental stone sculpture, construction of roads and bridges, agri-cultural terracing, temple mounds, human sacrifice and ritual can-

The circum-Caribbean states were based either upon conquest, as in the case of the Chibcha or Muisca of highland Colombia, or upon confederation, as exemplified by the confederacy of the Pancent, Fincent and Centifens of northern lowland Colombia. The supreme and usually hereditary ruler held great power and high status manifest by his many servants and wives or concubines, his travel in a litter, the obeisance accorded him by his subjects and the burial of his body together with accuted film by suggests and the both of his body opening must be followed by the luxury goods and the bodies of his retainers. A class of nobles held hereditary status in some areas but more often achieved status in two ways. First, men with supernatural powers became priests who conducted religious rites and human sacrifice in special temples. Second, successful warriors gained prominence through providing war captives as victims in sacrificial rites, through displaying human trophies (scalps, skulls and whole bodies preserved and stuffed) and through adding captive women to their households as concubines and agricultural These general circum-Caribbean features were found most workers. These general circum-Caribbean features were found most typically in Colombia, Ecuador, parts of Central America and in the Venezuelan Andes. The Arawak of the Greater Antilles had small states based upon religious hierarchies, but they lacked warfare, human sacrifice, temple mounds, monumental stone sculpture and metallurgy except placer gold.

The Tropical Forest Tribes,—The tropical forest culture was

found throughout the low, humid rain forests of the Amazon and Orinoco basins, coastal Venezuela, the Lesser Antilles, coastal Brazil and parts of Central America and Paraguay. It included many linguistic groups, the most widespread of which were Arawakan, Cariban (q.v.)

and Tupi-Guaranian (see Tupian).

Tropical forest tribes characteristically farmed root crops such as manioc, sweet potatoes and species of Diaccorea, but they also grew maize, beans and peanuts. To remove the poison from the bitter species of manioc, the most important native crop, they used a basketry squeezer. Because of soil exhaustion farm plots were cleared anew every few years by the slash and burn method: trees were ringed and burned and the crops planted between the stumps. To supplement the starchy vegetable diet, fish, turtles and manatees were taken in the rivers, and wild game was hunted in the forests with spears, bows and blowguns.

Villages were fairly permanent, usually being located on rivers, and they were often palisaded. Each consisted of one or more large, pole-and-thatch houses. The household typically consisted of a patrilineal lineage (that is, several families related through the male line), but in the Guianas it was matrilineal. Patrilineal clans occurred among the Mundurucu. Community chiefs were often shamans, whose authority was backed by supernatural power. The shaman generally devoted himself to curing sickness, but in some areas he presided over com-munity rites held for such purposes as crop fertility.

munity rites held for such purposes as crop fertility.

Warfare was a major preoccupation among some but not all tropical forest tribes. The Yagus of the upper Amazon did no fighting. Tupinamba warriors took prisoners whom they tortured and ate. Scalps were commonly taken, but headhunting was more limited. The shrunken heads made by the Jivaro of eastern Ecuador gave special powers to the takers. No tribes fought to conquer territory, and few took slaves.

Birth, puberty and death rites were common. Many tribes practised Birth, puberty and death rites where common. Many times practised the couvade, whereby the husband is confined for a certain period after childbirth. Puberty initiations variously included ant ordeals, especially for men, the cutting of hair, whipping and imbibing drugs. Earth burial, turn burial and cremation were practised in different areas. The material adjuncts of tropical forest life included hammocks,

dugout canoes, twilled and checker basketry, loom weaving, ceramics, wooden stools, rubber balls and syringes and bark cloth. Many body

wouden stoods, rudder data stringes and dark rudth. Many body ornaments were worn, but clothing was scant.

The Marginal Cultures—Cultures based on hunting, gathering and fishing occurred in areas unfavourable for digging-stick farming—the grassy pampas, arid Patagonia, the cold Chilean archipelago, the arid eastern Brazilian highlands and certain isolated areas scattered around the headwaters of the Amazon. These areas were sparsely populated, the social groups were small and generally based on kinship ties, the settlements were impermanent and shifted seasonally, the religion was largely shamanistic, and warfare consisted only of personal feuds or defensive fighting. The marginal tribes typically lacked ngon was laigely snamanistic, and warrare consisted only of personal feuds or defensive fighting. The marginal tribes typically lacked farming, domesticated animals (except the dog), pottery, loom weav-ing, metallurgy, permanent houses, religious structures, social classes, political institutions and leadership superceding informal kinship controls, group religious observances, priests and warfare for conquest or tribute

Subdivisions of the marginal tribes include the archipelagic tribes, Subdivisions of the marginal tribes include the archipelagic tribow, which lived in family groups, travelling the coast in bark canoes and subsisting upon shellfish and sea fowl; the Pampean tribes of Tierra del Fuego and Patagonia, which were guanaco hunters, grouped in small, patrilineal, patrilocal, exogamous bands of 50 or 60 persons; the Gespeaking tribes of eastern Brazil, which were small-scale farmers and were notable for their proliferation of moieties or dual groupings within each village for purposes of games and ceremonies, of age-grade so-cieties of men and of men's houses The marginal tribes around the headwaters of the Amazon were isolated groups that had failed to borrow farming, permanent houses, dugout canoes, weaving, ceramics and other features characteristic of the tropical forests.

Bibliography — Julian H. Steward (ed.), Handbook of South Amer-

LILLOCKAPHY—Juliah H. Steward (ed.), Indiadoso of South American Ethnology, bulletin 143,6 vol. (1946-50); Wendell C. Bennett and Junius B. Bird, Andean Culture History, American Museum of Natural History, Handbook Series no. 15, (1949); C. Wissler, The American Indian, 3rd ed. (1938); Paul Radin, The Indians of South America (1942).

SOUTH AMERICAN LANGUAGES. The languages of South America are for the most part still very imperfectly known, and the number of linguistic stocks considered independent of and unrelated to any linguistic family in the New or Old World is reckoned at 75.

For many of them we have only vocabularies, often very scanty and of doubtful accuracy. Grammars are rare and nearly all compiled on the model of Latin by missionaries who did not realise that the methods of Latin are totally unsuited for describing languages with essentially different structure and syntax. Finally for most of the languages we have no ancient material. On the Pacific side the main languages are as under:

Chibcha was once spoken almost all over Colombia up to the frontier of Nicaragua and northern Costa Rica, with representatives as far as the latitude of Guayaquil in Ecuador, prior to the Inca invasion, when Chibcha speech was ousted by Kichua

on the Andean Ecuadorian plateau.

Kichua.-The language of the Inca, Kichua or Runa-Simi, is still spoken by Indians on the high plateau of Ecuador and Peru, in Bolivia (Cochabamba, Chuquisaca and Potosí), in the northwest of the Argentine (Jujuy, Santiago del Estero). It is the only language in America which was an element of civilization before the Discovery, when it was the instrument of an invading culture brought by an organized conquering people. Inca imperialism forced it on the vanquished peoples, then the Catholic missionaries completed the work of the overlords of Cuzco.

Aymara. Speakers of Aymara exist in Peru (in two provinces of the department of Puno and in the departments of Arequipa and Moquegua) and in Bolivia. Before the spread of Kichua it was more widely diffused and the builders of the famous monuments of Tiahuanaco almost certainly spoke it.

Araukan .- This language still exists in Chile between the Pacific and the Andes, between the 27th and 43rd degrees of latitude and in the Argentine up to Buenos Ayres.

Choko was spoken on the Pacific side between eight and four degrees North and Esmeralda on the north coast of Ecuador.

On the Atlantic side at the time of the Discovery the people were at a low level of civilization and we find there several large language families and a great number of small independent groups:

Tupi-Guarani.-In the north this language was spoken in Guiana (Oyampi and Emerillon), in the west up to the slopes of the Andes and in the plains west of the Bolivian Grand Chaco (Chiriguano). Southward it is still spoken throughout Paraguay. In the east, tribes of this speech, at the time of the Discovery,

occupied the largest portion of the Brazilian coast up to the mouths of the Amazon.

Old Tupi or Abañeenga had two dialects, that of the south or Guarani, the parent of modern Guarani, as still spoken in Paraguay and adjoining territories, and the northern, Tupi, the forerunner of modern Tupi or Neengatu, the "lingoa geral" used in commerce and missionary work throughout the Amazon basin.

Carib .- A wider area was covered by the Carib, whose place of origin is thought to have been the region between the Upper Xingu and the Tapajoz, whence they spread northwards to the Lesser Antilles and to the southernmost point of Florida. They reached the Andes on the west and small groups entered Colombia (Motilon, Opon and Carare Indians) and Peru in the Jaen area (Patagon). On the east they found the coast at Guiana (Oyana, Rukuyen, Kaliña, Galibi, etc.).

Arawak.-The Arawak area is almost identical with that of the Caribs, and in some cases they seem to have migrated together. Their centre of dispersion was somewhere in the Venezuelan-Brazilian area, about the basins of the Orinoco and the Rio Negro. Arawaks were found in Florida and southwards in Paraguay, in Peru (Uru and Pukina) and in the east at the mouths of the Amazon (Araua). So far this form of speech is the earliest of the forms found in the Peruvian-Bolivian area, being earlier than

Aymera, which was ousted by Kichua.

Pano.-Of the three geographical groups of this family, the most important is found on the south bank of the Amazon, from the Jutahy east to the Huallaga west, on both banks of the Ucayali from its mouth to parallel 10° and the right bank of its tributary, the Urubamba, in the entire basin of the Upper Jurua and the sources of the Purus. The second group covers the basin of the Inambari, while the third group holds the banks of the Mamore, the Beni and the Madre de Dios between qo 15' and 12° 30' latitude and 64° 45' to 67° 30' longitude.

Ge .- This family probably represents one of the oldest elements in South America and extends over the whole of the southern half of the Brazilian plateau reaching Xingu on the west and the Atlantic coast on the east, whence its speakers were expelled by Tupi-Guarani in the 15th century. The classification of Ge speech has yet to be accomplished and is one of the most urgent linguistic

tasks awaiting the Americanist.

Tukano.—The first or eastern of the three geographical groups of the Tukano family covers the basins of the Uaupes, Curicuriary and Apaporis The western group occupies the entire basin of the Napo from its junction with the Amazon up to the mouth of the Aguarico, along the latter river, along the Putumayo from its source to its junction with the Yaguas, along the upper Caqueta to about the 74th degree longitude. The northern group is found at the sources of the Manacacia, a tributary of the Meta.

Katukina .-- An immense area south of the Amazon between 72° 30' and 62° 30' longitude and between 4° and 9° latitude is

occupied more or less continuously by this family.

Puinave.-Like the Ge group the speakers of the Puinave languages are among the most primitive peoples of South America and represent a very ancient element of the population. The Puinave are found in the basin of the Inirida and the nomadic Maku between the Rio Negro and the Yapura, between 69°30' and 61° 45' longitude.

Guaykuru.—The Guaykuru languages are spoken by a series of tribes along the banks of the Paraguay, the Parana and their tributaries and in the Chaco, e.g., Mbaya-Guaykuru, Guachi,

Payagua, Toba, Mokovi, Abipon.

Matako-Mataguayo.-In the lesser Chaco a compact group

Matako-Mataguayo.—In the lesser Chaco a compact group is formed by the following: Mataguayo, Matako, Vejoz, Choroti, Ashluslay, Tanguages.—All over the western portion of South Am and are spread isolated languages, such as Jirajara, Timote, Tanguages, Gugatibo, Saliba, Maku, Shiriana, Auake, Kaliana, Gugatibo, Saliba, Maku, Shiriana, Auake, Kaliana, Gorje, Kofane, Zaparo, Chirino, Kahuapana, Cholona, Amuesha, Tomeri, Leko, Moseten, Yurakare, along the eastern slopes of the Andes and the upper tributaries of the Amazon from acuthern Colombia to Rolivia: Wittor Yur and Mura on the southern Colombia to Bolivia; Witoto, Yuri and Mura on the

upper and middle Amazon; Mobima, Kayuvaya, Kanichana, Itonama, Chapakura, Mashubi, Huari, Nambikuara, Karadja, Trumai, Bororo, Chiquito, Guato, Samuku, Maskoi, Enimaga and Shavante in central and southern Brazil, in eastern Bolivia and in Paraguay; Kariri in eastern Brazil; Charrua formerly spoken in Uruguay; Vilela-Chulupi, Sanaviron, Allentiak, Het and Puelche in the Chaco and in the Argentine Plain.

Australian Affinities .- Of the three southernmost languages of the continent, Alakaluf, Yahgan and Chon, only the last, now spoken by the Patagonians or Tehuelche of the Argentine l'ampa, and by the Ona in Tierra del Fuego, has been identified and is found to belong in respect of vocabulary to Australian languages. The migration of Australians to America must have taken place via the Antarctic during the post-glacial optimum when the climate of those regions was sensibly more favourable than now, a period counted by geologists as not less than 6,000 years distant. (Rivet, Bulletin de la Société de linguisthat de Paris, t. xxvi. 1-2, pp 23-63, 1925; Compte-rendu sommaire des si ances de la Société de bio-géographie, Paris, 3éme année, no. 18, séance Feb. 19, 1926)

Although links have been established with Australia and in the north with Malayo-Polynesian Australasian (e.g., the Hoka group) and with Sino-Tibetan (e.g., the Na-Dene group), linguists have failed to prove any relationship between the languages of North and of South America or with those of Central America. Information is also needed about the dying languages before they have completely disappeared.

BIBLIOGRAPHY.—Les Langues du monde, by a group of specialists under the direction of A. Meillet and Marcel Cohen (1924); W. Schmidt, Die Sprachenfamilien der Erdkreise (1926).

SOUTHAMPTON, HENRY WRIOTHESLEY, 3RD EARL OF (1573-1624), one of Shakespeare's patrons, was the second son of Henry Wriothesley, 2nd earl of Southampton, and his wife Mary Browne, daughter of the 1st Viscount Montague. He was born at Cowdray House, near Midhurst, on Oct. 6, 1573, and succeeded to the title in 1581, when he became a royal ward, under the immediate care of Lord Burghley. He entered St. John's College, Cambridge, in 1585, graduating M A. in 1589; and his name was entered at Gray's Inn before he left the university. At seventeen he was presented at court, where he made friends with the earl of Essex, and received extraordinary marks of the queen's favour. He became a munificent patron of poets. Nashe dedicated his romance of Jack Wilton to him, and Gervase Markham his poem on Sir Richard Grenville's last fight. His name is also associated with Barnabe Barnes's Parthenophil and Parthenope, and with the Worlde of Wordes of John Florio, who taught him Italian. But he is best known as a patron of the drama and especially of Shakespeare. Venus and Adonis (1593) is dedicated to Southampton in terms expressing respect, but no special intimacy; but in the dedication of Lucrece (1594) the tone is very different. "The love I dedicate to your lordship is without end ... What I have done is yours; what I have to do is yours; being part in all I have, devoted yours." Nicholas Rowe, on the authority of Sir William Davenant, stated in his Life of Shakespeare that Southampton on one occasion gave Shakespeare a pres-

If the sonnets were addressed to Southampton, the earlier ones urging marriage upon him must have been written before the beginning (1595) of his intrigue with Elizabeth Vernon, cousin of the Earl of Essex, which ended in 1598 with a hasty marriage that brought down Queen Elizabeth's anger on both the contract-

ing parties, who spent some time in the Fleet prison.

ent of £1,000 to complete a purchase.

Meanwhile in 1596 and 1597 Southampton had accompanied Essex on his two expeditions to Cadiz and to the Azores, in the latter of which he distinguished himself by his daring tactics. In 1598 he had a brawl at court with Ambrose Willoughby, and later in the same year he attended Sir Robert Cecil on an embassy to Paris. In 1500 he went to Ireland with Essex, who made him general of his horse, but the queen insisted that the appointment should be cancelled, and Southampton returned to London. He was deeply involved in Essex's conspiracy against the queen, and in February 1601 was sentenced to death. Cecil obtained the commutation of the penalty to imprisonment for life.

On the accession of James I Southampton resumed his place at court and received numerous honours from the new king On the eve of the abortive rebellion of Essex he had induced the players at the Globe theatre to revive Richard II, and on his release from prison in 1603 he resumed his connection with the stage. In 1603 he entertained Queen Anne with a performance of Love's Labour's Lost by Burbage and his company, to which Shakespear belonged, at Southampton House.

Southampton was an active member of the Virginia company's council. He seems to have been a born fighter, and engaged in more than one serious quarrel at court, being imprisoned for a short time in 1603. He was in more serious disgrace in 1621 for his determined opposition to Buckingham. He was a volunteer on the Protestant side in Germany in 1614, and in 1617 he proposed to fit out an expedition against the Barbary pirates. In 1624 to the later of the United Provinces of the Netherlands against Spain. Immediately on landing they were attacked with fever, to which both succumbed, the father surviving until Nov. 10, 1624.

There exist numerous portraits of Southampton, in which he is depicted with dark auburn hair and blue eyes, compatible with Shakespeare's description of a "man right fair." Sir John Beaumont (1583–1627) wrote a well-known elegy in his praise, and Gervase Markham wrote of him a tract entitled Honour in his Perfection (1624).

For further information see "Memoirs of Henry Wriothesley, the third Earl of Southampton," in Boswell's Shakespeare (1821), xx, 427 sqq, where many of the elegies on Southampton are printed

COUTHAMPTON, THOMAS WRIGHTESLEY, IST EARL OF (1505-1550), obtained extensive lands between Southampton and Winchester at the dissolution of the monasteries. He was made one of the king's principal secretaries in 1540, was knighted in the same year, and was created Baron Wriothesley of Titchfield in 1544. Having been lord keeper of the privy seal for a few months, he became lord high chancellor in 1544, in which capacity he beame notorious by his proceedings against Anne Askew. He was one of the executors of Henry VIII's will, and was created earl of Southampton in Feb. 1547. However, he had committed an offense in appointing four persons to relieve him of his duties as lord chancellor and he was deprived of his office in March, when he left privy council. Again in the council, Southampton helped to arrange the fall of Somerset. He died on July 30, 1550.

For the career of the 1st earl see Lord Campbell, Lives of the Lord Chancellors; E. Foss, Judges of England.

SOUTHAMPTON, a seaport and parliamentary, county and municipal borough, in the county Hampshire, England, 76 mi. S.W. of London by road. Pop. (1951) 178,326. Area 17.3 sq.mi. The town stands near the head of Southampton water, an inlet of the English channel, on a peninsula formed by the rivers Test and Itchen. It is the third largest in importance among English ports and the first in regard to passenger traffic. In AD. 43 there was a Roman settlement, Clausentum, on the east bank of the Itchen, and inscribed stones, coins, pottery, etc. have been found. Southampton (Hamtune, Suhampton) superseded the Saxon Hamtune and was a royal borough before 1086. The earliest town charter was given by Henry II, probably in 1154-55, but the borough was not incorporated until 1445. Henry VI, in 1447, created Southampton a county in itself. A charter which remained in force until 1835 was granted by Charles I in 1640. It was from Southampton that the Mayflower sailed with the Pilgrim Fathers to America. The town has returned two members to parliament since 1295. It is a quarter sessions borough. Southampton gives name to a bishopric suffragan to Winchester. Natives of the town include Isaac Watts (1674-1748), Sir John Millais (1829-96) and Earl Tellicoe (1859-1935).

There are remains of the Norman walls which were strengthened by towers and had six main gates. An old house known as King John's palace is one of the earliest 12th-century domestic buildings in England. The south (God's House gate) and west town gates date from the early 14th century; Bar gate (the north gate), as it stands, is mostly later and retains good Decorated work.

St Michael's church has an 11th-century tower and arches and a font of Tournai marble (c 1150). The spire (1745) was raised a further 9 ft. in 1877 as a mark for mariners. The priory of St. Denys, an Augustinian foundation of 1124, gives its name to a suburb by the Itchen. Netley (q.v.) abbey is 3 mi. southeast.

The old guildhall, long used as a courthouse, is over the archway of the Bar gate. Tudor house, a mediaeval merchant's residence, is the museum. King Edward VI Grammar school was founded in 1550 but now occupies modern buildings near the common. Taunton's school was founded in 1760 and is now in large modern buildings at Highfield. The University College of Southampton, evolved from the former Hartley institute, was removed to Highfield in 1914. It received its charter as a university in 1952. The town suffered severely from air raids in World War II. many houses and three-quarters of the old district in the centre having been devostated and important port installations destroyed. The civic centre, completed in 1939, comprises the new guildhall; municipal offices; police headquarters and law courts; and the public library and art gallery. The tower is a landmark for shipping and contains a clock and bells. There are a large sports ground (268 ac.), a common and several parks

The Port and Its Trade .- The modern importance of the port begins with the creation of a pier and harbour commission in 1803 and the erection of the Royal pier in 1831. The prosperity of the town was enhanced by the opening of railway communication with London in 1840. The harbour is one of the finest natural harbours in the kingdom and has the advantage of a double tide, the tide of the English channel giving it high water first by way of the Solent and two hours later by way of Spithead. In 1892 the docks became the property of the then London and South-Western railway company, now British Railways, but were taken over by the Docks and Inland Waterways executive in 1950. The older docks lie at the confluence of the Test and Itchen rivers; large modern extensions lie to the northwest of these alongside the Test river. The old docks cover more than 200 ac. and in addition to the river quays there are three large tidal basins, the Ocean dock, Empress dock and the Outer dock, leading to the Inner dock The Ocean dock accommodates the largest liners on the North Atlantic route; a modern terminal building adjoins it. The new docks, with 12 mi, of deepwater quay facing the Test river, include the King George V dry dock, one of the largest in the world.

Dock or quay	Year opened or completed	Area	Nominal dredged depth below chart datum	Length of quays	Width of en- trance
Outer Dock Inner Dock Itchen Quays Empress Dock	1842 1851 1876-95	16 ac 16 ac 18½ ac	Open at high tide only 20-31 ft. 26 ft.	2,621 ft 2,575 ft 3,346 ft 3,880 ft	150 ft. 50 ft. 165 ft.
Test Quays and South Quay Ocean Dock New Docks	1890-1902 1911 1934		307,32 ft. 40 ft 40 ft.	4,679 ft 3,807 ft 8,014 ft	400 ft.

Southampton is England's chief port for express transatlantic services and is also used by ships bound for South America, East Africa, Australia, New Zealand and the far east. There are cross-channel services by British Railways ships and a ferry to the Isle of Wight. Southampton airport is at Eastleigh, 5 mi. northeast. Flying boat services operate from the marine air terminal.

Principal industries are shipbuilding and ship repairing, building and contracting, dock and harbour services, distribution services and marine engineering. There is also a wide range of light industries. A large new oil refinery was opened at Fawley on Southampton water in 1951.

**SOUTH AUSTRALIA**, a state of the commonwealth of Australia, occupying 380,070 sq.mi. (12.78%) in the central southern portion of the continent.

# PHYSICAL FEATURES

Natural Regions.—Situated athwart the junction line of the great western plateau and the great central plains of Australia, South Australia can be divided into a number of different physical areas. Its relief is nowhere so marked as that of the eastern states, and there is relatively little land above 2,000 ft. The northwest

quarter is occupied by the southwestern extension of the western plateau. The northeastern quarter is occupied by the Lake Eyre depression, with its horseshoe of mud and the marsh-filled depressions—"Lakes" Frome, Callabonna, Blanche, Gregory, Eyre (3,700 sq.mi.) and Torrens—surrounding the northern Flinders ranges. Southward from these lies an area where recent (Pliocene) cross-patterned warping and faulting, elevation and submergence have provided the most decisive features of the state: the Mt. Lofty-Flinders ranges, the northern part of Yorke peninsula, the Spencer gulf-Lake Torrens (semidrowned) valley; the Flinders Barrier spur or ridge, the extremities of the peninsulas, Kangaroo Island and perhaps also—though it is older—the Gawler range. South and east of this lie the Murtay river and the southeastern lowland plain, the western fringe of the great Murray (Tertiary sea basin) lowland and the counterpart of the Lake Eyre basin in the north.

The northeastern corner of the state (118,000 sq.mi.) forms part of the Great Artesian basin, the water-bearing beds lying at average depths of 4,000-5,000 ft. in the northeast but shallowing until, along the edge of the west Australian platform, the waters well up in a line of remarkable "mound springs." The soft strata of the lower Murray basin also yield plentiful supplies, often of good quality, from depths of 50-350 ft. and, toward the extreme southeast (Penola, Millicent) the underground water table intersects burface and has resulted in extensive swamps and coastal lagoons.

Climate.—The state may be roughly divided into two climatic regions, a northern warm, dry region with high summer temperatures and less than 10 in, of rainfall per annum, much of which is erratic and unreliable, and a southern region which is typically Mediterranean with moist winters and hot dry summers. Very few areas in this latter region receive more than 35 in. of rain each year. The settled part of the state averages between 15 and 25 in. Adelaide, for example, has a mean annual rainfall of just over 21 in. and is the driest state capital in the commonwealth. North of the 32nd parallel and in the eastern part of the state north of the Murray river, the mean annual rainfall is less than 10 in. but, as in most dry areas, distribution is very erratic. The driest known part of the whole continent occurs around Lake Evre. There the annual average rainfall is only 5 in., and it is rare for more than 10 in. to be recorded in any 12-month period. Generally the lake itself is dry and covered with salt.

South Australia is warm and sunny. The range of average temperature is greater in the summer than in the winter. In June, July and August most of the state experiences mean monthly temperatures between 50° F. and 60° F., whereas in the summer the southern part of the state has mean monthly temperatures around 50° F., while in the northern part of the state the monthly average is between 80° F. and 85° F. It is not uncommon at Oodnadatta for the thermometer to register 120° F. in the shade. Adelaide, on the average, has 13 days per annum when the temperature is more than 10° F.

Vegetation.—The natural vegetation consists mainly of five major types. Eucalypt woodland and forest is on the higher and wetter parts of the Mt. Lofty and Flinders ranges and in the southeastern part of the state. Mallee (dwarf eucalypt), she-cak and tea-tree used to cover the remainder of the southern portion of the state but large areas of mallee have been cleared for agriculture. In the drier north, the mallee gives way to mulga scrub (acacia) and on the fringe of the Nullarbor plain in the west, saltbush is dominant. In the northwest and northeast spinifex grass is the chief plant of the very dry areas, but in places there is no vegetation at all, but only sandy ridges or rough gibber (stony) plains.

One of the greatest changes in the vegetation pattern of the state has been the establishment of pine forests in the southeast. Pinus radiata was expected to cover 90,000 ac. by 1961. By the 1950s the forests already produced raw material for a cellulose factory, timber for packing cases as well as for buildings, and the Victorian match industry depended upon a supply of veneers produced at the government peeling plant at Mt. Burr and at a private plant at Nangwarry, 20 mi. N. of Mt. Gambier.

Soils.—The distribution of the different types of soils is naturally closely related to the climate and vegetation patterns. The podsols, or ash gray soil, are found in the wetter parts of the state where iron oxide and other soluble materials have been leached out leaving the surface soil ash gray in colour and poor in plant nutrients. Where the rainfall is slightly less and the evaporation higher the podsols give way to the red brown earths which extend north of Adelaide beyond Jamestown and in the southeast around Naracoorte and Bordertown and on Eyre peninsula. All these areas are important for agriculture and grazing. The mallee soils. rich in lime but poor in humus and phosphate, are closely associated with the mallee type of vegetation. With the application of superphosphate and some of the important trace elements (copper, zinc and molybdenum) many of these mallee soils, once thought to be of little economic value, are gradually being sown down with subterranean clover and it is expected that they will add considerably to the pasture acreage of the state. Desert-steppe soils and desert sand hills extend over the northern half of the state, and are used for extensive grazing where artesian water : available.

Water Supply.—Climatic conditions made the provision of an adequate water supply an early problem for settlers in South Australia. Throughout the arid areas of the state, settlers were forced to rely on surface catchments and later on artesian supplies. The Murray river water was used for irrigation purposes in isolated settlements along the banks. It was not until 1944 that a double pipe line of 230 mi. was completed from Morgan to Whyalla, being used on the way for boosting several rural reservoirs. An additional pipe line from the Murray was begun in 1951 to supplement the inadequate water supply of Adelaide.

#### HISTORY

The coast line of South Australia was explored by Matthew Flinders and Nicolas Baudin in 1802. Apart from occasional visits by whalers little was done about the settlement of the area until 1830 when preliminary plans were drafted by the National Colonisation society, founded by Anthony Bacon and Edward Gibbon Wakefield. These proposals were submitted to the colonial office in the form of the South Australian Land company, the members of which were philanthropic bankers and Whig politicians. After a year's negotiations, the company's proposal was rejected by Lord Goderich because it was "too republican." With the passing of the Reform bill however, a new society called the South Australian association was formed, the committee being mostly "advanced-liberal" members of parliament. In spite of antagonism from those opposed to the theories of systematic colonization, an act establishing South Australia as a British province was passed in Aug. 1834.

Among other things the Foundation act protected South Australia from becoming a convict colony and fixed a minimum price for land, the revenue from which was to be used entirely for sending emigrant labourers to the new province. It also divided the home administration of the colony between the colonial office and a board of commissioners. A sum of £20,000 was to be raised as a guarantee fund and £35,000 worth of land sold before the province could be gazetted. The fulfilment of these provisions was made possible by the South Australian company, a joint stock venture unconnected with either government or commissioners. This company not only made the first settlement in South Australia, but also, through its banking, mercantile, land and shipping operations, played an active part in forming the policies of early governors.

The surveying party sent out to select the site for settlement was understaffed and ill-equipped and was followed too soon by the main party of settlers. The official proclamation of the province was read at Holdfast bay, by Gov. John Hindmarsh on Dec. 28, 1836. Through the resolution and foresight of Col. William Light a town site was chosen and the survey of Adelaide completed by March 1837.

The division of powers between Governor Hindmarsh and the commissioner's agent rapidly developed into factional strife, but this was greatly diminished by the appointment in 1838 of George Gawler to the dual office of queen's representative and resident commissioner. As a result of administrative difficulties, almost three years passed before the surveys were sufficiently advanced

to permit country settlement. The colonists meanwhile spent their time and substance in speculating on town lands, a process accentuated by the public works program of Governor Gawler Immigrants continued to flow into Adelaide, and because provisions had to be imported, prices soared. The commissioners' resources were exhausted by the end of 1839 in spite of the fact that they had borrowed from the sacrosanct Land and Emigration fund. An appeal to the colonial office for assistance led to an inquiry into South Australian affairs by a select committee of parliament, the report of which was not completed till June 1841. In the meantime, the commissioners were obliged to defer payment on drafts from Adelaide, immigration ceased, and the province suffered a financial collapse. By an act of 1842 South Australia was placed wholly under the control of the colonial office.

Capt. George Grey, appointed as Gawler's successor, embarked on a program of strict economy. Before he arrived the exodus of states to the country had begun, and several large flocks of cattle and sheep had been overlanded from New South Wales. By 1842, the settlers had surplus grain for export. With the development of copper mining in 1845, a second, though more limited, speculation mania broke out. The flow of migrants recommenced, hundreds of Cornish miners and their families receiving free passages to the colony. The prospects of copper production were somewhat dimmed by the discovery of gold in Victoria in 1851—more than 18,000 South Australians proceeded to the diggings. Most of them returned however to the more dependable income from the wheat fields and copper mines of their home colony.

Throughout the foundation and early years of settlement, religious and civil liberty had been given great prominence. Religious freedom found expression in "a fair field for all churches" and, except for a brief period ending in 1850, there was no state aid to religion, the denominations in South Australia being supported entirely by the voluntary principle. Secular education subsidized by the state was also introduced in 1850. Religious equality was used as an additional inducement to prospective migrants, with the result that the proportion of nonconformits sects, especially Methodists, has always been higher in South Australia than in the other Australian states and helps to account for Adelaide's reputation as "a city of churches."

The first goal of civil liberty was self-government, which the Foundation act promised when the population reached 50,000. In 1843, with the population at about 17,000, four nonofficial colonists were admitted to the legislative council, and in 1850, the population being 63,700, the province was granted a chamber of 8 crown nominees and 16 elected representatives. This blended council prepared a constitution in 1853 providing for a legislature composed of a nominated council and an elective assembly. The impatience of the colonists with the nominee system, however, was expressed in a petition to the queen bearing more than 5,000 signatures. The authorities yielded to pressure and the Constitution act of 1856 gave South Australia two elective chambers. Although a small property qualification was retained for electors to the council, adult manhood suffrage was adopted for the assembly. Other principles of civil liberty which placed South Australia in the van of empire in 1856 were vote by ballot, one man one vote and triennial parliaments. A few years later, Robert Torrens introduced a simplified system for the transfer of land titles which was later copied in many countries. In 1887 payment of members was introduced, and votes for women followed in 1894. Though the colonists maintained a scrupulous loyalty to the crown, their resentment of interference in local affairs found expression in prolonged legal disputes such as those which led to the Colonial Laws Validity act of 1865. This act gave validity to the laws passed by all colonial legislatures provided that they were not repugnant to British statutes. It remained as the legal keystone of the empire until the Statute of Westminster, 1931.

The control of crown land revenue, secured in 1856, enabled the colonial legislature to begin a more systematic exploitation of natural resources. By a vigorous immigration policy, an average of 3,000 persons a year were brought to the colony between 1860 and 1880. A number of Germans were sent out by George Fife Angas and others in the early years of settlement but the great

majority of South Australians are of British stock.

By 1860 most of the colony had been explored and pioneer pastoralists had spread as far as water supplies would permit. Behind them agriculturists speedily extended the areas of crop. A severe drought in 1865 checked the expansion temporarily, and some attention was diverted to the settlement of the Northern Territory. The development of this project proved both costly and cumbersome to the South Australian government, although a few individuals profited through land speculation and mining, and-others by cattle raising round Alice Springs. Few objections were raised when the responsibility for the Territory was taken over by the commonwealth government in 1911.

New copper mines were discovered at Wallaron and Moonta in 1860 and the Murray river shipping trade was developed to reach a peak of over £1,250,000 in 1883, after which it declined through the competition of Victorian and New South Wales railways. Most of the state's capital and labour, however, was directed toward agriculture and wool growing. A network of some 2,000 mi. of railway connected the centres of rural production with easily accessible ports, from which a large proportion of the grain was taken to Europe by sailing vessels, the annual race of these ships heing followed with keen interest. In the year 1880 South Australia through its abundant wheat production earned the title of the "farinaceous state."

Among the many new adaptations made by the early settlers for wheat growing in South Australia, John Ridley's reaping machine deserves special mention as a labour-saving device which came into general use after 1850. Dry-farming techniques and the application of superphosphates were also important factors in bringing new land under cultivation and increasing agricultural production. As the supply of wasteland diminished, however, more attention was given to scientific research, aided both by state grants and generous gifts from private individuals. The instruction given at Roseworthy Agricultural college (established in 1885) and experiments at the Waite institute (1924) have benefited the whole continent. Improved methods of tillage and a ceaseless war against pests and plant diseases have greatly reduced the risks of rural production. The pastoralists, too, have benefited. The development of a large-framed Merino sheep suited for semiarid conditions, experiments with the top-dressing of pastures and the introduction of English breeds have made possible a flourishing export trade in fat lambs.

In the first 40 years of the colony the progress of education was impeded by the wide spread of population and the emphasis on rural production. State subsidies were first granted in 1846, and a Central Board of Education established a few years later but no spectacular advance was made till 1874. In that year the University of Adelaide was founded and a few months later compulsory and secular education was introduced. This was followed by the establishment of the Teachers' Training college in 1876 and the School of Mines ten years later. In the '90s primary education was made free, and attention was given to the creation of secondary schools. Until the introduction of motor transport, however, secondary education was largely confined to the vicinity of Adelaide. The city remained the centre, not only for mercantile interests but also for culture, entertainment and sport.

Whill the federation, South Australia was noted for its frequent changes of government and the independence of its feederd representatives. This was encouraged in part by the attitude of colonists outside parliament, expressed through a profusion of small and short-lived societies for social and political reform, and in part by the extreme difficulty of reshaping electoral divisions to conform with the continual shift of population. From the beginning, care was taken to assure a high proportion of representation to the rural districts counterbalance the indirect influence of urban voters through their counterol after the respective of the parliament in Adelaide. The system of multi-member electorates also encouraged voters to support individual candidates rather than a party program. The emergence of a Labour party after the industrial troubles of the early 1890s, therefore, made but little impression on the tradition of independence, especially after the outstanding leaders transferred their attention to the federal sphere. South Australian politicians played a prominent part in the drafting of the federal constitution, some of them making a strong bid for the retention of state rights. The activity of leading milliers and bankers in establishing commonwealthwide combines after the federal government took over the control of staffs was perhaps the most important single cause of the development of the party system in South Australia. To defeat the schemes of the monopolist conservatives" in 1903, a party of Independent Liberals

was formed, and with this group the Labour party made a compact. The Conservatives were defeated but the Labour-Liberal combination proved unsatisfactory. It was soon realized that the control of fiscal policy by the commonwealth greatly reduced the power and influence of state governments. The Labour party's insistence on adult suffrage for the legislative council and the ultimate abolition of that chamber was too radical for the Liberals but it nevertheless remained the central plank of Labour's platform.

In 1910 the Labour party was returned with a majority of two in the assembly and under the leadership of John Verran formed its first South Australian ministry. This government held office for two years, but its reforms made little headway against the Conservatives in the legislative council. It had, however, become closely identified with the Australian Labour party and had taken a stand on the close unification of states within the commonwealth. Though strongly supported in the urban electorates it came to grief in 1912 on the issue of state rights and did not regain office until the outbreak of World War I when its ranks were again split on the conscription issue, more than half the members going over to the new Nationalist party which then came to terms with the Liberals.

In 1921 four parties contested the state election. There were the in 1921 four parties contested the state election. There were the remnants of Labour, the Nationalists who had parted company with the Liberals, and those who supported the Farmers and Settlers' party. After the Australian Labour party adopted the "socialization of industry, production, distribution and exchange" as its central objective, dustry, production, distribution and exchange as its centar objective, there was increasing combination between the anti-Labour groups. For the next 12 years parliamentary power alternated between Labour and Liberal In 1933 there was a strong reaction to the old tradition of independent members, chiefly because of dissatisfactions caused by the depression. It was soon realized that it was impossible to isolate the state from the parties of federal politics, especially after the creation

of the commonwealth loan council.

In 1941, therefore, fewer Independents were returned and, with the backing of the Liberals and Country party, Thomas Playford became premier. His masterly grasp of the complexities of state-federal finance earned him the leadership of the less influential states in the premiers conferences at Canberra, while at home his vigorous and imaginative developmental policies broke, to a large extent, the almost complete economic dependence of the state on rural production. In 1953 his party was elected to office for the sixth time in succession.

#### POPULATION

The growth of population in South Australia is shown in the following table:

Population of South Australia, 1850-1950

						Population (in thousands)			
Year						Metropolitan	Other	Total	
1850 1870	-			-		32 61	31 123 186	63 184 318 406	
1870						6x	123	184	
1890		:				132	186	318	
1010						199	207	406	
1930						310	207 264 285	574	
1950						415	285	700	

Adelaide, the capital of the state, had a population of 646,073 in 1947; it was estimated to have 739,563 in 1952.

# AGRICULTURE AND INDUSTRY

Agriculture,-South Australia, although third in size of the Australian states, has a relatively small area that can be utilized for agriculture. More than four-fifths of the total area has an average rainfall of less than 10 in. a year and supports fewer than 2,000,000 sheep and 100,000 cattle. The following table showing the percentage of the total sheep population carried outside the roin, rainfall country indicates the trend that has been taking place over the last 50 years.

Distribution of Sheep, 1000-1050

Year								Number of sheep	Percentage outside 10 in. line
1900		-			•	•		5,667,000	28.2
1910								6,432,000	24.9
1930		•						6,186,000	24.9 18.7
1940						• •		9,941,000	20,1
1950		٠	٠	•	•	٠	٠	9,477,000	14.8

Goyder's line of rainfall marking out the southern extent of the 1865 drought was for many years regarded as a line of safety beyond which agriculture could not be carried out. The use of dry-farming which agriculture could not be carried out. The use of dry-larming methods and artificial fertilizes has, however, brought large areas outside the line into cereal production. In the higher rainfall areas sheep rearing and cereal production predominate. Many wheat farmers turned to fat lamb production after the depression of the 1930s and by 1940 the sheep population of the state had increased to 10,000,000. More land is being put under pasture for livestock as the

result of a wider use of subterranean clover, superphosphate and modern mechanical methods of clearing. Land previously considered use-less, or able to carry as little as a quarter of a sheep to the acre, is being converted to two sheep to the acre country or better. The area sown to pasture doubled between 1940 and 1950, and if the trend in the early 1950s of 100,000 ac. a year were to continue, it would have doubled again by 1960.

doubled again by 1960. Wheat for many years has been the dominating cereal in South Australia. A peak of 4,650,000 ac. was sown to cereals in 1930-31. Of this 4,180,000 ac. were sown to wheat, 252,000 ac. to harley and 218,000 ac. to oats. Livestock then began to be more important in areas formerly devoted exclusively to cereals, with the result that by 1951 the wheat acreage had declaned to less than half that of the peak year. The yield, however, increased slightly to an average of 12 bu. per acre for the 1940-50 period, resulting in an average production of about 26,000,000 bu. There has been a considerable increase in the acreage under barley in recent years.

Dairying is carried on mainly on the plains and in the hills within reach of Adelaide where markets and export facilities exist Vines and olives thrive on the lower western slopes (below 500 ft) of the Adelaide hills, while further northeast and north the Angaston, Tarthur and Clare districts are noted for their excellent wines. Oranges, lemons, peaches, apricots and almonds abound on the plains and in the valleys where water, shelter and warmth are available Around Renmark, Loxton, Berri and Barmera on the Murray river, citrus fruits, vine crops and vegetables are grown under irrigation.

The barrage at the mouth of the Murray has maintained satisfactory levels in Lakes Albert and Alexandrina. Around these lakes and along the lower Murray there are areas that could be used for the production of fodder crops for dairy cows or for market gardens to meet the increasing demands of the growing urban population for

fresh milk and vegetables.

Mining .- Although South Australia has never been rich in precious minerals there are a number of mineral resources that are becoming increasingly important not only for the state, but for the commonwealth as well. The discovery of silver lead at Broken hill in the neighbouring colony of New South Wales was exploited by the South neignouring colony of New South Wales was exploited by the South Australians. The mines were connected by rail with Port Pirie where treatment plants were established. Among the metallic minerals iron will be significant for a long time to come. In the dry Middleback ranges west of the northern part of Spencer gulf the ore occurs in Iron Knob, Iron Monarch and several other hills and provides the raw material for the heavy industries at the near-by port of Whyalla as well as for the steel industries at Newcastle and Port Kembla in New South Wales. Conput declined in importance after the Monata New South Wales. Copper declined in importance after the Moonta New South wates. Copper declined in importance after the months mines were closed in 1923, but in the 1950s investigations were being made to discover new workable deposits.

A later nonmetallic substance to be developed is sulphur, an im-

portant raw material for the manufacture of sulphuric acid neede ever increasing quantities for the production of superphosphate. than 30,000,000 tons of pyrites—enough to produce 3,000,000 tons of sulphur—had been discovered at Nairne in the Adelaide hills by 1953. Gypsum, one of the state's mineral products since the 19th century, had become the basis for the manufacture of plaster of paris for the building industry. The state is the main producer of salt in the commonwealth, and besides the deposits on Yorke and Eyre peninsulas, large areas of flat land on the coast north of Adelaide are being used for the production of salt by flooding and evaporation on a large scale. The coal deposits at Leigh Creek, 350 mi. N. of Adelaide, have been developed as a state undertaking, and in 1953 it was hoped that the annual output would soon reach 1,200,000 tons, and so supply the state with a fair percentage of its needs. The field has been proved state with a rain pertensage or its needs. The neith as been provent to contain not less than 380,000,000 tons of subbituminous coal with a moisture content between 30% and 40%. Limestone in all grades and of the purest quality is worked in various parts of the state. Important recent discoveries include high grade cosmetic tale in the north Filinders range and uranium or at Radium hill and Mt. Painter.

Industry—Datil its centenary in 1936, South Australia was essentially a primary producing state. However, after 1936 there was a remarkable development of secondary industry, and employment in manufacturing in 1933 far exceeded that in agriculture. This development received active encouragement from the South Australian government and was stimulated during World War II when munition factories of many kinds were established.

Manufactures of every description are undertaken, ranging from motor bodies to textiles, from consumers' durables to steel tubes. At Whyalla, a modern blast furnace and shipyards have been established, and at Salisbury there is the headquarters of the Long-Range Weapons establishment. The latest developments include industries associated with the processing of uranium ores. All this growth in manufacturing production has been assisted by improved power supplies, made pos-

production has been assisted by improved power supplies, made possible by the use of Leigh Creek coal deposits.

The rapid increase in factory employment between 1938–39 and 7949–50 illustrates the industrialization of the state. Over this period factory employment increased by 84%, as compared with an increase of 17% in the state's population. By the 1947 census 37% of male breadwinners were engaged in secondary production, whereas only 22% were in primary production, the remainder being involved in the service industrics. This emphasizes the remarkable shift in the balance

between primary and secondary production.

BIBLIOGRAPHY.—The most complete work on South Australia is The Centenary History of South Australia, prepared by the Royal Geographical Society of Australiasia, South Australian branch (Adelaide, 1936). The Proceedings of the South Australian Royal Geographical Society (Adelaide, 1838—) contain many valuable studies. See also E. Hodder, The History of South Australia from Its Foundation to the Year of Its Jubilee, 2 vol. (London, 1804); A. Grenfell Price, The Foundation and Settlement of South Australia, 1829–1845 (Adelaide, 1924); C. E. Fenner, South Australia, Geographical Study (Melbourne, 1931). (P. H. K.; G. H. LN., D. H. PE.)

(Melbourne, 1931). (P. H. K.; G. H. L.N., D. H. P.E.)

SOUTH BEND, a city of northern Indiana, U.S., county
seat of St. Joseph county; 86 mi. E. by S. of Chicago, Ill., at the "south bend" of the St. Joseph river, where it turns northward to Lake Michigan. It is on federal highways 20, 31 and 33 and is served by the Grand Trunk, the New Jersey, Indiana and Illinois, the New York Central, the Pennsylvania, the Chicago, South Shore and South Bend (electric) railways, and by major air lines. The production was 115,698 in 1950 and 101,268 in 1940 by the federal census. The city has an area of 19.7 sq.mi. Industries include automobiles and accessories, aviation products, agricultural implements, toys, paints and varnishes, sewing machines, lathes, baits and fishing rods, steel ranges, home laundry machines, folding cartons and boxes, men's and women's wear, bearings, special machinery and tools, wallpaper, wastepaper baskets, metal furniture, elastic and surgical goods, electrical equipment, brass, iron and semisteel castings and dress patterns. South Bend is surrounded by rich peppermint-growing muck, which also produces potatoes, celery and onions, besides various truck produce. Dairying is important. The water supply comes from about 115 wells, and electric energy is supplied by steam and hydroelectric plants. La Salle and Father Marquette were the principal figures in South Bend's early history. South Bend's best-known educational institutions, the University of Notre Dame and St. Mary's college and academy, were both founded by the Congregation of the Holy Cross. A trading post for the American Fur company was established in 1820 and settlers came in 1823. In 1831, when the population was 128, a town was laid out. It was incorporated in 1835 and chartered as a city in 1865. The population was 1,652 in 1850, after which it grew steadily and substantially.

SOUTH BOSTON, a city of Halifax county, Va., U.S., on the Dan river, 30 mi. N.E. of Danville. It is served by the Norfolk and Western and the Southern railways.

The population was 6,079 in 1950 and 5,252 in 1940 by the federal census. Tobacco, corn and wheat are grown in the area, and the city has condensed milk plants, a bottling works, a foundry, flour mills and tobacco processing plants.

Under the city's council-manager form of government, the mayor and the six members of the council are directly elected for terms of two years. The city owns and operates a water works.

South Boston has the Carrington Memorial Public library, and two weekly newspapers are published there. The South Boston Hospital, Inc., was established in 1943.

SOUTHBRIDGE, a town of Massachusetts, U.S., on the Quinebaug river. Pop. (1950) 17,511; (1940) 16,825 by the federal census. The river falls 165 ft. at this point, furnishing abundant water power. Optical goods are its most distinctive product. In 1801 a poll parish (popularly called Honest Town) was formed from parts of Charlton, Dudley and Sturbridge; and in 1816 it was incorporated.

SOUTH CAROLINA, popularly called the "Palmetto state," is an Atlantic coast state of the U.S., and one of the original thirteen. Its area is 31,955 sq.mi., of which 461 sq.mi. are water. It lies between the extremes of approximately 32° 4′ and 35° 12′ N. and 78° 31′ and 83° 32′ W.

Physical Features.—South Carolina is mainly in the coastal plain and Piedmont plateau regions, but in the northwest it extends slightly into the Appalachian mountain region. Locally the coastal plain region is known as the low country, and the Piedmont plateau and Appalachian mountain regions are known as the upcountry. The coast is low, and islands increase in size and number toward the Georgia border. For about ro mi. inland the coastal plain is occupied largely by salt marshes. Then, although continuing flat, the surface rises at the rate of about 2 ft. per mile for

50 mi. or more. Parts of the Blue Ridge rise abruptly from the foothills to 3,436 ft in Mt. Pinnacle, 3,218 ft. in Caesar's Head and 3,124 ft. in Table Rock. The highest point in the state is Sassafras mountain (3,560 ft.) in the Blue Ridge and on the North Carolina state line. The mean elevation of the state is about 350 ft.

The principal rivers rise in the Appalachian mountains and flow southeast into the Atlantic ocean. Santee river is formed by the confluence of the Wateree (known above Wateree creek north of Camden as the Catawba) and the Congaree, which is in turn formed by the Broad and the Saluda. The basin of this system embraces about half the area of the state. In the northeast the Waccamaw and the Pee Dee and its tributaries—the Little Pee Dee and Lynches—are wholly within the coastal plain, but the main stream of the Pee Dee is a continuation below the fall line of the Yadkin river which rises in the mountains of North Carolina. The Edisto is the principal stream in the southeast.

In the Piedmont plateau there are rapids, but in the coastal plain the current becomes sluggish, and in time of high water the rivers spread over wide areas

Flora.—Palmettos grow on the coast but only artificially inland. For some distance from the coast there are magnolias, live oaks draped with long gray moss, and reed-covered marshes. In the swamps are cypress, gum and bay trees.

In most of the uplands of the coastal plain the longleaf rine is predominant, but large water oaks and undergrowths of several other oaks and of hickories are not uncommon. On the Piedmont plateau and in some of the more hilly sections below the fall line there is some shortleaf pine, but most of the trees in these areas are hardwoods. Deciduous oaks are most common, but beech, birch, ash, maple, black walnut, chestnut, sycamore and yellow poplar also abound. On the mountains are oaks, chestnut, laurel, white pine and hemlock. Among indigenous trees, shrubs and vines are the blackberry, grape, persimmon, plum, crah apple, hickory, chestnut and hazelnut.

CHmate.—Along the coast the climate is mild and equable. At Charleston, the mean winter temperature is 51°, the mean aumer temperature 80°, the mean annual temperature 66° and the range of extremes from 104° to 7°. For the state the mean temperature is about 63°. In nearly all sections January is the coldest month and July the warmest. Aiken, near Augusta, Ga., has a very mild winter season and is a popular resort. The mean annual rainfall for the state is about 47.75 in and its distribution is excellent. Seventeen inches fall during the summer. Snow is uncommon in the southeast but elsewhere there may be several inches, occasionally more than a foot.

The frost-free season ranges from 245 days on the coast to 204 days on the uplands. Tornadoes sometimes occur in the west and the coast suffers from hurricanes.

Soils.—In general the soils of the Piedmont plateau are such as have been formed by the disintegration of the underlying rocks. These consist mostly of granite and gneiss, but in the north central section there is traprock and in the southeast section some slate. On the Piedmont plateau the subsoil is a reddish or yellowish clay. In the upper section of the coastal plain the soil is for the most part a loose sand, but near the coast it becomes more fertile, much being underlain by marl.

History.—The history of South Carolina may be divided into the periods of discovery and exploration (1521-1670), proprietary rule (1670-1719), royal rule (1720-75) and statehood (from 1776). The first Europeans to visit the coast were a party of Spaniards from Santo Domingo in 1521. The first settlement was made by Spaniards under Lucas Vásquez de Ayllón in 1526, but after a few months it was abandoned. The Spaniards, again settling in 1566, maintained a fort on Parris Island for about 20 years. In the meantime (1562) French Protestants under Jean Ribaut made an unsuccessful attempt to establish a colony on Parris Island (see Port Royal). In 1629 Charles I granted to his attorney general, Sir Robert Heath, all the territory lying between the 31st and the 36th parallels and extending through from sea to sea, but no settlement was made, and in 1663 the same territory was granted to the earl of Clarendon (1609-74) and seven other favourites of Charles II. A second charter in 1665 extended the limits to 29° and 36° 30′. The proprietors were to legislate for the province "by and with the advice, assent and approbation of the freemen." They were empowered, though not required, to grant religious freedom to dissenters. Circulars were issued in 1663 and 1665 offering most liberal terms to prospective colonists. In the fundamental constitutions adopted by the proprietary board in 1669, John Locke and Lord Ashley (1621–83) prepared for the province an elaborate reducal system of government which would have been obsolete even in Europe. The colonial assembly refused (as the charter gave it the right to do) to adopt them. They were, nevertheless, an element in arousing the feeling of discontent among the colonists which culminated in the overthrow of proprietary rule, and they encouraged the large-plantation system which constituted the foundation of the slaveholding aristocracy.

The first permanent English settlement was made in April 1670 at Albemarle point on the west bank of the Ashley river, but as the situation proved unfavourable the government and most of the people moved over in 1680 to the point between the Ashley and Cooper rivers, the site of the present city of Charleston. The area of settlement was gradually extended along the coast in both directions, but did not penetrate far into the interior. There were many English from Barbados and French Protestants, both of whem strongly influenced the history of the province.

South Carolina's political history during the colonial era is the story of a struggle between popular and prerogative interests, first between the people and the lords proprietors, later between the people and the crown. From 1670 to 1700 the principal questions at issue were the refusal of the settlers to subscribe to the numerous editions of the fundamental constitutions and disputes over the collection of quit rents. Concessions were finally made which brought the government more directly under popular control. In 1693 the commons house, elected by the people, secured the privilege of initiating legislation. The truce was followed by a controversy between churchmen and dissenters. A test act requiring members of the assembly to conform to the Church of England and to take the sacrament of the Eucharist according to the rites and usages of that church (1704) was defeated only through the intervention of the Whig house of lords in England. By an act of Nov. 30, 1706, which remained in force until 1778, the Church of England was made the established religion. After a few years of peace and prosperity, the proprietors, acting on the advice of Chief Justice Nicholas Trott (1663-1740), adopted a reactionary policy, vetoed several popular laws and could not give aid in the desperate 1715 Indian war. In 1719 the people rebelled, overthrew the existing government and elected their leader, James Moore, governor. The result of the revolution was accepted in England, and the province at once came under royal control, although the rights of the proprietors were not extinguished by purchase until 1729. Theoretically South Carolina and North Carolina constituted a single province, but, as the settlements were far apart, their governments were always separate. Until 1691 each had its own governor. From 1691 to 1712 there was usually a governor at Charleston and a deputy for the northern settlements, and after 1712 there were again separate governors. The first attempt to define the boundary was made in 1730, but the work was not completed until 1815.

The period 1725-75 was a period of great prosperity, based upon the trade in pelts (mainly deer skins) and more permanently on the rapidly expanding rice and indigo culture. The southern colonies' Indian trade centred mainly in Charleston. This, and a rich agriculture and the large commercial business to serve them, supplied the economic basis of a coast country society of notable intelligence and culture. One of the earliest theatres in America, musical culture, libraries and the education of a large number of youths in England gave the society around Charleston a tone and finish at that time rare in the new world.

Passing under the royal government did not check the encroachments upon the governor and council by the commons house of assembly, which defiantly announced the powers of the British commons as its model. By 1760 the council had almost ceased to exercise any real control over legislation. It rarely initiated or

amended a bill and never attempted to change a money bill without incurring violent denunciation from the popular house and paralyzing legislative action, once for years.

The province was unconsciously preparing for independence. Though measures of the British government after 1763 were not especially oppressive to the province, the people were too long accustomed to having their own way, and had, especially in the bitter dispute over the Wilkes fund (1769–75) involving the right of the commons alone to control finance, developed too fully a sense of general American and even British freedom to submit to measures which they regarded as subversive of the principles of liberty. Delegates were sent to the Stamp Act congress (1765) and to the continental congresses (1774 and 1775). A council of safety appointed by an extralegal provincial congress virtually took over the government in June 1775. Royal administration ended when, on Sept. 15, the governor dissolved the assembly and field.

Wars with the Spanish in 1686, 1702-04 and 1740, with the Spanish and French in 1706, with pirates in 1718, with the Yemassee Indians in 1715 and the Cherokees in 1760-61, with aid only in 1760-61 from British troops, and a slave rising in 1739 had accustomed the people to arms. The state suffered severely during the Revolution both from British troops and from the presence of numerous loyalists. A British fleet attempting to capture Charleston was repulsed by Fort Moultrie, June 28, 1776. Calm prevailed until Gen. Sir Henry Clinton returned in 1780 with an overwhelming force and Gen. Benjamin Lincoln surrendered the city May 12.

Completely overrun, there followed two years of fighting involving more battles, though most of them small, than occurred in any other state. A continental army under Gen. Nathanael Greene, assisted by state troops under Thomas Sumter, Francis Marion and Andrew Pickens, slowly drove the British back into Charleston and wrecked the plan of British troops from the south to join those from the north to crush Washington. The chief battles fought in the state were Fort Moultrie (June 28, 1776), the siege of Charleston (March 12-May 12, 1780), Camden (Aug. 16, 1780), King's mountain (Oct. 7, 1780, Cowpens (Jan. 17, 1781), Hobkirk's hill (April 25, 1781) and Eutaw Springs (Sept. 8, 1781).

The generation following the Revolution witnessed an ambitious program of transportation development. The Santee canal, connecting Charleston with the whole Santee-Waterce-Broad-Saluda river system, was opened in 1800. Highway building followed. The latter was dropped and the canal was ruined by railroad development. The South Carolina railroad, 133 mi. from Charleston to Hamburg opposite Augusta, when completed in 1833 was the longest railroad in the world.

The early state period was characterized by a bitter struggle between the older low country and the newer upcountry, the latter settled largely by Scotch-Irish coming down the Piedmont belt from Pennsylvania, Virginia and North Carolina. In 1786 it was necessary, to allay discontent, to consent to the removal of the capital to a newly located site to be called Columbia. Although removal took place in 1790, state officers until 1865 kept offices both in Columbia and Charleston and the supreme court met in each city to hear appeals from the two sections respectively. The upcountry (then comprising a larger area than now thus designated), containing four-fifths of the white population and one-fifth of the wealth, in 1808, with the help of a liberal low country minority led by Joseph Alston, secured a constitutional amendment apportioning one senator to each county and representatives to each county in proportion equally to white population and wealth. This left the control of the upper house to the low country and that of the lower house to the upcountry. Manhood suffrage followed in 1810. The low country's fear for its slave interests was allayed as slavery, fostered by cotton culture, spread up the state.

The South Carolina college was chartered in 1801 largely to allay sectional enmity. Only the necessity of standing unitedly against antislavery and reconstruction agitation from the north prevented the more numerous element from forcing its democratic changes until late in the 10th century.

Northern antislayery agitation and the adoption of a tariff harm-

ful to southern agriculture united both sections in the passage of and South Carolina were the only states voting against the repeal the ordinance of nullification, Nov. 24, 1832, forbidding the execution of the tariff in South Carolina. The readiness of a powerful minority to assist President Jackson, combined with a reduction of the tariff, operated to deter the majority from forcing the issue to armed conflict, but left a bitterness within the state that disappeared only toward 1850 in the face of graver danger from outside.

Following the slave conspiracy of 1822 and northern abolitionism the slave code was severely revised (1840-44), even to forbidding the sending of a slave to freedom anywhere in the world. The years 1850-52 saw most of the people deterred from secession only from lack of the co-operation of other states. After 1828 Virginia's southern leadership was superseded by the more uncompromising leadership of South Carolina under John C. Calhoun. South Carolina was the first state to secede, its ordinance of Dec. 20, 1860, being almost unanimously approved by With a white population of 291,300, the state put into the field 62,838 effectives, with a total enrolment, including reserves, of 71,083, of whom 22% were killed or died in prison Gen. W. T. Sherman's march across the state. February to March 1865, was accompanied by enormous destruction, including the burning of Columbia.

The misfortunes of war were more easily borne than the humiliation of reconstruction. Under President Johnson's guidance, the white population elected officers who were soon ejected under the congressional plan of reconstruction, disfranchising many whites and transferring power to the Negroes, northern adventurers ("carpetbaggers") and native whites ("scalawags") joining them. In the spring of 1868 the state was "readmitted" to the union under the control of these elements, and entered upon a period of eight years of crime and corruption, accompanied by arrogance on the part of the Negroes that the whites found galling. Much legislation was by bribery. Stealing extended from large blocks of state property to the price of a politician's whisky. Two hundred trial justices were said to be unable to read. Daniel H. Chamberlain. able carpetbagger and would-be reformer of his own party (governor 1874-76), declared in 1901 that if he had been re-elected in 1876 his party, even with white assistance, could not have given government "fit to be endured." The most urgent pleas on a nonpartisan basis failing to draw the least sympathy in Washington, the whites in 1876, by combined fraud, intimidation and persuasion of Negroes, elected Gen. Wade Hampton (1818-1002) governor by a narrow majority. President Hayes's withdrawal of troops in March 1877 marked the collapse of "radical" rule.

In 1878-80, under the leadership of M. W. Gary (1831-81), the old conflict between uncountry and low country became a fight mainly between the poorer masses and the propertied classes.

The triumph under Benjamin R. Tillman (governor 1890-94; U.S. senator 1895 to his death in 1918), prominent "farmers' movement" leader, was facilitated by acute agricultural distress. Col. A. C. Haskell's appeal to the Negro against Tillman, with proviso that there should be only white officials, was generally condemned even by his own class, drew almost no Negroes and served only to embitter feeling among the whites. The farmers', or more broadly "reform," movement was marked by the establishment of Clemson Agricultural and Mechanical college (1889), the dispensary system of state liquor monopoly (abandoned because of corruption and failure to restrain intemperance) and the work of the constitutional convention of 1895 disfranchising so far as possible the Negro. Direct primary elections, long in use in most of the counties, beginning in some in 1878, were adopted in 1896 for naming U.S. senators, governor and state officers. State politics after 1890 presented a strange combination of rancorous personal politics, mass conservatism and dislike for "aristocratic" influence. Class feeling was strongly manifested in the campaigns of Coleman L. Blease (governor 1911-15). R. I. Manning's administrations (1915-19) were notable for progressive legislation. Factionalism subsiding, Blease was in 1924 elected senator, after having been badly defeated in 1918 on a platform condemning U.S. participation in World War I.

Agriculture and banking suffered severely in the deflation of 1920-21, and all business still more from 1929 to 1937. North

of national prohibition in 1933. In 1935 Gov. O. D. Johnston climaxed his long hostility to the highway department and its chief commissioner, Ben M. Sawyer, by military seizure of the department until condemned by both legislature and supreme court. Public esteem for the construction by the department seemed justified by the failure to discover any wrong. Extensive violent strikes in 1935-36 caused a conservative reaction. President Roosevelt's attempt to defeat Sen. E. D. Smith resulted in Smith's overwhelming re-election, 1938, although the state supported Roosevelt's general policies.

From 1876 almost the entire white population was Democratic, partly from historical reasons and partly because of the conviction that union under the only national party that had defended them against Negro rule in the past was necessary for the maintenance of white supremacy. Only in 1948 did the state bolt the Democratic party, casting its eight electoral votes for Gov. J. Strom Thurmond, of the dissident States' Rights party.

Population .- The population of South Carolina in 1790 was 249,073; in 1840 it was 594,398; in 1880, 995,577; in 1910, 1,515,-400; in 1940, 1,899,804; and in 1950, 2,117,027. This last figure represents an increase of 11.4% over the population in 1940. The population per square mile in 1950 was 69.9, as compared with 62.1 in 1940 and with 50.7 for the U.S in 1950.

Of the 1950 population, 609,225 or 28 8% lived in incorporated places of 2,500 or more, as compared with 24.5% in 1940, when these places constituted the urban area. The entire urban population, under a new definition set up for 1950, which included also the thickly settled suburban area, or "urban fringe," adjacent to the city of Columbia, and 22 unincorporated places of 2,500 or more outside this fringe, amounted to 777,921, or 36.7% of the state total

The number of households in 1950 was 514,660, as compared with 434,968 in 1940.

The average population per household had declined from 4.4 in 1040 to 4.1 in 1050.

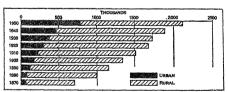
The population of the state was distributed by colour and nativ-

Table I .- Population of South Carolina and Its Principal Cities

Area			Population	Per cent of increase		
		1950	1940	1930	1940-50	1930-40
The state .		2,117,027	1,899,804	1,738,765	11.4	9.3
Urban .		777,921*	466,111	371,080	66.0	25.0
Rural .		1,339,106*	1,433,693	1,367,685	-6.6	4.8
Per cent urba	n	36.7*	24.5	21.3		
Principal cities						
Columbia .		86,914	62,396	51,581	39.2	21.0
Charleston .		70,174	71,275	62,265	-1.5	14.5
Greenville .		58,161	34,734	20,154	67.4	1.01
Soartanburg		36,705	32,240	28,723	14.1	12.3

<sup>\*</sup>Final figures for 1950 based on new definition. See comment in text.

ity in 1950 as follows: 60.7% native white; 0.4% foreign-born white; and 38.9% nonwhite, practically all Negro. There were 99.1 males per 100 females in the native white population and 93.0 in the Negro population; 5.4% of the population was 65 years old or over; and 56.2% of the population 14 years old and over was in the labour force.



BY COURFREY OF THE U.S. BUREAU OF THE CENSUS

URBAN AND RURAL POPULATION OF SOUTH CAROLINA: 1870 TO 1950 The crosshatched part of the 1950 bar represents the population of the additional areas counted as urban under the new 1950 definition

Of the total number of employed males, 31.1% were engaged in agriculture, 7.9% in construction, 27.7% in manufacturing and 17.3% in transportation and trade,

Government.—South Carolina was governed from 1670 to 1719 under the provincial charter of 1665, from 1719 to 1775 under commissions and instructions from the crown, and from 1776 under constitutions of 1776, 1778, 1790, 1865, 1868 and 1895. An amendment to the constitution may be proposed in either house of the legislature. If approved by two-thirds of the members elected to each it must be submitted to the people at the next election for members of the house of representatives. If it is approved by a majority of those voting upon it and subsequently by a majority vote in each house of the general assembly chosen at that election, it becomes a part of the constitution. A convention to revise the constitution may be called by a two-thirds vote in each house ratified by a majority of those voting for representatives at the next election.

A voter must be 21 years old, a resident of the state two years, of the county one year and of the voting precinct four months and must obtain a certificate of registration conditioned on showing that he or she is able to read and write the constitution or the past year paid taxes on property assessed at \$300 or more. (Assessments are usually at about one-fourth value.) Paupers, idiots, the insane, prisoners and persons ever convicted of certain crimes, unless bardoned, are disfranchised.

The Democratic nonvnation is equivalent to election. Voting in the Democratic primary was confined to whites without other qualification than age and residence until federal courts in 1948 ordered Negroes admitted to party membership (few joined immediately). Qualifications became the same as for the general election.

Constitutional amendments changed the terms of the governor and other state officers from two to four years, beginning with those elected in 1926. The governor is ineligible for immediate re-election. He may veto "any one or more of the items or sections contained in any bill," but may be overruled by a two-thirds majority of those voting in each house. In practice the item veto has been used only for appropriation bills. The governor cannot grant pardons except on the recommendation of the pardon board, but he may reduce a death sentence to life imprisonment.

The general assembly, meeting annually, is composed of the senate (one member from each of the 46 counties elected for four years) and the house of representatives (124 members elected for two years from the counties in proportion to population). The state elects six congressmen.

The 5 supreme court judges and the 14 circuit court judges are elected by the legislature for ten and four years respectively. Magistrates (justices of the peace) are appointed by the governor with senate confirmation, although the recommendation of the senator from the county or of the primary election practically determines the selection.

In a few counties a county court with an elected judge disposes of a large part of the lesser civil and criminal cases elsewhere burdening the circuit courts. The probate judge in each county (elected) has also the duties of a juvenile court. The state is divided into two federal court districts.

Local Government.—The unit of local government is the county. Counties are divided into townships, which have no governments and exist largely for the assessment of taxes and the care of local roads. Although the forms of municipal government are prescribed under general statutes and enjoy certain constitutional rights, they are considerably subject to state legislative authority. They may exempt new industries from taxes for five years, except for school purposes, provided a majority in a popular election approves.

The county is administered by a commission, almost always popularly elected. Road or hospital commissions, etc., are frequently appointed by the governor, usually on recommendation of the county legislative delegation. Most of the county officers are elected, except the auditor and treasurer, who are appointed by the governor with senate confirmation; however, the governor almost always names the successful primary election candidates

without question. Since only Charleston has a county council the state legislature is oppressed with a mass of local legislation. It enacts usually without question whatever the senator and representatives of the county concerned agree upon. The latter thus form in effect a county legislature. The senator, by controlling action in the senate, exercises an enormous extralegal power.

Miscellaneous Laws.—Any officer negligently permitting a more to be lynched forfeits his office and becomes ineligible to any office unless pardoned. The county, without regard to the conduct of the officers, is liable to damages of not less than \$2,000 to the heirs of the deceased. In 1949 divorce became allowed for adultery, drunkenness, physical cruelty or desertion.

Finances.—The state tax commission, created in 1915, supervises all tax administration and directly administrates those taxes from which most of the state revenue is derived, such as taxes on incomes, gasoline, retail sales, drinks, electric power, corporations and business. There exists in practice a considerable control of state and local tax sources, the local governments depending mainly on the general property tax; however, the counties receive a share of state gasoline and income taxes, and both county and municipality share the state tax on beverages. The state debt, mainly for roads, on June 30, 1950, was \$68,995,598. The general appropriations bill for the year ending June 30, 1951, totalled \$108,538,717.

Education .- As early as 1710 public-school education was provided for indigent children. The modern free school system was established in 1868. The educational system is under the supervision of a state superintendent of education, with the assistance of a board composed of the governor, the superintendent of education and seven other persons appointed by the governor. State support and regulation of high schools were greatly increased in 1907. South Carolina maintains a dual school system: one for white and one for Negro children. Enrolment in the public elementary schools for the year 1949-50 was 377,356, of whom 190,-465 were white and 186,891 Negro; in the high schools there were 116,829, including 81,840 white and 34,989 Negro. There are adult night schools, enlarged facilities for agricultural, vocational and home economics training, state standard certification of teachers and effective state supervision. By the 1919 law, four months' school attendance became compulsory, but enforcement remained lax despite improvement after 1937.

Agriculture.—South Carolina's farm products are normally valued at much less than its factory output. Thus in 1950, when the gross income from agriculture for the state was \$284,780,000, the value of manufactures was \$1,708,383,629. A notable change in the period 1930–50 was the great increase in the production of peaches. In several years the crop was second only to that of California.

The total farm acreage in 1940 was 11,238,697, or 57.4% of the whole area of the state, a slight increase over the figures for 1930, which were, respectively, 10,39,300 and 53.3%. The total harvested acreage in 1950 was 4,097,000, being 13% below the average for the period 1939-48. Of the 137,558 farmers in 1940, more than half, or 76,251, were white. White owners were 42,783, Negro 17,084; white tenants were 32,990, Negro 44,194; white managers were 478, Negro 29. The percentage of tenancy was 56.1.

The valuation of all farm land and buildings in 1940 was \$338,-494,517; of the average farm, \$2,461. The average value per acre of land alone was \$30.12. The farm population decreased during the ten-year period 1930-40 only slightly, from 914,098 to 913,312. Cotton, though no longer heading the list in acreage, still held

TABLE II .- Principal Crops of South Carolina, 1950

Crop				Acreage	Product	Value
Cotton (bales) Cottonseed (tons) Tobacco (lb) Corn (bu.) Cost (bu.) Hay (tons) Sweet potatoes (bu.) Wheat (bu) Peanuts (lb.) Cowpeas (bu.)	:	:	:	870,000 870,000 114,000 1,446,000 678,000 422,000 156,000 21,000 65,000	400,000 162,000 150,480,000 33,258,000 18,984,000 3,44,000 5,671,000 2,184,000 15,750,000 3,58,000	\$79,800,000 12,442,000 82,463,000 46,551,000 17,086,000 10,064,000 9,641,000 4,805,000 1,922,000 1,700,000

first place in total crop value at mid-20th century. The state has two great cash crops, cotton and tobacco; five grain crops, corn, wheat, oats, rye and barley; four legumes that yield both hay and grain, cowpeas, soybeans, velvet beans and peanuts; two for syrup, sorghum and sugar cane. Potatoes, both white and sweet, fruit and vegetables also add to the wealth of the state.

The coastal region, with a mild climate and a soil responding quickly to intensive cultivation, is especially suited to commercial truck farming. The chief products, exclusive of potatoes and cane grown for syrup, are watermelons, cabbages, cucumbers, snap beans, beets, asparagus, tomatoes and lettuce. Strawberries, dewberries, blackberries, figs and grapes add to the fruit wealth

Dairying and the livestock industry as a whole were capable of much further development at mid-century. The state produced only about one-third of the creamery butter it consumed, there being little more than one cow to the farm on an average. In 1950 there were reported 172,000 milch cows in the state; in 1949 the total milk production was 615,000,000 lb. The total value of the principal classes of livestock was \$77,047,000.

Forests and Fisheries.-The total stand of saw timber on South Carolina commercial forest land in 1947 was estimated at 25,696,200,000 bd.ft., of which 14,991,400,000 bd.ft. were in softwoods and 10,704,800,000 bd ft. in hardwoods. The annual growth was estimated at 1,457,100,000 bd.ft. In 1946 lumber production in the state was 1,520,198,000 bd.ft., or about 2.5% of the nation's total. Small quantities of turpentine and rosin are produced from the slash pine forests of the coastal plain.

The commercial fisheries are located in the five coastal counties -Beaufort, Colleton, Charleston, Georgetown and Horry. Oysters are canned in quantity, but several other kinds of fish are

also taken.

Minerals.—South Carolina's mining output is small, amounting in 1950 to less than .01% of the total mineral value of the United States. The principal mineral products were clay products, stone, sand and gravel. The stone quarried is chiefly granite and granite-gneiss. High-grade granite, the "Winnsboro Blue," is quarried in Fairfield county near Rion.

Manufactures.-In 1949 there were 1,783 manufacturing establishments in South Carolina, employing 173,926 wage earners and producing \$1,701,839,000 worth of goods. Activity had somewhat recovered from the depression by 1933, was nearly normal by 1940 and increased substantially during World War II and after. Of the total value of product, cotton goods constituted about 70%. The number of textile manufacturing plants in 1949 was 278, the number of producing spindles 5,741,916 and the number of operatives 124,379. The amount of raw cotton consumed was 1,799,404 bales, and the value of the output was \$1,175,337,-135. Almost every grade of cotton cloth is produced. Factors contributing to the rapid development of the cotton textile industry in South Carolina were the abundance of cheap hydroelectric power from the numerous streams, a suitable climate and dependable native labour. The Piedmont section led in the textile industry. The values of the output in 1949 for the chief producing counties were as follows: Greenville, \$221,429,249; Spartanburg, \$219,112,346; Anderson, \$201,571,602; York, \$79,724,-489; and Greenwood, \$73,552,669. Laurens, Lancaster and Chester are also large manufacturers of textiles. Charleston and Richland counties are important for diversified industry.

During 1949 paper and pulp were valued at \$77,679,802; clothing, \$62,760; electric current, \$42,594,385; fertilizers, \$35,921,-923; meat packing and abattoirs, \$26,813,226; barrels, boxes, baskets and veneering, \$25,013,178; cottonseed oil, meal and cake, \$22,985,863; foundry and machine shops, \$19,469,471.

Hydroelectric development greatly aided industry and improved living conditions. Of the numberous hydroelectric installations the greatest is the publicly owned Santee-Cooper project. Its two reservoirs (Lakes Marion and Moultrie) have a combined area of 160,000 ac. and develop approximately 133,000 kw. Lake Murray dam, about 10 mi, above Columbia on the Saluda river, 208 ft. high and 7,000 ft. long (one of the largest -earth dams), forms a lake about 50,000 ac. in area and develops

130,000 kw. The state's total hydroelectric capacity in 1950 was about 673,000 kw. The average residential consumer in 1948 was using about three times as much electricity as in 1932. On June 30 1948, 27,460 mi. of rural electric lines were serving 152,-275 customers.

Transportation and Commerce.-The chief railway systems of South Carolina are the Southern, the Atlantic Coast Line and the Seaboard Air Line. Steam railway mileage was gradually reduced from 3,780 mi. on Dec. 31, 1930, to 3,563 mi. in 1950, not including second tracks or sidings. During the same period there was a steady increase in the mileage of paved roads built by the state government. The mileage of state highways on June 30, 1950, was 21,036, of which 12,083 mi. were hard-surfaced. Mileage under county systems was 27,376. Automobile registration was 231,274 in 1929, 324,290 in 1940 and 571,840 in 1950.

Inland water communication is possible on a number of the larger navigable rivers, but is not greatly developed. South Carolina in the year ending June 30, 1950, carried on foreign trade to the value of \$94,200,000, of which \$34,600,000 represented imports and \$59,600,000 exports. Duties collected totalled \$2,522,-

050. Coastwise tonnage is greater than foreign.

o50. Coastwise tonnage is greater than foreign.

Bibliography.—M. Toumey, Report on the Geology of South Carolina (1848); Publications of the State Historical Commission; Annual Reports of various state departments; D. D. Wallace, Civil Gogernment of South Carolina (1922 and later eds.), South Carolina Constitution of 1895, University of South Carolina bulletin (1923); E. Dienglish, Author Lits of Caroliniana in University of South Carolina Library, University of South Carolina Congress, Select List of References, No. 457 (on reconstruction in South Carolina); B. R. Carroll, Historical Collections of South Carolina (1836); South Carolina Historical and Genealogical Magazine; South Carolina Historical Society Collections; D. D. Wallace, History of South Carolina, 3 vol. (1924), 1-vol. abridgement (1951); zme; South Caroina Historical Society Collections; D. D. Wallace, History of South Carolina, 3 vol. (1934), 1-vol. abridgment (1951); Edward McCrady, History of South Carolina under the Proprietary Government (1897), History of South Carolina under the Royal Government (1890), History of South Carolina in the Revolution; 2 vol. (1901-02); D. Ramsay, History of South Carolina (1809); W. J. Rivers, South Carolina to Close of Proprietary Period (1856); W. R. Smith, South Carolina as a Royal Province (1993); D. D. Wallace, Life of Henry Laurens, with a sketch of John Laurens (1915); B. Wisheld Williams Course Exchandible of the Carolina (1905); W. S. Wisheld Williams Course Exchandible of the Carolina (1905); W. S. Wisheld Williams Course Exchandible of the Carolina (1905). Life of Henry Laurens, with a sketch of John Laurens (1915); B. Mitchell, William Gregg, Factory Master of the Old South (1928); Laura A. White, R. B. Rhett (1932); Anne K. Gregorie, General Sunter (1931); A. G. Holmes and G. R. Sherilll, Thomas G. Clemson (1937); S. M. Derrick, Centennial History of South Carolina Rathroad (1930); R. Mills, Statistics of South Carolina (1826), Alias of South Carolina, W. A. Sheppard, Red Shirts (1935); W. Allen, Governor Chamberlain (1888); F. B. Simklins and R. H. Woody, South Carolina during Reconstruction (1932); P. D. Jervey, R. Y. Hayne (1909); F. B. Simklins, Tillman Movement in South Carolina (1926); J. C. Calhoun, Works, and Letters in American Historical Association Report (1800); C. Meriwether, Hisher Education in South Carolina (1980); (1890) houn, Works, and Letters in American Historical Association Report (1899); C. Meriwether, Higher Education in South Carolina (1880); W. P. Trent, W. G. Simms (1822); G. A. Wauchope, Literary South Carolina (1923). Elementary books are Mary C. S. Oliphant, History of South Carolina (numerous late eds.), and Helen K. Hennig, Great South Carolinians (1940); South Carolina, "American Guide Series," Federal Writers' Project, WPA (1941). (D. D. W.; C. E. Cn.) SOUTH CHARLESTON, a city of Kanawha county, W. Va.,

U.S., on the south bank of the Kanawha river, 4 mi. W. of Charleston. It is on U.S. highway 60 and is served by the Chesapeake and

The population was 16,686 in 1950 and 10,377 in 1940 by the federal census. South Charleston is a chemical manufacturing centre; its plants produce alcohols, resins, ethers, acids and chlorinated hydrocarbons. Antifreeze liquids, thermoplastics and dentures are also manufactured there.

Under a mayor-council form of government the city's mayor and eight councilmen are directly elected for terms of four years. The South Charleston seaplane base is located on the south bank of the Kanawha river 1 mi. W. of South Charleston. Facilities at the base include mooring equipment, floats, a marine railway and hangar.

Hospitals in South Charleston are the Dunn hospital, established in 1915, the Kanawha Valley Medical centre, established in 1944, and the Herbert J. Thomas Memorial hospital, established in 1946.

There is a conical Indian burial mound 175 ft. in circumference at the base and 30 ft. high in Staunton park, a triangular park near the western end of the city. The federal government opened the mound in 1883 and found ornaments, stone weapons, fragments of pottery and a number of human skeletons.

SOUTHCOTT, JOANNA (1750-1814), English religious fanatic, was born at Gittisham in Devonshire. Her father was a farmer and she herself was for a considerable time a domestic servant. She was originally a Methodist, but about 1792, becoming persuaded that she possessed supernatural gifts, she wrote and dictated prophecies in rhyme, and then announced herself as the woman spoken of in Revelation xii. Coming to London at the request of William Sharp (1749-1824), the engraver, she began to "seal" the 144,000 elect at a charge varying from 12s. to a guinea.

When over 60 she affirmed that she would be delivered of Shiloh on Oct. 19, 1814, but Shiloh failed to appear, and it was given out that she was in a trance. She died of brain disease on Oct. 29, 1814. Her followers are said to have numbered more

than 100,000, and are not yet extinct.

Among her 60 publications, all equally incoherent in thought and grammar, may be mentioned: Strange Effects of Faith (1801-02); Free Exposition of the Bible (1804); The Book of Wonders (1813-14); and Prophecies Announcing the Birth of the Prince of Peace (1814).

A lady named Essam left large sums of money for printing the Sacred Writings of Joanna Southcott.

See D. Roberts, Observations on the Divine Mission of Joanna Southcott (1807); R. Reece, Correct Statement of the Circumstances attending the Death of Joanna Southcott (1815).

SOUTH DAKOTA, the "Coyote" or "Sunshine" state, is one of the north-central states of the United States. It is about 380 mi. (east-west) by 200 mi., with an area of 77,047 84,mi., of which 511 sq.mi. are covered by rivers or lakes. Its extreme points are approximately 42° 29′ and 45° 57′ N. and 96° 26′ and 104° 3′ W. It is a state of great variety of natural features and of production. Dakota territory, named for the Dakota or Sioux Indians, originally also included Montana and Wyoming, but when North and South Dakota, the only twin states in the union (simultaneously created), were admitted on Nov. 2, 1889, the territory so divided consisted of the states as they now exist.

Physiography.—The eastern part of the state to the Missouri river, which originally flowed in the valley of the modern James river, was covered by the advancing great glacier and is largely flat prairie. In the northeastern section are many lakes lying in the glacier-created hills known as Coteaus. The James river has scant fall across the state. The Missouri river, formed by the glacier, is, down to the mouth of the James river, a deep narrow river plain, being seldom more than 2 mi. in width and often



ROCK NEEDLES IN BLACK HILLS, SOUTH DAKOTA

constricted to a river plain less than I mi. wide. East of the Missouri there is little wasteland; most of the land is tillable and with sufficient moisture. West of the Missouri the land is largely rolling grassland, cut by a number of streams of considerable size. chief of which are the Grand, Moreau, Cheyenne, Bad and White rivers. South of the White river the soil is sandy and most of the creeks flow water at all times. On either side of the White river, and particularly north of it, in the area between it and the South Fork of the Cheyenne, is an area known as the Bad Lands, the Mauvaises Terres of the early French. This area is prolific in fossil finds. The ground forms are grotesque and picturesque and interspersed therein are numerous well-grassed flat-topped tablelands. The Black hills are in fact mountains, the highest of which. Harney Peak (7,240 ft.), is the highest point in the United States east of the Rocky mountains. This great upthrust stands out from a surrounding prairie region. Its granite-topped peaks are verdure-clad nearly to their summits and, combined with pine forests, mountain streams and a large number of man-made lakes, create a picturesque and pleasing prospect. The Rushmore National memorial is located near the centre of this area, adjacent to the South Dakota State park, largest state park in the nation. There are several large caves in the Black hills, the largest and most beautiful being Wind cave, a national memorial in the southern hills, and Crystal cave, north of Rapid City. North from the Black hills are the Cave hills and the Slim buttes, great masses of land rising from surrounding prairies. The Slim buttes are particularly weird and beautiful.

With the exception of a small area in the extreme northeastern part of the state adjacent to Lake Traverse, the entire state is drained to the Missouri river by north-and-south streams, the Sioux, Vermilion and James rivers east of the Missouri, and, in the west river area, by the east-and-west rivers named above. There are a large number of lakes in the northeastern area and on the high ground between the Sioux and James rivers.

The woodland area of South Dakota is almost exclusively in the Black hills, consisting of an estimated 2,500 sq.mi. &f 3.25% of the entire land area. Except for tree claims (1870–90) planted east of the James river, other woodlands are found only surrounding lakes or along streams. There is a wide diversity of trees including the elm, oak, box elder, cottonwood and hackberry native in the eastern section, and the ponderosa pine, spruce, aspen, white birch and cedar native to the Black hills. Small cedars are found in much of the rough country west of the Missouri, particularly along the White and Little White rivers. There are three national forests in the Black hills, the Harney, Custer and Black Hills forests, composing in all more than 1,000,000 ac.

Climate.—There is considerable variety in the climate because of the state's distance from great bodies of water and its rather large variation of altitude (from 1,000 to 6,000 ft. above sea level). Rainfall varies, except in the Black hills area where it compares with that of the southeastern section, from the southeast across the state to the northwest. Yankton (28.15 in.), Pierre (16.11 in.) and Camp Crook (13.89 in.) have typical averages. The growing season is limited by the periods between frosts-110 to 120 days in the northern part of the state and 140 to 160 days in the south and southeastern portions. Winters vary greatly, some including from 90 to 150 days of cold and snow and many having little snow. Temperatures vary from an average of 42° in the northeast to 48° in the southwest. Summer temperatures frequently reach 110° but because of the dryness are not oppressive, and the nights ordinarily are cool. There are recurrent years of drought with none very extensive except in the 1930s, when seven of the ten years were extremely dry.

History.—Archaeologists discovered from the contents of mounds and village sites a people who lived in the area prior to the Aricara Indians, whose history antedates A.D. 1500. White men knew considerable about South Dakota prior to 1700, if not by actual penetration into the area. The first certain penetration was made in 1742 by the Vérendrye brothers, who came into northwestern South Dakota via the Mandan villages of North Dakota and who on March 30, 1743, planted a leaden plate at Fort Pierre where they gave up their search for a western sea.

In 1780 or thereabouts Pierre Dorion settled near Yankton and during the next two decades many traders arrived. Some, notably Jacques d'Eglise, crossed the state on the Missouri to trade with the Mandans. The first building certainly constructed by white men in South Dakota was by Jean Baptiste Truteau, on the river to mi. S. of Lake Andes in 1794. John Valle had been near to if not to the Black hills prior to 1804 and traders from the upper Mississippi had been in the northeastern part of the state. That year Meriwether Lewis and William Clark ascended the river on their notable trip to the Pacific. France first claimed the area. then in 1762 secretly deeded it to Spain, which returned it to Napoleon; the latter sold it to the United States in 1803. The Lewis and Clark report was so glowing that the area promptly became a mecca for the fur seekers, Manuel Lisa, Pierre Choteau, Registre Loisel and many others, who sought to open posts in the area. The War of 1812 seriously impeded trade but by 1817 Teach LaFramboise had started a post at Fort Pierre, the site of the first permanent settlement in the state. The fur trade prospered greatly In 1823 the Aricara Indians barred the ascent of the Missouri to traders and a bloody battle ensued When this was reported to Col. Henry Leavenworth at Fort Atkinson 600 mi. downstream, he led a small group of U.S. soldiers and a motley array of trappers and traders with some highly uncertain Indian allies up the Missouri in record time to the mouth of Grand river, where he broke the power of the Aricaras. Fort Pierre was the fur capital of a trade territory of 250,000 sq.mi. In 1831 the first steamboat, the "Yellowstone," mounted the Missouri to that point and the steamboat, with its ease of travel and transport was mainly responsible for the decimation of the buffalo, which by 1855 no longer roamed in countless numbers. Fort Pierre was then sold to the government as a military post.

No attempt at settlement by other than traders was made until 1856 when pioneers from Iowa and Minnesota, drawn by the power prospects at the falls of the Sioux river, located there and at Medary farther north. These settlements persisted until the War of the Indian Outbreak in 1862. Meanwhile some settlers were moving into the bottoms of the Missouri adjacent to the present Sioux City and a permanent settlement was effected at Yankton in 1859. In 1862, when Dakota became a territory, Yankton was made its capital. In the next decade, however, only 11,915 people had made the area their home; the settlements were largely on the Missouri and its tributaries, the Sioux, Vermilion and James rivers. The railroad from Sioux City to Yankton was completed in 1872, to Sioux Falls in 1878 and to Watertown in 1873 (abandoned, but again completed in 1878). The discovery of gold in the Black hills in Aug. 1874 by Gen. George A. Custer had started a great inrush into that area, which provoked the Indian activities of 1876 culminating in the Custer massacre in Montana. The first gold was discovered in French creek near Custer, which in the winter of 1875-76 boomed to a town of 6,000. But the deposits there played out and a rush to the discoveries at Deadwood began. In the Deadwood area the deposits were of greater value. The Dakota boom of the 1880s was soon in progress. There were 327.21 mi. of railway prior to 1880. In the next decade 1,800.65 mi. had been added, and the population had more than tripled to 328,808. Free homesteads were to be had for the occupancy and "tree claims" could be planted and added to the free land available. The area east of the Missouri and the Black hills was pretty well settled by 1800.

In 1883 and again in 1885 constitutional conventions met. Finally in July 1889 an omnibus bill was passed, granting statehood to the two Dakotas, Wyoming, Idaho, Montana and Washington. The Dakotas qualified first, and Pres. Benjamin Harrison signed the proclamations and published them simultaneously, the only "twin" states in the union, as of Nov. 2, 1889. The advent of the new states was inauspicious; 1889 and the following eight years saw much drought; many homesteaders went bankrupt and left the area. In the first five years the population was static, a gain of only 2,167 being recorded until 1895. Better rainfall, a political change and a war boom raised the state population to 401,570 by 1900. The early settlement had largely been by people of native stock, but in the 1870s and 1880s large numbers of north-

ern Europeans came into the country, staying for the most part during the depression of the 1890s. The country west of the Missouri except for the Black hills area was largely Indian reservation. The area between the White and Cheyenne rivers and west of Pierre to Rapid City had been opened in 1889 but with very few homesteaders. By 1903 there was a movement into that area. Meanwhile the effort to open the reservations to settlement persisted; in 1905 the eastern Rosebud was opened, and in 1909 the areas in Tripp and Mellette counties in the Rosebud and in Dewey, Corson and Ziebach counties in the Rosebud and Standing Rock reservations were opened. Railroads were built into the areas and general prosperity resulted in a large population increase, to 583,888 by 1910.

South Dakota had been created by a strongly Republican congress elected in 1888 and for its first 25 years was a Republican state with the exception of the years 1897 to 1901 when a Democratic administration, the result of the Populist movement of the 1890s, came into power. The state suffered three periods of depression and drought: the early 1890s, the years 1910-12 and 1931-39. In the election of 1906 the Republican party was split into two groups, the Standpatters and the Progressives, who were successful for a long time. This faction was responsible for the constitutional amendments that permitted the state to enter into a variety of business affairs, including rural credits, state bonding, state coal mining, state hail insurance, state cement plant and state guarantee of bank deposits. These various projects involved the state in about \$60,000,000 of indebtedness. With the exception of the state cement plant, all had been liquidated by mid-20th century and the indebtedness largely paid off. Some financial scandals growing out of these business affairs resulted in the election of a Democratic administration in 1927. The Standpat faction of the Republican party elected a governor in 1931, but the commencement of the drought and the low prices of 1032 ousted him for a Democratic administration from 1033 to 1937, after which date the state was solidly Republican and antisocialistic. World War I and the postwar prosperity of 1919-20, together with unjustifiably high land and cattle prices, saddled the farmers with debt, and the deflation of the early 1920s resulted in liquidation of many banks and the elimination of the state bank guaranty fund. High farm prices created by World War II and bumper crops placed the financial affairs of the state and its citizens in a favourable condition in 1950.

Government.-The state constitution adopted on admission to statehood in 1889 has been amended many times. The state legislature, consisting of a senate of 35 and a house of 75 members, makes laws subject to the people's right to refer its laws and to initiate laws of their choosing: South Dakota was the first state to adopt such measures (1808). Either can be invoked by a petition of 5% of the voters. All state officers are elected for two years. The governor has the usual right of veto, except for initiated measures; the veto can be overridden by a two-thirds vote. He has the customary power to pardon and reprieve. The courts consist of a supreme court, 12 circuit courts, county courts and municipal and justice courts. Supreme court judges are chosen from given districts for six-year terms, circuit judges serve for four years and all others for two years or as may be fixed by municipal ordinance. In 1950 there were 20 circuit judges for the 12 circuits.

Population.—The area which now forms South Dakota had 11,776 inhabitants in 1870 and 348,600 in 1890. The population of the state in 1910 was 583,888; in 1940, 642,961; and in 1930, 652,740. This last figure represented an increase of 1.5% over the population in 1940. The population per square mile in 1950 was 8.5, as compared with 8.4 in 1940 and with 50.7 for the U.S. in 1950.

Of the 1950 population, 216,151, or 33.1%, lived in incorporated places of 2,500 or more, as compared with 24.6% in 1940. South Dakota had neither cities of 50,000 or more nor unincorporated places of 2,500 or more, but its urban area in 1950 included a part of the urban fringe of Sioux City, Ia., making a total of 216,710, or 33.2% of the total. The population of the state and its principal cities is summarized for recent censuses in the table,

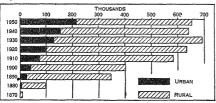
The number of occupied dwelling units (or households) in 1950 was approximately 180,000, as compared with 165,000 in 1940.

Area			Population	Per cent of increase		
		1950	1940	1930	1940-20	1930-40
The State .	_	652,740	642,961	692,849	15	-7 2
Urban* Rural*	:	216,710 436,030	158,087 484,874	130,907 561,942	37 0 10 I	20 8 -13 7
Per cent urban Principal cities	٠	33 2	24 6	189		
Sioux Falls . Rapid City .	•	52,696 25,310	40,832 13,844	33,362	28.9 83.0	22 4 33 I
Pierre		5,715	4,322	3,659	32 0	181

\*Final figures for 1950 based on new definition. See comment in text

The average population per household had declined from 3.9 in 1940 to 3.6 in 1950.

The population of the state was distributed by colour and nativity in 1940 as follows: 89.4% native white; 6.9% foreignborn white; and 3.7% nonwhite, practically all Indians. Of the foreign-born white population 38.1% were born in Scandinavian countries (19.8% in Norway, 9.9% in Sweden and 8.4% in Denmark), 18.9% in Germany and 14.7% in Russia. There were 105.4 males per 100 females in the native white population, and



BY COURTESY OF THE U.S. BUREAU OF THE CENSUS

URBAN AND RURAL POPULATION OF SOUTH DAKOTA: 1870 TO 1950

132.0 in the foreign-born white; 6.8% of the population were 65 years old or over; and 50.3% of the population 14 years old and over were in the labour force. Of the total number of employed males, 57.5% were engaged in agriculture, 3.7% in construction, 48% in manufacturing and 17.7% in transportation and trade.

Education .- The public- and secondary-school system of South Dakota is under the supervision of the state superintendent of education, a constitutional officer. There were on June 15, 1950, 156,372 persons of school age in the state. Of this total, 117,675 were in public elementary and high schools and 10,243 in parochial schools. The total cost of public-school education in 1949-50 was \$25,984,238, or \$221 per pupil. The state's educational institutions with 1950 school enrolments were as follows: University of South Dakota, Vermilion, 1,622; South Dakota State College of Agriculture and Mechanic Arts, Brookings, 1,732; South Dakota School of Mines, Rapid City, 473; Northern State Teachers college, Aberdeen, 643; Southern State Teachers college, Springfield, 177; General Beadle State Teachers college, Madison, 150; Black Hills Teachers college, 412; School for Deaf, Sioux Falls, 89; School for Blind, Gary, 37. There were in addition five privately endowed colleges as follows: Huron college, 289; Yankton college, 290; Dakota Wesleyan university, Mitchell, 281; Augustana college, Sioux Falls, 774; and Sioux Falls college, 243.

Charities and Corrections.—The state maintains a penitentiary at Sioux Falls with a constantly fluctuating number of inmates (46 in 1950); a training school for boys and girls at Plankington (117 in 1950); a hospital for the insane at Yankton (1,732 immates in 1950); and a home for the feeble-minded at Redfield, with about 800 immates.

Finance.—The state originally had a constitutional limitation of indebtedness of \$100,000. By a series of amendments in 1916 and 1918, however, this limitation was removed for specific purposes and in 1920 the gross debt, largely for rural credits, had increased to about \$60,000,000. As of 1950, the debt had been

reduced to \$19,730.994, sinking funds considered. This sum included a balance of \$12,324,520 still due on a \$21,000,000 bond issue of 1949 to pay a veterans' bonus. The state general fund, much of which could be applied on state debt, with legislative sanction, was on Oct. 1, 1950, \$16,915,568. The 1950 total assessed valuation was \$1,320,257,692, of which real estate was 62,43%. Total local and state revenues from all sources in 1949–50 amounted to \$88,182,234,38. Federal taxes paid the same fiscal year amounted to \$57,995,865, op a total burden of taxes and excises of \$146,178,199,45—a per capita burden of \$224,90.

Purely state receipts from all sources were \$59,441,588.88 for the fiscal year 1948-49, of which \$2,010,661.56 came from moneys and credits, maintenance of insane, inheritance taxes and game and fish funds derived from county treasurer receipts; \$38,263,232.29 from motor fuel, sales tax, cigarette stamps, beer tax and licences and similar sources; \$13,534,316.32 from federal aid to highways, state college, health, public instruction, game fish and possible social security and like agencies; \$2,170,223.11 from local endowments and fees, tuitions and sales of endowment lands; \$2,462,955 60 from sales of school and public lands, rentals and interest. Of this sum, \$57,346,940.49 was disbursed for the following purposes educational institutions \$4,464,715.33; motor fuel refund (to farmers for nonhighway purposes) \$3,380,474.31; veterans' bonus \$2,052,321.75; cement plant \$2,638,627.37; highways \$18,777,018.44; appointive offices \$1,595,950; constitutional offices \$779,803.75: penal and charitable institutions \$2,137,687; rural credits (debt) \$2,771,000; social security \$8,416,825.17; common school aid \$3,240,711.05; game-fish parks \$1,260,301.13; buildings and improvements \$902,040.53; all other \$4,928,969.66. Federal aid items amounted to 23.3% of federal taxes paid. National banks as of April 24, 1950, had assets of \$262,120,000, with loans and discounts of \$74,241,000 or 28%; state banks had assets of \$227,241,341.73 and loans and discounts of \$65,748,962.32 or 29%. Total bank assets amounted to \$489,361,341 or \$753 per

Agriculture and Livestock .- The growing of crops and livestock for market is South Dakota's chief resource. The average production for principal crops during 1938-47 was: corn, 79,028,-000 bu.; wheat (all), 37,530,000 bu.; oats, 77,963,000 bu.; barley, 33,186,000 bu.; rye, 6,464,000 bu; flaxseed, 3,069 bu.; buckwheat, 42,000 bu.; potatoes, 2,390,000 bu.; soybeans, 209,300 bu.; sorghum (all), 1,957,000 bu.; hay (all), 2,638,000 tons; alfalfa seed, 29,000 bu.; sweetclover seed, 38,800 bu. Value of production over this decade averaged \$246,315,000 annually. The 1948 production alone amounted to \$485,954,000. Much of South Dakota production is marketed in the form of animals. The 1939-48 averages were as follows: all cattle and calves, 2,176,000, worth \$154,261,000; horses, 314,000, worth \$14,546,000; mules, 4,000, worth \$279,000; hogs and pigs, 1,628,000, worth \$43,038,-000; sheep and lambs, 1,829,000, worth \$16,980,000; chickens, 9,278,000, worth \$8,754,000; turkeys, 206,000, worth \$607,000. This represents an average annual total value of \$238,465,000. The 1949 value of farm animals was \$472,942,000. In 1949 there were 334,000 cows producing 1,369,000 lb. of milk and 52,000,000 lb. of butterfat. There were 8,083,000 hens producing 1,060,000 eggs for a cash income of \$28,586,000; at the same time the gross income from sales of chickens was \$10,647,000 and of turkeys \$1,403,000. In 1949, 715,000 sheep were shorn, producing 5,928-000 lb. of wool valued at \$2,786,000. In the same year 2.286,971 hogs, 892,570 cattle and 579,517 sheep were marketed. The 1949 farm income from all sources was: crops and livestock \$527,389,-000, government payments \$4,241,000; total \$531,630,000.

Manufactures and Mining.—South Dakota has few industries. In 1947, 494 establishments with 8,662 workers added \$51,398,000 in value to materials processed. Food processing plants accounted for 5,359 or 64% of the workers, lumber products 903 and printing and publishing 712. The rest were engaged in the fabrication of machinery, metal products, stone, clay and chemicals.

In 1949 the value of mineral production in South Dakota exceeded \$23,000,000, the chief item being 464,613 oz. of gold with a value of \$16,221,699. The chief source of gold was the giant

Homestake low-grade deep mine situated at Lead. Silver production was 109,150 oz. valued at only \$98,777. The production of other metals was as follows (in tons): iron ore \$1,50; beryl 63; feldspar 37,930; lithium ore \$1,27; mica 944; quartz 32. These totalled \$65,059 in value. Baser production included bentonite 17,81,38 tons, \$1,603,424; brick and tile 17,000 tons, \$60,200; cement 687,331 lb., \$1,787,060; granite 264,469 cu.ft., \$2,150,250; gypsum 7,081 tons; lime 1,513 tons. The production of galena ore was at a standstill because of the low prices of silver and lead. South Dakota annually ranks first or second in gold production. The Homestake mine at mid-20th century had produced more than \$450,000,000 in gold. The Black hills area has deposits of almost every known precious mineral but frequently not in paying quantities. In 1914–18 tungsten to the value of \$1,106,740 was produced.

Transportation.—Railways operating in 1950 had 4,665.27

10.0 Markekage serving 492 communities; 3.972 mi. of track were
main line. There is only one transcontinental railroad, the Chicago, Milwakee, St. Paul and Pacific, operating nearly 1,800 mi.
The Chicago and North Western operates about 1,200 mi. Gross

freight earnings for 1949 were \$27,907,770.

The highways of South Dakota in 1950 included 426.1 mi. of concrete; 3,131.9 mi. of oiled surface; 27,455.6 mi. of gravel; and 62,994.7 mi. of made road. During the fiscal year 1949–50 the state highway commission spent \$16,552,620.87 on road building and maintenance.

BIBLIOGRAFHY.—Publications of the various state departments and reports of officials; South Dakota Manual; S. S. Visher, Geography of South Dakota (1918); D. Robinson, History of South Dakota (1930); G. W. Kingsbury, History of Dakota Territory (1975); E. F. Peterson, Historical Aldas of South Dakota (1904); G. F. Will, Archaeology of the Missouri Valley (1904); P. Rosen, Pa-ha-sa-pah, or, The Black Hills of South Dakota; A. D. Tallent, The Black Hills. See also Collections of the South Dakota; The Black Hills. See also Collections of the South Dakota Guide Beries" prepared by the Federal Writers' Project, WPA (1938).

SOUTHEND-ON-SEA, a county and parliamentary borough and watering place in Essex Eng. A2 mi, from London

SOUTHEND-ON-SEA, a county and parliamentary borough and watering place in Essex, Eng., 43 mi. from London by road. Pop. (1951) 351,830. Area 16.7 sq.mi. It was visited by Queen Caroline in 1804 and is the nearest seaside resort to London. The bathing is good, but the tide recedes rapidly for nearly a mile. The pier, which is more than 14 mi. in length, permits the approach of steamers at all tides. Westcliff-on-Sea is a favestern suburb. To the westward again is Leigh-on-Sea; its lofty Perpendicular church tower is visible from afar. The castle was built in the 13th century, and two ruined towers remain. Canvey Island, 10 mi. W. of Southend, is a holiday resort. Southend was incorporated in 1892, became a county borough in 1914 and a parliameters because in 1818.

parliamentary borough in 1918. It returns one member.

SOUTHERNE, THOMAS (1660-1746), English dramatist,
was born at Oxmantown, near Dublin, in 1660, and entered Trinity
college in 1676. Two years later he was entered at the Middle
femple, London. His first play, The Persian Prince, or the Loyal
Brother (1682), contained a flattering portrait of James II as the
"loyal brother." The poet received a commission in Princess
Anne's regiment, but his military career came to an end at the
Revolution. He then gave himself up entirely to dramatic writing. In 1692 he revised and completed Cleomenes for John Dryden; and two years later he scored a great success in the sentimental drama of The Ratal Marriage, or the Innocent Adultery
(1694). The piece is based on Aphra Behn's The Nun, with the
addition of a comic underplot. It was frequently revived, and
in 1757 was altered by David Garrick and produced at Drury
Lane. It was known later as Isabella, or the Fatal Marriage.

The general spirit of his comedies is well exemplified by a line from Sir Anthony Love (1691): "Every day a new mistress and a new quarrel." This comedy was his best.

Southerne scored another conspicuous success in Oroonoko, or the Royal Slave (1696). He died on May 22, 1746.

His other plays were The Disappointment, or the Mother in Fashion (1684), founded in part on the Curioso Impertinente in Don Quixote; The Wives' Excuse, or Cuckolds Make Themselves (1692); The Maid's Last Prayer, or Any, Rather Than Fail (1692); The Fate of Capua (1700); The Spartan Dame (1719), 21-D

taken from Plutarch's life of Aegis; and Money the Mistress

SOUTHERN OCEAN. By Southern ocean is understood the oceanic areas from the antarctic continent to about lat. 40° S. This region is often dealt with as an entity because the climatological features, water masses and currents are similar all around the continent. In geography, however, it has been the established practice to consider the Atlantic, Pacific and Indian oceans (qq.v.) as extending to the antarctic continent. (H. U. S.)

SOUTHERN OVERLAND MAIL. In 1850 monthly mail services were established by the federal government from Independence, Mo., to Santa Fe, N.M., and to Salt Lake City, Utah. A one-way trip on each route took approximately 30 days. A similar service was inaugurated in 1851 between Salt Lake City and Sacramento, Calif. There were no stations along the routes, and it was usually necessary to use one team for the entire trip. Since these facilities proved inadequate, most of the mail to the west was sent via Panamá by steamship.

In 1857 the Overland California Mail bill was passed by congress. Provisions of the act set the itinerary of the proposed route from St. Louis, Mo., to Little Rock, Ark., and then through

El Paso, Tex., and Yuma, Ariz., to California.

Under this act, the semiweekly Southern or Butterfield Overland route began in 1858 on a 25-day schedule. The choice of the Southern route was opposed by advocates of a central route through Salt Lake City.

The postmaster held that unfavourable northern weather would make the central route impractical. To prove that the central route should be developed, the operators of the semimonthly stagecoach on that road began the celebrated pony express (q.v.) in April 1866.

During the Civil War, the Southern Overland Mail was removed to the central route, which was in union territory. Ben Holladay, an entrepreneur who became known as "the Napoleon of the plains," purchased the line in 1862 and extended it to Oregon and Montana.

Wells, Fargo and company purchased it in 1886. After the establishment of the first transcontinental railroad, it continued to operate for many years in local areas which were not served by a railroad.

SOUTHERN PACIFIC COMPANY, a U.S. transportation system, comprising, with its affiliated companies, railway and water lines, motor-truck routes and bus routes. It serves directly a large part of the United States west of the Mississippi river (at New Orleans, La.) through to the Pacific coast. It established steamship service between New York city and the ports of New Orleans, Galveston, Houston, Boston, New Bedford, Baltimore and Norfolk. Its lines were extended into Mexico as far south as Guadalajara. Its first unit, the Central Pacific main line, completed in 1869, was the link from California across the Sierra Nevada to Ogden, Utah, now 778 mi. from San Francisco, which completed the first through rail line across the North American continent. In 1883 the Sunset route was opened between New Orleans and San Francisco via El Paso and Los Angeles, distance now 2,472 mi. In 1887 the Shasta route was completed. giving a rail line between San Francisco and Portland, Ore., distance now 725 mi. Southern Pacific is also part of the Golden State route from Los Angeles to Chicago, its line, Los Angeles to Tucumcari, N.M., 1,145 mi., being about half the distance to Chicago.

The construction of Central Pacific and Southern Pacific and the merged operation of both was under the inspiration of four citizens of Sacramento: Leland Stanford, Collis P. Huntington, Mark Hopkins and Charles Crocker. Stanford, prior to his death, founded and endowed Stanford university. After the fleath of these men E. H. Harriman secured control and carried to conclusion projects previously planned, including the straight and level 102-ml. line from Lucin to Ogden, of which 31½ ml. were built across Great Salt lake.

In 1952 the Southern Pacific operated 15,055 mi. of road.
(A. D. McD.)

SOUTHEY, CAROLINE ANNE (1786-1854), second

wife of Robert Southey  $(q\ v.)$  and the daughter of an East Indian captain, Charles Bowles, was born at Lymington, Hants. on Oct. 7, 1786. After her mother died in 1816 she was left in dire financial straits through the fraudulence of a guardian. In order to support herself, she determined to turn her talents to account in literature. She sent anonymously to Southey a narrative poem called "Ellen Fitzarthur," which may be taken as typical, in its prosy simplicity, of the rest of the author's work.

Southey became interested in her, and their acquaintanceship and long friendship developed through a correspondence that lasted 20 years. Southey was visited by her at Keswick, and, while there, she was shown the surrounding countryside by Wordsworth.

A combination of prose and verse in eight volumes, Solitary Hours, was published in 1826. This was succeeded by her work Chapters on Churchyards, a group of stories first published in Blackwood's Magazine and later in complete form in 1829. Her writing was simple yet had power and a strong element of pathos.

She was at her best in prose or blank verse rather than in lyric, since her main gift was as a teller of stories. On the appearance in 1836 of her longest poem, "The Birthday," Henry Nelson Coleridge called her "the Cowper of our modern poetesses."

Öther prose writings which were published included Tales of the Moors (1828) and Selwyn in Search of a Daughter (1835). Besides the works already mentioned, Mrs. Southey wrote The Widow's Tale, and Other Poems (1822) and Robin Hood in conjunction with Southey, at whose death the poem was incomplete.

In 1839 she was married to Southey. Soon after the marriage, however, her husband's mental state became hopeless. From that time till his death in 1843, and indeed till her own, her life was a sad one. She was not on good terms with her stepchildren, and her share in Southey's life was hardly noticed in Charles Cuthbert Southey's Life and Correspondence of his father. But with Edith Southey, who was the wife of J. W. Warter, she was always in friendly relations, and she supplied the valuable additions to Southey's correspondence published by Warter.

Her correspondence with Southey, neglected in the official biography, was edited by Edward Dowden in 1831. Mrs. Southey died at Buckland cottage, Lymington, on July 20, 1854, two years after Queen Victoria had granted her an annual pension of £200.

**SOUTHEY, ROBERT** (1774–1843), English poet and man of letters, was born at Bristol on Aug. 12, 1774. His father, Robert Southey, an unsuccessful linendraper, married Margaret Hill in 1772.

1772.
When he was three, Southey passed into the care of Elizabeth Tyler, his mother's half-sister, at Bath, where most of his child-hood was spent. Miss Tyler was a whimsical and despotic person, of whose household he left an amusing account in the fragment of autobiography written in a series of letters to his friend John May. Before Southey was eight years old he had read Shakespeare and Beaumont and Fletcher, while his love of romance was fostered by the reading of Hoole's translations of Tasso and Ariosto, and of the Faerie Queene.

In 1788 he was entered at Westminster school. After four years there he was privately expelled by William Vincent (1730-1815) for an essay against flogging called "The Flagellant," written for a school magazine. At Westminster he made two friends who proved faithful and helpful to him through life—Charles Watkyn Williams Wynn and Grosvenor Bedford. His uncle, Herbert Hill, chaplain of the British factory at Lisbon, who had paid for his education at Westminster, determined to send him to Oxford with a view to his taking holy orders, but the news of his escapade at Westminster had preceded him, and he was refused at Christ Church. Finally he was admitted at Balliol, where he matriculated on Nov. 3, 1792, and took up his residence in the following January. His father dide soon after his matriculation. At Oxford he lived a life apart and gained little or nothing from the university except a liking for swimming and a knowledge of Epictetus.

Revolutionary Youth.—In the vacation of 1793 Southey's enthusiasm for the French Revolution found vent in writing an epic poem, Joan of Arc, published in 1796 by Joseph Cottle, the Bristol bookseller. In 1794 Coleridge, then on a visit to Oxford,

was introduced to Southey, and filled his head with dreams of an American Utopia on the banks of the Susquehanna. The members of the "pantisocracy" were to earn their living by tilling the soil, while their wives cared for the house and children. Coleridge and Southey soon met again at Bristol, and with Robert Lovell developed the emigration scheme. Lovell had married Mary Fricker, whose sister Sara married Coleridge, and Southey became engaged to a third sister, Edith. Miss Tyler, however, would have none of "pantisocracy" and "aspheterism," and drove Southey from her house. To raise the necessary funds for the enterprise Coleridge and he turned to lecturing and journalism. Cottle generously gave Southey £50 for Joan of Arc; and, with Coleridge and Lovell, Southey dashed off the drama, printed as the work of Coleridge, The Fall of Robespierre. A volume of Poems by R. Southey and R. Lovell was also published by Cottle in 1795.

Southey's uncle, Hill, desired him to go with him to Fortugal. Before he started for Corunna he was married secretly (Now-1795) to Edith Fricker. On his return to England his marriage was acknowledged, and he and his wife had lodgings for some time at Bristol. He was urged to undertake a profession, but the church was closed to him by the Unitarian views he then held, and medicine was distasteful to him. He was entered at Gray's Inn in Feb. 1797 and made a serious attempt at legal study, but with small results. At the end of 1797 his friend Wynn began an allowance of £160 a year, which was continued until 1806, when Southey relinquished it on Wynn's marriage. His Letters Written During a Short Residence in Spain and Portugal was printed by Cottle in 1797, and in 1797-09 appeared two volumes of Minor Poems from the same press.

In 1798 he paid a visit to Norwich, where he met Frank Sayers and William Taylor, with whose translations from the German he was already acquainted. He then took a cottage for himself and his wife at Westbury near Bristol, and afterward at Burton in Hampshire. At Burton he was seized with an illness which had been threatening for some time. He moved to Bristol, and after preparing for the press his edition of the works of Thômas Chatterton, undertaken for the relief of the poet's sister and her child, he sailed in 1800 for Portugal, where he began to accumulate meterials for his history of Portugal. He also had taken with him the first six books of Thôlaba the Destroyer (1801), and the remaining six were completed at Cintra. The unrhymed, irregular metre of the poem was borrowed from Sayers.

Life at Greta Hall.-In 1801 the Southeys returned to England, and at the invitation of Coleridge, who held out as an inducement the society of Wordsworth, they visited Keswick. After a short experience as private secretary to Isaac Corry, chancellor of the exchequer for Ireland, Southey in 1803 settled at Greta hall, Keswick, which he and his family shared thenceforward with the Coleridges and Mrs. Lovell. There he accumulated a library of more than 14,000 volumes, including valuable manuscripts and a collection of Portuguese authorities probably unique in England. After 1809, when Coleridge left his family, the whole household was dependent on Southey's exertions. His nervous temperament suffered under the strain, and he found relief in keeping different kinds of work on hand at the same time, in turning from the History of Portugal to poetry. Madoc and Metrical Tales and Other Poems appeared in 1805, The Curse of Kehama in 1810, Roderick, the Last of the Goths, in 1814.

This constant application was lightened by a happy family life. Southey was devoted to his children and was hospitable to the many friends and even strangers who found their way to Keswick. His friendship for Coleridge was qualified by a natural appreciation of his failings, the results of which fell heavily on his own shoulders, and he had a great admiration for Wordsworth. He met Walter Savage Landor in 1808, and their friendship lasted until Southey's death.

From the establishment of the Tory Quarterly Review Southey, whose revolutionary opinions had changed, was one of its most regular and useful writers. He supported church and state, opposed parliamentary reform, Roman Catholic emancipation and free trade. He did not cease, however, to advocate measures for the immediate amelioration of the condition of the poor,

With William Gifford, his editor, he was never on very good terms, and would have nothing to do with his harsh criticisms on living authors. His relations with Gifford's successors, Sir J. T. Coleridge and Lockhart, were not much better. In 1813 the laureateship became vacant on the death of Pye. The post was offered to Scott, who refused it and secured it for Southey. A government pension of some £160 had been secured for him, through Wynn, in 1807, increased to £300 in 1835. In 1817 the unauthorized publication of an early poem on Wat Tyler, full of his youthful republican enthusiasm, brought many attacks on Southey. He was also engaged in a bitter controversy with Byron, whose first attack on the "ballad-monger" Southey in English Bards and Scotch Reviewers nevertheless did not prevent them from meeting on friendly terms. Southey makes little reference to Byron in his letters, but Byron asserts (Letters and Journals, ed. Prothero, iv. 271) that he was responsible for scandal spread the self and Shelley. In this frame of mind, due as much to personal anger as to natural antipathy to Southey's principles, Byron dedicated Don Juan to the laureate, in what he himself called "good, simple, savage verse." In the introduction to his Vision of Judgment (1821) Southey inserted a homily on the "Satanic School" of poetry, unmistakably directed at Byron, who replied in the satire of the same name. The unfortunate controversy was renewed even after Byron's death, in consequence of a passage in Medwin's Conversations of Lord Byron.

Meanwhile the household at Greta Hall was growing smaller. Southey's eldest son, Herbert, died in 1816, and a favourite daughter in 1826; Sara Coleridge married in 1829; in 1834 his eldest daughter, Edith, also married; and in the same year Mrs. Southey, whose health had long given cause for anxiety, became insane. She died in 1837, and Southey went abroad the next year with Henry Crabb Robinson and others. In 1839 he married his friend Caroline Bowles. (See Southey, Caroline.) But his memory was failing, and his mental powers gradually left him. He died on March 21, 1843, and was buried in Crosthwaite churchyard. A monument to his memory was erected in the

church, with an inscription by Wordsworth.

Works.-The amount of Southey's work in literature is enormous. His collected verse, with its explanatory notes, fills ten volumes, his prose occupies about forty. But his greatest enterprises, his history of Portugal and his account of the monastic orders, were left uncompleted, and this, in some sense, is typical of Southey's whole achievement in the world of letters; there is always something unsatisfying, disappointing, about him. This is most true of his efforts in verse. Some of Southey's subjects, "The Poet's Pilgrimage" for instance, he would have treated delightfully in prose; others, like the "Botany Bay Eclogues," "Songs to American Indians," "The Pig," "The Dancing Bear," should never have been written. Of his ballads and metrical tales

If we turn from his verse to his prose we are in a different world; there Southey is a master in his art, who works at ease with grace and skill. "Southey's prose is perfect," said Byron, truly. His interest and his curiosity are unbounded as his Common-Place Book will prove; his stores of learning are at his readers' service, as in The Doctor, a rambling miscellany, valued by many readers beyond his other work. For biography he had a real genius. The Life of Nelson (2 vols., 1813), which has become a model of the short life, arose out of an article contributed to the Quarterly Review; he contributed another excellent biography to his edition of the Works of William Cowper (15 vols., 1833-1837), and his Life of Wesley; and the Rise and Progress of Methodism (2 vols., 1820) is only less famous than his Life of Nelson. But the truest Southey is in his Letters: the loyal, gallant, tender-hearted, faithful man is revealed.

A collected edition of his Poetical Works (10 vols., 1837-38) was followed by a one volume edition in 1847. Southey's letters were edited by his son Charles Cuthbert Southey as The Life and Correspondence by ms son charges Cutinert, Souther as I he Lage and Correspondence of the late Robert Southey (6 vols., 1849-50); further selections were published in Selections from the Letters of Robert Southey (4 vols., 1856), edited by J. W. Warter; and The Correspondence of Robert

Southey with Caroline Bowles. To which are added: Correspondence with Shelley, and Southey's Dreams (1881), was edited, with an introduction, by Professor E. Dowden. An excellent selection from his whole correspondence, edited by Mr. John Dennis, as Robert Southey, the story of his life written in his letters (Boston, Massachusetts, 1887), was reprinted in Bohn's Standard Library (1894). See also Southey (1879) in the English Men of Letters Series, by Professor E. Dowden, who also made the selection of Poems by Robert Southey (1893) in the Golden Treasury Series. W. Haller, Early Life of Robert Southey (1774-7803) (Columbia, 1917). A full account of his relations with Byton is given in The Letters and Journals of Lord Byron (vol. vi. 1901, edited "Quarrel between In the Letter's that Southest of the Southest of Lorentz of Lorent Southey and Porson, and two between Southey and Landor.

SOUTH GEORGIA, an island in the South Atlantic Ocean, 800 mi. E. of the Falkland Islands, of which it is a dependency. Length is 100 mi., maximum breadth 20 mi., and area 1,450 sq.mi.; est. pop. (1941) 360. Chief settlement is Grytviken, in Cumberland bay, on the N. coast; it has a wireless station and is served by a vessel of the Falkland Islands company. Whaling is the sole industry. Captain Cook claimed the island for Great Britain in 1775. "Discovery II" made coastal surveys during 1926-30.

See L. H. Matthews, South Georgia (1931); D. Ommaney, South Latitude (1938), in the U.S. titled Below the Roaring Forties (1938).

SOUTH HADLEY, a town of Hampshire county, Massachusetts, U.S.A., occupying 18.5 sq.mi. on the Connecticut river, 12 mi. N. of Springfield, directly opposite Mt. Tom. It is served by connections with the Boston and Maine railway at Holyoke, across the river. The population was 10,145 in 1950; (1940) 6,856; (1930) 6,773 by the federal census. Mount Holyoke college (established 1837) is at South Hadley.

SOUTH HOLLAND, the most crowded province of the Netherlands; area, 1,133 sq.mi.; pop. 2,382,898 (1950). The province has strips of dunes, geest lands, low fen and clay but the southwest area consists of ramifications of the Lek, Mads and Waal producing a mozaic of islands such as Dordrecht, Voorne-Putten, etc.; Goeree-Over Flakkee is wholly detached. Traffic from East Britain converges on the coastal Hook of Holland harbour (built 1866-1872) en route by water or rail for the Rotterdam (q.v.), Schiedam (72,630) industrial area with Dordrecht (70,793) farther southeast on the Rotterdam-Antwerp route. Many old sites along the "dune-foot" line have decayedthe famed Teilengen castle (near Sassenheim) where Jacqueline of Bavaria died (1433) has almost disappeared-but The Hague (q.v.) remains the capital of both province and kingdom. Eastward is the triangle of towns: Leyden (86,914), university, and Delft (64,876), pottery, with Gouda (37,283), cheese and earthenware. East and south on the borders are the historic rivers sites of Vianen (Lek), the reputed Fanum Dianae of Ptolemy and Gorichem (Waal),-taken by the "Sea Beggars" from the Spaniards (1572). South Holland suffered perhaps more than any many have passed into familiar use as poems for the young.

Among these are "The Inchcape Rock," "Lord William," "The subjected to widespread destruction by aerial bombing on May Battle of Blenheim," and the ballad on Bishop Hatto.

In 1949, South Hohand suffered perhaps in the thair any subjected to widespread destruction by aerial bombing on May Battle of Blenheim," and the ballad on Bishop Hatto. 14, 1940; the whole business centre was wiped out and at least 25,000-30,000 persons were killed. During the winter of 1942-43 the Germans tore down at least 20,000 homes and the famous 17th century wood, Haagsche Bosch, in The Hague, in order to build defense works. The sea resort of Scheveningen was also razed to a large extent.

SOUTH KINGSTOWN, a town of Rhode Island, U.S.A. Pop. (1950) 10.145. It is an old tree-shaded town, on an arm of Point Judith salt pond, and has colonial houses. In Great Swamp on Dec. 19, 1675 the Narragansett Indians made their last stand in King Philip's War, and were defeated by the forces of the Massachusetts, Plymouth and Connecticut Colonies under Governor Josiah Winslow (of the Plymouth Colony).

SOUTH METROPOLITAN GAS COMPANY. This undertaking in London possesses by statute the sole right to supply gas to nearly the whole of the county of London south of the Thames, with nearly two million people. It is an amalgamation of supply companies, completed in 1885.

In 1938 the South Metropolitan company had behind it a history of 114 years of enterprise. It was in 1802 that William Murdock, the friend and assistant of Matthew Bolton and James Watt, lit with coal gas the famous engine works at Soho, near Birmingham, and gas lighting was used in London for the first time when the Carlton Palace Gardens were illuminated by an enterprising German named Winsor. The company began work very soon after the first experiments were made. (L.C.M.)

SOUTH MILWAUKEE, a city of Milwaukee county, Wis., U.S., on Lake Michigan, 10 mi. S. of Milwaukee; served by the Chicago and North Western railroad. Pop. (1950) 12,855; (1940) II.134 by federal census. The city was founded in 1892 and in-

corporated in 1897

SOUTH MOLTON, a municipal borough in Devonshire, Eng., 12 mi, S.E. of Barnstaple by road, on the river Mole. Pop. (1951) 3,125. Area 9.24 sq.mi. There are flour mills and factories for shirts and collars. It is a tourist centre for Exmoor with a Perpendicular church. The weekly market and one fair date from 1246, and the fair held on St. John the Baptist's day dates from

SOUTHOLD, a township of Suffolk county, N.Y., occupying the peninsula at the northeast of Long Island, and including the islands east-northeast of this peninsula; Plum Island, on which defenses protect the eastern entrance to Long Island sound. Little Gull Island, Great Gull Island and Fisher's Island. Pop. (1950) 11,632. The mainland area is about 25 mi. long and its average width is 2 mi. A permanent settlement was made in 1640.

A meeting house was built in 1642, and biblical laws were enforced Southold was originally one of the six towns under the New Haven jurisdiction, but in 1662 was placed under Connecticut; in 1664 it objected strongly to the transfer of Long Island to the duke of York; in 1670 refused to pay taxes imposed by Gov. Francis Lovelace of New York; in 1672 petitioned the king to be under Connecticut or to be a free corporation; in 1673, when the Dutch got control of New York, withstood the Dutch commissioners, with the help of Connecticut; and, in 1674, after English supremacy was again established in New York, still hoped to be governed from Connecticut. The township was chartered by Gov. Edmund Andros in 1676.

See Epher Whitaker, History of Southold, L.I.: Its First Century (1887); Southold Town Records, 2 vol. (1882-84); Peter Ross, A History of Long Island (1902); Ella B. Hallock, The Story of the 275th Anniversary Celebration of the Founding of Southold Town (1918); B. F. Thompson, History of Long Island (1918); Ann Currie-Bell, Old Southold Town's Tercentenary (1940).

SOUTH ORANGE, Essex county, N.J., only chartered village in the state, between Orange and Maplewood. Pop. (1950) 15,230 by federal census. It is a residential community, 300 ft. above sea level. Among the landmarks are an old stone house mentioned in documents as early as 1680, the Baldwin house (c. 1717) and the Timothy Ball house (1743).

SOUTH PASADENA, a suburban city of Los Angeles county, Calif., U.S. Pop. (1950) 16,935. It is located on the Arroyo Seco parkway, nine minutes from downtown Los Angeles. It is noted for its fine climate, beautiful homes and good schools.

SOUTHPORT, a municipal, county and parliamentary borough, Lancashire, Eng. Pop. (1951) 84,057. Area 15 sq.mi. Extending 8 mi, along the coast between Liverpool and Preston, it is a very popular holiday resort with a large residential population. The present town was built on wind-blown sand and reclaimed land during the 19th century. Southward the coast is bordered by high sand dunes while inland the ground is marshy. Southport was known as Meols (Scandinavian "sand dunes") until the early 19th century. Liberal planning, with emphasis on gardens and flowers, produced handsome thoroughfares such as Lord street and several parks. The annual flower show is famous. Engineering is the most important industry. Southport returns one member to parliament,

SOUTH PORTLAND, a city of Maine, U.S., opposite Portland, with which it is connected by four bridges. Pop. (1950) 21,866. The state reform school for boys is there. Until 1895 South Portland was part of the town of Cape Elizabeth.

SOUTH RIVER, a borough of New Jersey, U.S., served by the Raritan River railroad. Pop. (1950) 11,308. There are operated by the borough meets the costs of government. A settlement was established there in 1720 by Samuel Willett. The bor-

ough was incorporated in 1896. SOUTHSEA: see PORTSMOUTH.

SOUTH SEA BUBBLE, the name given to a series of financial projects which originated with the incorporation of the South Sea Company. In 1711 the South Sea Company was formed, and was granted a monopoly of the British trade with South America and the Pacific islands. It was highly successful, and early in 1718 the king became its governor. Towards the end of 1710 the directors of the company put before the Government, the head of which was Charles Spencer, 31d earl of Sunderland, a more anibitious scheme. In return for further concessions the company offered to take over the whole of the national debt (£51.300.000) and to pay £3,500,000 for this privilege. The aim of the directors was to persuade the annuitants of the State (the bulk of the debt was thus held) to exchange their annuities for South Sea stock:

the stock would be issued at a high premium and thus a large amount of annuities would be purchased and extinguished by the issue of a comparatively small amount of stock. Moreover, when this process had been carried out the company would still receive from the Government a sum of something like £1,500,000 a year in interest. The offer was accepted in 1720, the company having

raised its bid to £7,567,000 in competition with the directors of

the Bank of England.

In a few weeks the company had persuaded over one-half of the Government annuitants to become shareholders in the company. Meanwhile the stock of the company had been appreciating steadily in value, and when the new scheme was launched the public began to purchase it eagerly. From 1284 at the beginning of the year the price had risen by June to 800, and in July it touched 1,000. At this tremendous premium the directors sold five millions of stock. The extraordinary success of the company produced a crowd of imitations-many of them audacious hoaxesand the wild speculation which followed involved the numerous honest companies in disaster. In August the fall in the price of South Sea stock began. By November it had fallen to 135, and in four months the stock of the Bank of England fell from 263 to 145. Thousands were ruined, and many who were committed to heavy payments fled from the country. A committee of secrecy of the House of Commons reported in February 1721. company's books contained fictitious entries, and it was shown that favours secured from the State had been purchased by gifts to ministers, some of whom had also made large sums of money by speculating in the stock. The chief persons implicated were John Aislabie (1670-1742), chancellor of the exchequer; James Craggs, joint postmaster-general; his son James Craggs, secretary of state; and to a lesser degree the earl of Sunderland and Charles Stanhope, a commissioner of the Treasury. Aislable resigned his office in January, and being found guilty of the "most notorious, dangerous and infamous corruption," was expelled from the house and imprisoned. Both the elder and the younger Craggs died in March, while, owing to the efforts of Walpole, both Sunderland and Stanhope were acquitted, the latter by the narrow majority of three. By act of Parliament the estates of the directors were confiscated; these were valued at £2,014,123, of which £354,600 was returned to them, the balance being devoted to the relief of the sufferers. The company continued to exist until the 19th century.

SOUTH SHETLANDS, a chain of islands in the South Atlantic ocean, with Graham's Land constituting a group of dependencies of the Falkland Islands (q.v.). The northern point of the South Shetlands is about 500 mi. S. of the Falklands. While there is no permanent population, the group is visited periodically by whalers, whose base is Port Foster, on Deception Island. Instances of volcanic activity have been numerous since the first definite record of an earthquake in 1923. The water in the harbour of Port Foster frequently becomes agitated by the subterranean heat, the shores in places being obscured by the dense vapour emitted. The South Shetlands were sighted and taken possession of for Great Britain by Captain Cook in 1775. William Smith, of the brig "Williams," landed on King George I Island in brick and tile works. Profit from the public utilities owned and 1819, and in 1820 Captain Bransfield examined the group. Coastal surveys were made by "Discovery II" during 1925-33.

See A. G. Bennett, Whaling in the Antarctic (1931); E. R. Gun-

ther, Notes and Sketches Made during Two Years on the Discovery Expedition, 1925-27 (1928).

SOUTHWARK, a central borough of London on the south bank of the River Thames. Pop. (1951) 97,191. Area 1.8 sq mi. It is connected with the City of London by Blackfriars, London and Southwark bridges. The convergence of roads to cross London bridge gave Southwark its mediaeval importance, and its inns became famous (e.g., the Tabard of the Canterbury Tales and the George, the last surviving galleried inn in London, now owned by the national trust). In 1337 Edward III granted Southwark to the citizens of London forever and its title of "The Borough" still survives; the charter was renewed by Edward IV and Edward VI, when the ward of Bridge Without was constituted (1550), the alderman of which is not elected but is the senior alderman of the time. The authority of the City over the borough is now merely nominal.

The name Southwark is taken from the southward works, or fortifications, of London. Numerous Roman remains have been found. The hospital of St. Thomas, founded in 1213, was removed to Lambeth in 1868; its chapel became the chapter house of the cathedral. Opposite is Guy's hospital, founded by Thomas Guy in 1722. Various bishops had town houses in Southwark; the grandest was Winchester house, used for five centuries from 1107. Paris garden was a centre of amusement in the 16th and 17th centuries, and in it were bear gardens and the Swan theatre (1595, burned down 1633). The Globe theatre, where many of Shakespeare's plays were produced, was built in Bankside in 1599 and was burned down in 1613.

The Augustinian priory of St. Mary Overie (over rie=over the water), founded in 1106, became the parish church of St. Saviour in 1540. In 1905, when the diocese of Southwark was created, it became the cathedral church and in 1937 was renamed the Cathedral and Collegiate Church of St. Saviour and St. Mary Overie. It lies well below the level of the streets at the southern end of London bridge. Built in the 13th and 14th centuries (the original having been burned down), it was restored in the 19th century. The choir and Lady chapel are Early English, the transepts are Decorated and Perpendicular and the nave is 19th century. The Harvard memorial chapel was restored in 1907 in memory of John Harvard, the founder of Harvard university. There is also a Roman Catholic cathedral.

SOUTHWELL, ROBERT (c. 1561–1595), English Jesuit and poet, son of Richard Southwell of Horsham St. Faith's, Norfolk, was born in 1560/61. He was educated at Douai and at Paris, joining the Society of Jesus. In 1584 an act was passed forbidding any English-born subject of the queen who had taken priest's orders in the Roman Catholic Church since her accession to remain in England longer than 40 days on pain of death. But Southwell at his own request was sent to England in 1586 as a Lesuit missionary with Henry Garnett. He went from one Catholic family to another, administering the rites of his church, and in 1589 became domestic chaplain to Ann Howard, whose husband, the first earl of Arundel, was in prison convicted of treason. It was to him that Southwell addressed his Epistle of Comfort. This and other of his religious tracts, A Short Rule of Good Life, Triumphs over Death, Mary Magdalen's Tears and a Humble Supplication to Queen Elisabeth, were widely circulated in manu-

script. That they found favour outside Catholic circles is proved by Thomas Nashe's imitation of Mary Magdalen's Tears in Christ's Tears over Jerusalem.

After six years of successful labour Southwell was arrested (1592). He was imprisoned at first in Richard Topcliffe's house, where he was repeatedly put to the torture in the vain hope of extracting evidence about other priests. Transferred to the gate-house at Westminster, he was so abominably treated that his father petitioned Elizabeth that he might either be brought to trial and put to death, if found guilty, or removed in any case from "that fifthy hole." Southwell was then lodged in the Tower, but he was not brought to trial until Feb. 1595. Much of his poetry, none of which was published during his lifetime, was probably written in prison. On Feb. 20, 1595, he was tried before the court of King's Bench on the charge of treason, and was hanged at Tyburn on the 21st. In 1920 he was beatified.

St Peter's Complaint with other Poems, published anonymously in 1595, was reprinted 13 times during the next 40 years. A supplementary volume entitled Maconiae appeared later in 1595, and A Foure fould Meditation of the foure last things in 1606. This, which is not included in Grosart's reprint (1872) in the Fuller Worthies Library, was published by Charles Edmonds in his Isham Reprints (1895). A Hundred Meditations of the Love of God, in prose, was first printed from a manuscript at Stonyhurst College in 1872.

See Sidney Lee's account in the Dict. Nat. Biog.; Alexis Possoz, Vie du Père R. Southwell (1866); and a life in Henry Foley's Records of the English Province of the Society of Jesus, i, 307–367 (1877). Foley's narrative includes copies of the most important documents connected with his trial, and gives full information of the sources.

SOUTHWELL, a town and rural district of Nottinghamshire, England, 14 mi, N.E. of Nottingham by road. The rural district of 55 parishes had a population (1951) of 39,705; area 185 sq.mi. It has hosiery works, a flour mill and an interest in the neighbouring market-garden area (Bramley seedling apples are said to come from Southwell), but is chiefly known for its minister, a successor of a 7th-century church generally attributed to Paulinus; certainly there was a church there in the 8th century. The present building was begun in the 12th century and has a Norman nave, transepts and towers, an Early English choir and a Decorated octagonal chapter house. It is cruciform and is 306 ft. long. There are no cloisters. Particularly noteworthy are the magnificent 14th-century stone rood screen, intricately carved, and the carved animals and foliage on the doors of (and within) the chapter house.

In 958 land at Southwell was granted to the archbishop of York by Edwy and a detailed description of the manor appears in Domesday Book. Southwell was a collegiate establishment and remained under the lordship of the see of York until it was taken over by the ecclesiastical commissioners. Remains of the archbishop's place (15th-century; "great chamber" restored 1880) are incorporated in the bishop's palace. The episcopal see founded in 1884 included the counties of Nottingham and Derby, but the latter was detached in 1926 when the see of Derby was established.

SOUTH-WEST AFRICA. Formerly a German colony, after 1920 this territory was administered under a League of Nations C-type mandate by the Union of South Africa. Its area is 317,725 sq.mi., excluding the Walvis Bay territory (374 sq.mi.), which is an integral part of the Union Cape province. The territory of South-West Africa lies between the lower Cunene and middle Okavango (Okovango, Cubango) rivers and the parallel of 17° 23'S, in the north, and the lower Orange river in the south, and between the Atlantic coast and the meridians of 20° and 21° E., the Caprivi corridor extending from the northeast corner about 275 mi. east to the Zambezi river.

Physical Features.—The territory falls into two distinct physiographic regions: the plateau, which extends eastward to the Kalahari desert, and the western marginal area, which includes the Namib coastal desert and the slopes ascending to the plateau edge. The highest part of the plateau is to the southwest, south and northeast of Windhoek where the Khomas, Auas and Onyati highlands have average altitudes of between 6,000 and 7,000 ft., the highest point being Molkteblick, 8,750 ft. The highest point in

the territory, however, is the isolated mass of the Brandberg, 8,550 ft., in the northern Namib. Large numbers of pans occur in the territory, the largest being the Etosha pan in the north which covers an area of about 1,404 sq.mi. Most of the pans are dry in the winter and contain water after the summer rains.

The climate is very dry in the south, becoming gradually moister northeastward; owing to the effect of the Benguela current the coastal area is cool, temperatures generally rising toward the interior. The rainfall of the Namib coastal belt is about one inch or less a year; inland the rainfall increases to about 12 in. in the centre and 22 in. in the north. Except for the Cunene and Okavango rivers in the north, the Zambezi and Linyanti (Cuando) in the northeast, and the Orange in the south, there are no perennial streams. Fresh water can generally be obtained from shallow wells in the beds of the intermittent streams.

Vegetation.—The Namib is almost devoid of vegetation near the coast except for such plants as can exist on account of the fogs, e.g., Sarcocaula, Aloe dichotoma and the Welwitschia bainesii About 25 mi. inland cacti and euphorbias appear, and in the river channels thorn trees (Acacia spp.) occur. On the plateau, in the south, semidesert conditions prevail, low shrubs and scant grass being the chief plants, with trees along the river beds. The commonest plants there are Salsola aphylla (the Ganna bush), Rhigolum trichotomum (the three thorn bush), Acacia girafue (Kameeldoorn) and species of aloes and euphorbias. Northward, as far as Rehoboth, karroo (dry tableland) conditions are characteristic. Then a parklike grass country studded with thorn trees is reached. From about Windhoek the country northward is covered with bush, mostly thorn trees. Toward the north the bush becomes thicker and includes belts of Mopane forest; about the Okavango the vegetation becomes more tropical. (J. H. WN.)

#### HISTORY

The first European to set foot in the territory was the Portuguese navigator Diogo Cão who planted a pillar at Cape Cross in his voyage of 1485-86. At the end of 1487 his compatriot Bartolomeu Diaz (Dias) touched at the modern Walvis Bay and at Diaz point, where he erected a pillar near Angra Pequena. It was not until 1670 that any serious effort to explore these shores was made. In that year the Dutch East India company's ship "Grundel" sailed up the coast and was followed by the same company's "Bode" in 1677. Though the interior still remained unknown, the coastal waters were not neglected; sealing and whaling attracted ships of various nationalities. Then, more than a century after the cruise of the "Bode," in 1793, Capt. F. R. Duminy, of the Dutch ship "Meermin," proclaimed certain areas to be the property of the Dutch government. In 1795, Capt. Alexander of H.M.S. "Star" hoisted the British flag at various points on the coast but his action was later disowned by his government. Meanwhile, in 1760, Jacobus Coetzee found a way into Great Namaqualand by the overland route from the Cape. He was followed in 1761-62 by Hendrik Hop and thereafter by a fairly steady stream of explorers of whom the most famous, and possibly the most successful among the later ones, was C. J. Andersson, a Swede, who in 1853 crossed from Walvis bay to Lake Ngami in Bechuanaland. The London Missionary society was represented on the Orange river as early as 1802 and in 1807 established a station at Warmbad. This society withdrew and was succeeded by the Wesleyans. In the 1840s, the German connection with the territory began with the arrival of the Rhenish Missionary society.

In 1868 tribal wars prompted the missionaries to appeal for British protection. In this they were actually supported by the German government, but the British government turned the proposal down. In 1876 the Cape colony sent a special commissioner, W. C. Palgrave, who made treaties with chiefs anxious to secure British protection. This placed the whole territory up to the Portuguese colony of Angola under British control. The British high commissioner in South Africa approved Palgrave's action but the British government was unwilling to assume these new responsibilities and was only with difficulty persuaded to consent to the annexation of Walvis Bay and some adjacent territory (1878). The guano islands off the coast had been annexed in 1867. In 1880

tribal war again broke out and the German government itself asked Great Britain to protect the life and property of its subjects but the British reply was negative.

Deutsch-Südwestafrika.—In 1883 Heinrich Vogelsang, agent of F. A. E. Luderitz, a merchant of Bremen, obtained from the Hottentot chief, Joseph Frederick of Bethany, a cession of land at Angra Pequena, later known as Lüderitz Bay. Bismarck, still unconverted to a colonial policy, caused the British government to be informed beforehand of the project in words that were almost an invitation to Great Britain to assume sovereignty over the territory and to act as protecting power. This opportunity, like the previous one, was allowed to slip away and in April 1884 Bismarck took the initiative and assured Lüderitz and his establishments of German protection. Belated attempts by the British and Cape governments to retrieve the situation were unavailing, and in due course protection over German traders developed into full-fledged German annexation of the whole territory. British anxiety—man designs in the territory and the lear that the Germans might join across the continent with the Boers of the Transval was one of the reasons that prompted the British government to declare a protectorate over Bechuanaland in 1884–85.

The first German representative, sent to the territory in 1885, was H. E. Göring. He was succeeded by Kurt von François, who transferred the capital from Otjimbingue to Windhoek. It was there that the first German farmers settled in 1893. In 1893 there was trouble with Hendrik Witbool, the Hottentot chief. The Germans statcked Witbool's village and 150 of his subjects, including women and children, were killed. Von François was succeeded in 1896 by Theodot Leutwein who tried to treat the natives with consideration. The latter found much cause for dissatisfaction, and it required only a spark to set the country ablaze. The Bondelswaartz Hottentots rose in 1903. This rising was suppressed, but early in 1904 the Herero revolted and killed a number of German (but not British or Boer) settlers. The rebellion was speedily quelled but in the "Cleaning up" operations the Herero were ferociously harried by Gen. Lothar von Trotha, Leutwein's successor from 1904, and were in the end reduced from a tribe of 80,000 people to 15,000 starving refugees, many of whom found sanctuary in Bechuanaland. Von Trotha was recalled toward the end of 1905 and his successor, Friedrich von Lindequist, a diplomat, extended an amnesty to the Herero. Various groups of Hottentots wfo had joined in the rebellion still held out, and it was not until early in 1907 that the war could be declared at an end.

In the years that followed these troubles the depopulation resulting from the methods used in suppressing the rebellion caused a labour shortage which hampered the development of the territory. The discovery of diamonds in 1908 near Lüderitz Bay led to a considerable increase in the European population which rose to nearly 15,000 by 1913. The government did much to encourage European enterprise, and though the territory never paid its way, there were, up to the outbreak of World War I, some hopes of future prosperity.

and though the territory never paid its way, there were, up to the outbreak of World War I, some hopes of future prosperity.

On Aug. 6, 1934, the government of the Union of South Africa undertook to assume all obligations resting upon the British regular garrison
in South Africa and on Aug. 10 to send a military expedition of its own
to German South-West Africa. Soon after the preliminary occupation of Lüderitz Bay the Boer rebellion interrupted operations but
once this was overcome the campaign against the Germans developed
rapidly and successfully. In Jan. 1915 South African forces advanced
into the country from different points and after a campaign of swift
movement in semidesert and waterless country forced the surrender of
the Germans on July 9, 1915.

The Union government treated the conquered Germans with much leniency. At the end of the campaign the German troops were interned and later (in 1979) repartiated with about 600 undesirables. German civilians, on the other hand, were allowed to return to their homes in the territory and to continue their ordinary pursuits.

Under the South African Mandate.—Under the treaty of Ver-

Under the South African Mandate.—Under the treaty of Versailles, Germany ceded its colonies to the principal Allied and associated powers. South-West Africa was designated as a C mandate and was conferred on "his Britannic majesty for and on behalf of the government of South Africa." The newly created League of Nations was charged, inter alia, with the supervision of mandates. Subject to the mandate South Africa was given full powers of legislation and administration over the territory as an integral part of the Union. The exercise of these powers was vested by the house of assembly in the governor-general (Union act 49 of 1970) who later delegated them to a resident administrator. The S.W.A. Naturalization of Allien act of 1924 provided for the automatic naturalization of all German adult males domicilled in the territory on Jan. 1, 1924, unless they specifically objected. Less than 300 Germans did object and 3,228 became British subjects.

During the first few years of the mandate the territory was administered somewhat after the fashion of a crown colony, with an administrator assisted by an advisory council. In 1926 a legislative assembly of 12 elected and 6 nominated members, with an executive committee was set up to legislate for subjects like roads and bridges, works, agri-

culture and taxation, while the rest of the administrative functions remained in the hands of the administrator

In general the natives accepted Union rule without difficulty In 1917 it became necessary to send a military force to Ovamboland where for it became necessary to send a minutary note to ovanious answers. German authority had been slight, but thereafter relations with the Ovambo were excellent. In 1922 the Bondelswaartz Hottentots, moved by various grievances, rose in revolt. The rising was suppressed in a manner that gave lise to criticism and provoked an inquity. In 1925 the Bastaards of Rehoboth, a group of mixed descent, defied the the Bastaards of Rehoboth, a group of mixed descent, defied the authority of the government but the matter was settled without bloodshed.

Until the rise of Hitler the Germans in the territory had been reasonably co-operative. By 1933 they changed their attitude and were gradually almost all absorbed in the Nazi complex. By 1939 the grip of the National Socialist party on all Germans in the territory was practically complete. At the outbreak of World War II the Union government acted with dispatch. By Dec. 1939 about 150 Nazi leaders were arrested and the organizations themselves proscribed. By Oct. 1040 the number of persons interned was 1,200 or one-third of the German adult male population. By the Naturalization and Status of 

Germans reverted to their former German status.

Trusteeship or Incorporation?—At the end of World War II, South Africa became involved in an international controversy on two South Africa decade involved in an international controvery on two questions affecting the territory. The first was that of trusteeship, the second of incorporation of South-West Africa in the Union. With the demise of the League of Nations the Union government held that there was nothing in the covenant that empowered it to

transfer or delegate its powers as regards mandates to any organization In this contention South Africa was supported in 1950 by an opinion of the International Court of Justice, which held that the Union was under no obligation to place the territory under a United Nations trusteeship, but that on the other hand an obligation rested on South Africa to submit reports on the administration of the territory to the UN. In spite of pressure South Africa firmly refused to agree to the inclusion of the territory in the international trusteeship system, but was willing to submit reports to Great Britain, the United

States and France as a matter of courtesy.

The proposal that South-West Africa should be incorporated in or should become a fifth province of the Union arose in 1946 when the subject was referred to a series of tribal meetings and it was reported that the majority of natives was in favour of the proposal, the Herero being the only substantial body against it. Later in the same year Gen. J. C. Smuts asked the United Nations that the territory should be incorporated in accordance with the wish of its people but the request was refused. The South African government did not press the demand but declared its intention, and this applied both to trusteeship and to incorporation, to continue to administer South-West Africa in the spirit of the mandate. However, the association of the two countries, already close, was made much closer by the South-West African Affairs (Amendment) act of 1949, which gave the territory six elected representatives in the Union house of assembly and four in the senate, of whom two are elected and two nominated by the governor-general. The same act substituted for the 12 elected and 6 nominated members of the legislative assembly a wholly elected body of 18 members. The South African Citizenship act of 1949 made it possible for those who had been "denaturalized" in (Ay. Sy.) 1942 to apply once more for naturalization.

# POPULATION, ADMINISTRATION AND ECONOMY

In 1951 the population, exclusive of Walvis Bay, numbered 414,601, including 48,588 Europeans, 3 Asiatics and 366,010 natives (including coloured). Among the native inhabitants are Bushmen, Nama or Hotcoloured). Ämong the native inhabitants are Bushmen, Nama or Hotientots, Ovambo and Herero or Damara. The administrative capital, Windhoek, had in 1951 a population of 11,000 Europeans and 9,500 non-Europeans. Other towns with a European population of 800 or more were (1946): Ketemanshoop (1,673), the centre of a small mining industry; Swakopmund (1,569), the former German port serving Windhoek; Lüderitz (834), the southern seaport. Walvis Bay in 1946 had 646 Europeans and 1,778 non-Europeans.

Education—Primary education is free but fees are charged for secondary education. Native and coloured education is largely under the supervision of missions, though the state pays the teachers, supplies free furniture and equipment, and subsidizes the sale of books and stationary. There were, in 1051, 26 coloured schools with 2,336

and stationery. There were, in 1951, 26 coloured schools with 2,336 pupils and 229 native schools with 21,000 pupils.

The usual medical services were provided, and there were hospitals

in most centres.

Administration.—The territory is divided into a "police zone" to the south of the Eleoha pan and the Kaokoveld, in which the European population resides, and the northern native area which includes mainly the Kaokoveld, Ovamboland and the Okavango native territory, including the Captivi strip. There are r6 magisterial districts under magistrates who have both judicial and administrative functions. In the native areas the system of rule is "indirect"; that is to say, the people are ruled as far as possible through their own thefs, whose traditional powers and duties are preserved in so far as a far as Administration. -The territory is divided into a "police zone" these do not conflict with justice and humanity. All civil disputes between natives and all crimes committed by natives, except capital

offenses, are tried by the native authorities according to native law and custom.

Agriculture and Trade.-In the moister northern area, maize, potatoes, pumpkins and beans are grown, and farther south are several good artesian wells which offer opportunities for irrigation and the growth of wheat, but the country is in general better suited to pas-toralism. Sheep, goats and cattle are raised, the Karakul sheep industry being particularly noteworthy Karakul pelts head the list of agricul-tural exports overseas, mainly to the United States Pelts to the number of 2,398,863 were exported in 1949. The numbers of the principal animals returned at the livestock census of 1946 were: cattle 1,340,950, karakuls (grade) 2,488,837, goats 7,54,807, horses 37,120, donkeys 73,707. In addition to these there were in the natives' reserves 395,945 large stock and 548,441 small stock.

large stock and \$48,441 small stock.

Among the minerals exported in 1949 were (in short tons); lead and copper concentrates 79,445 (value \$2,80,000), lead and vanadium concentrates 9,242 (\$2,66,000), zinc concentrates 25,830 (\$2,58,3000); 252 carats of diamonds were sold for \$5,200,000. Other less important minerals exported included tin concentrates and salt, with phosphates (guano), beryl, lithium, graphite and tungsten in small amounts.

Transport and Communications.—There are 1,470 mi. of rail-way linking up the chief towns and joining the South African railway system (from Upington in the Cape province) at the southeastern

system (from Upington in the Cape province) at the southeastern border of the territory.

A system of main roads links Windhoek with Otavi, Walvis Bay, and Lüderitz via Keetmanshoop. Near Keetmanshoop another road takes off to the southeastern border where it joins the Union system.

The postal service, which provides the usual facilities for letters, telegrams and telephones, also includes such business as saving bank accounts, money orders and postal orders. It extends to every district, and in addition there are wireless transmitting and receiving sets at remote stations which are not served by land telegraph and telephones.

There are commercial airports at Windhoek, Keetmanshoop and

There are commercial airports at windhoek, Keetmanshoop and Alexander Bay.

Bibliography — M. Ritchie, West Botha in the Field (London, 1915); Theodor Seitz, Südafrika im Weltkriege (Berlin, 1920); W. Eveleigh, South-West Africa (London, 1931); A. F. Calvett, South-West Africa During the German Occupation, 1880-1919 (London, 1915), Helnrich Vedder, South West Africa in Early Times (London, 1935); W. O. Aydelotte, Bismarck and British Colomial Policy: The Problem of South West Africa (Philadelphia, 1937); Sir Charles Dundas, South West Africa: The Factual Background (Capetown, 1946).
SOUTH-WESTERN ISLANDS or SERWATTI ISLANDS, the

name of two chains of islands in the Banda sea, of the Malay Archipelago. Wetar, the largest island, is 70 mi, by 20 mi. They are a part of the Netherlands Indies.

Administratively the islands form part of the division Tual, residency of the Moluccas. The estimated population of all the islands is about 40,000, Wetar having 7,500. Kisar has as settlers the descendants of European soldiers of the time of the old Dutch East India company.

SOUZA-BOTELHO, ADÉLAIDE FILLEUL, MARQUISE DE (1761-1836), French writer, was born in Paris on May 14, 1761. Her mother, Marie Irène Catherine de Buisson, daughter of the seigneur of Longpré, near Falaise, married a bourgeois of that town named Filleul. It was reported, though no proof is forthcoming, that Mme. Filleul had been the mistress of Louis XV. Her husband became one of the king's secretaries, and Mme. Filleul made many friends, among them Marmontel. Their eldest daughter, Julie, married the marquis de Marigny (1727-1781); Adélaide married in 1779 Alexandre de Flahaut de la Billarderie, comte de Flahaut, who was many years her senior. In Paris she soon gathered round her a salon, in which the principal figure was Talleyrand. There are many allusions to their liaison in the diary of Gouverneur Morris. In 1785 was born her son Auguste Charles Joseph de Flahaut (q.v.), who was generally known to be Talleyrand's son. Mme. de Flahaut fled from Paris in 1792 and joined the society of émigrés at Mickleham, Surrey, described in Mme, d'Arblay's Memoirs. Her husband remained at Boulogne, where he was arrested on Jan. 29, 1793, and guillotined. Mme. de Flahaut now supported berself by writing novels, of which the first, Adèle de Sénange (London, 1794), which is partly autobiographical, was the most famous. She presently left London for Switzerland, where she met Louis Philippe, duke of Orleans. She travelled in his company to Hamburg, where she lived for two years, earning her living as a milliner. She returned to Paris in 1798, and in 1802 she married José Maria de Souza-Botelho Mourão e Vasconcellos (1758-1825), Portuguese minister plenipotentiary in Paris. Mme. de Souza lost her social power after the fall of the First Empire. She died on

SOVA, ANTONIN (1864-1928), Czech poet, began his literary career early in the '90s with verse, describing Prague and his native region of Southern Bohemia. His introspective poems, in Lyrics of Love and Life, Mastered Sorrows and Once Again Shall We Return, include good lyrics, and he has been compared with Verlaine. Disillusionment drove him to seek escape in visionary poems which reveal symbolism. In 1913 appeared Harvests, a volume in which reconciliation predominates. In some Sova is the spokesman of Czech aspirations. He also wrote novels and short stories.

SOVEREIGN: see Numismatics: British Coins; Pound STERLING.

SOVEREIGNTY. While society is in a rude state or only tribally organized there is no distinct sovereignty, no power which all persons habitually obey. Thus there is no sovereignty among wandering groups of Australian savages: each family is isolated, each horde is a loose and unstable collection. When the horde has become a tribe there may exist no definite sovereign. Distinct in time of war, the power of the chief may be fluctuating and faint in time of peace; even in time of war it may be subject to the authority of a council. Tribes of the same ethnic stock may form a sort of federation, permanent or temporary. "With the council of the confederacy," it has been said, "and, more generally, in the confederacy, sovereignty arises and the true political tradition is evolved" (F. H. Giddings, Principles of Sociology, p. 285). When the city and the State are conterminous the seat of sovereignty becomes defined. Such was the condition of things in Greece, as considered by Aristotle in his Politics. He discusses the question what is the supreme power in the State (3. 10), which he defines as an aggregate of citizens (3. i.), and he recognizes that it may be lodged in one, a few, or many. In his view the distinctive mark of the State is not so much sovereignty (7.4) as self-sufficiency; a State is not a mere aggregate of persons; it is a union of them sufficient for the purposes of life (7.8). The early Roman jurists speak little of sovereignty. But later, with the belief in the existence of an empire entitled to universal sway, an absolutist theory of sovereignty was developed in the writings of jurists.

Among the theories prevalent in the middle ages was one that mankind formed a unity, with the pope and the emperor at the head of it: the universal church and the universal emperor ruled the world. (Rehm, Geschichte der Rechtswissenschaft, p. 198). When the power of the emperor was weakened, and the idea of a universal ruler was gone, a new test of sovereignty was applied -that of external independence; the true sovereign States were universitates superiorem non recognoscentes. There were times and countries in the middle ages in which the collective power of the community was small: many of the great corporations were virtually autonomous; the central authority was weak; the matters as to which it could count upon universal obedience were few. In such circumstances the conception of sovereignty was imperfect. The modern theory is first clearly stated in Jean Bodin's book On the Commonwealth (French ed., 1576; Latin version, 1586). He writes thus: "Respublica est familiarum rerumque inter ipsas communium, summa potestate ac ratione moderata multitudo." His theory, which corresponded to the France of Louis XI., was a theory of despotism.

One favourite theory was that sovereignty originated in a social contract. Hobbes, in his Leviathan expounded his notion of an agreement by which absolute power was irrevocably transferred to the ruler. Rousseau assumes his famous pacte social, the terms of which are: "Chacun de nous met en commun sa personne et toute sa puissance sous la suprême direction de la volonté générale; et nous reçevons encore chaque membre comme partie indivisible de tout" (Du Contrat social, r. c. 6).

Among the different senses in which "sovereign" has been used are the following:-

a. "Sovereign" may be titular—the king in Great Britain.

b. The legal sovereign: the person or persons who, according to the law of the land, legislate or administer the government.

c. The political or constitutional sovereign: the body of per-

April 19, 1836. She brought up her grandson, Charles, duc de sons in whom the actual power at any moment or ultimately Morny, her son's natural son by Queen Hortense. sometimes this is designated "the collective sovereignty."

d. Sovereignty is also used in a wider sense, as the equivalent of the power of the whole nation or society (Gierke, 3. 568).

The distinction between real and nominal sovereignty was familiar to mediaeval writers, who recognized a double sovereignty, and distinguished between (1) the real or practical sovereignty resident in the people, and (2) the personal sovereignty of the ruler (Adolf Dock, Der Souveranitätsbegriff, etc., p. 13).

Sometimes sovereignty is defined as the organized or general will of the community. "Sovereignty resides in the community"

(Woodrow Wilson).

This was the belief in the French Revolution. "Sachez que vous êtes rois et plus des rois," said a revolutionary orator cited by Taine. It was the language of the founders of the American constitution and contemporary political writers.

The same theory assumes a more subtle form, especially in the writings of Hegelians. Sovereignty is with them a term descriptive of the real will of the community, which is not neces-

sarily that of the majority.

Sovereignty is used in a further sense when Plato and Aristotle speak of the sovereignty of the laws (Laws, 4. 715; Politics, 4. 4; 3. 15). Thus Plato remarks: "I see that the State in which the law is above the rulers, and the rulers are the inferiors of the law, has salvation." (See also Gierke, Genossenschaftsrecht, 3. 8.) Even in mediaeval writers, such as Bracton, is found the notion that the king is subject to the laws (J. N. Figgis, The Divine Right of Kings, p. 13). We find the same expressed by many German jurists (Gierke iii., x.). In Der Souveranitätsbegriff im Bodin, etc., by Adolf Dock [1897] p. 6, and in *La Conception juridique de l'état*, by Combothecra, p. 90. There are many definitions—some ideal-of sovereignty.

Half Sovereign States.—The phrase half sovereign States was invented by J. J. Moser to describe States possessing some of the attributes of sovereignty. Under this class are grouped very

diverse communities.

Feudalism had terms to express the varieties of fiefs which existed under it; modern international law has no generallyaccepted terminology for the still greater variety of States which now exist. These varieties tend to multiply, and it is difficult to reduce them all to a few types. The theory that States are equal, and possess all the attributes of sovereignty, was never true. It is still more at variance with the facts in these days when a few great States predominate, and when the contact of western States with African and Asiatic States or communities gives rise to relations of dependence falling short of conquest. We have:

1. States which have complete independence, complete autonomy, external and internal, and which are recognized in inter-

national law as sovereign States.

2. States which have complete external independence, but are more or less subject permanently to other States as to their internal affairs. Of this class there are now few examples.

States which enjoy complete autonomy as to internal affairs, but which are more or less subject to other States as to

foreign relations. These are some examples:a. Protectorates and Suzerainties (qq.v.).

b. The unions between a superior and inferior State, e.g., the relations of the various States to the old Holy Roman empire; the relations of the Ottoman Porte to its Christian provinces. In the middle ages the question was often mooted whether States subject to feudal superiors, or the States forming the empire, were sovereign. Grotius (1. 1. ch. 3, 23, 2), holds that the nexus feudalis is consistent with summum imperium.

4. States which have, by treaty or otherwise, parted with some portion of their sovereignty and formed new political units: what Herbert Spencer calls "compound political heads." For years one of the burning questions in the politics of the United States was the question whether the individual States of the Union remained

sovereign.

5. Another division includes anomalous cases, such as Egypt, until August 1936, in which one Government administers a country as to which another State retains certain powers.

6. The territories governed or administered by chartered companies form a class by themselves. Nominally such companies are the delegates of some States; in reality they act as if they were true sovereigns.

7. Two other classes may be mentioned: (a) cases of real minon between States, as formerly between Austria and Hungary; (b) personal unions, distinguished from the above-named forms—e.g., the union of Great Britain and Hanover.

8. A small group consists of instances of condominium or arrangements similar thereto; e.g., the arrangements as to the Samoa islands from 1889 to 1899.

According to modern usage the appellation "sovereign State" belongs only to States of considerable size and population exercising without control the usual powers of a State, e.g., able to declare peace or war.

Colonies.—It is sometimes suggested that self-governing colonies are to be regarded as true States. Undoubtedly some of them can no longer be regarded as colonies in the old sense The self-governing colonies forming part of the "multicellular British State," as F. W. Maitland describes it (Political Theories of the Middle Ages, p. x.), have an essentially "state-like character." If Liberia is a State, the same may surely be said of Canada.

With the creation of the League of Nations, however, the theory of sovereignty has become still more academic and impracticable. India and the Dominions are equal members with Great Britain of the League. As a member of the League the sovereignty of Great Britain is limited to the same extent as that of Ireland or any other member. And there are at least a dozen States in Europe members of the League, which enjoy, both in fact and in law, less independence than the dominions. The old distinction between sovereign and non-sovereign States has ceased to exist. A sovereign State is now obsolete. Even the United States is not absolutely sovereign. There is no State more rigorously bound by treaties. Nevertheless a new life has been given to the doctrine by the appeal of the succession States in central Europe to the League in their attempts to coerce their minorities to respect their sovereignty. The only valid sovereignty is that of the rule of law.

Many attempts have been made to enumerate the attributes of sovereignty, i.e., the regalia, prerogatives, etc, as they were called. For example, Bodin gives a list of the properties of majestas or sovereignty: (a) "Legem universis, etc., singulis civibus dare posse; (b) bellum indicere aut pacem inire; (c) to appoint and change magistrates; (d) power of final appeal; (e) power of pardon; (f) raising revenue; (g) coining money" (De republica, vol. i. ch. 10). Bluntschli (Allgemeine Staatslehre, i. 575) enumerates these attributes: (a) right of recognition of majestas; (b) independence; (c) power to determine constitution; (d) right of legislation; (e) action through deposed organs; (f) irresponsibility. These enumerations are open to the objection that they merely describe the action of the State at a particular time or indicate a theory of what an ideal State should be. See PROTECTORATE, SPHERES OF INFLUENCE, SUZERAINTY.

BIBLIOGRAFHY.—The literature of the subject is immense; every book on political science, from the Republic of Plato and the Politics of Aristotle, has dealt with or touched sovereignty. A few of the chief modern works are: J. C. Bluntschil, Allgemeine Staatslehre (Munich, 1832); J. Austin, Lectures on Jurisprindence (3rd ed., 1869); H. Maine, "Minute on the Käthiäwär States," Life and Speeches (1869); H. Maine, "Mistory of Institutions (1875); R. von Mohl, Encyslopädie der Staatswissenschaften (and ed., Tübingen, 1872); P. Laband, Staatercht des deutschen Rieches (Freiburg-im-Breisgau and Tübingen, 1876); G. Meyer, Lehrbuch des deutschen Staatsrechts (Leipzig, 1878); G. Gierke, Johannes Althains (Breslau 1880) and Das deutsche Genossenschaftsrecht (1863–81); K. Gareis, Allgemeines Staatsrecht (1883); G. Jellinek, Die Lehre von den Staatsverbindungen (1882) and Über Staatsfragmente (1896); H. Rosin, Souveranitätstaat (1883); G. Salomon, L'Occupation des Territoires sans Maitres (1889); T. M. Cooley, Constitution (1885, 8th ed. 1915); C. Salomon, L'Occupation des Territoires sans Maitres (1889); T. M. Cooley, Constitution and Limitations (6th ed. 1890); J. B. Westerkamp, Staatenbund und Bundestsaat (Leipzig, 1892); J. R. Green, Works (1892); W. W. Fowler, City State of the Greeks and Romans (1893); I. Clauss, Die Lehre von den Staatsdienstbarkeiten (1894); K. Bornhak, Einsettige Abhängigkeitsverhälbnisse unier den Modernen Staatsen (1896); W. W. Willoughby, The Nature of the State (1890); X. Combothecta, La Conception

juridique de l'état (1899); H. Rehm, Allgemeine Staatslehre (1899); F. H. Giddings, Principles of Sociology (3rd ed., 1899); J. W. Burgess, Political Science and Constitutional Law (Boston, 1899); C. E. Merriam, History of the Theory of Sovereignty Since Rousseau (1000); Bryce, Studies in History and Jurisprudence (2. Essay x. 1901); J. B. Moore, Digest of International Law (1906), vol. i., ch. xviii. seq., and "Notes on Sovereignty, 'American Journal of International Law, vol. I. (1907); W. B. Keith, Responsible Government in the Colonies (1906); T. Batty, International Law (1909); H. H. L. Bellot, "The Rule of Law," in Quarterly Review (April, 1926); H. Goitein, "Some Problems of Sovereignty," in Publications of the Grotius Society, vol. XIII. (1938).

SOWER, CHRISTOPHER (1693-1758), printer and publisher, was born at Laasphe, Ger., and emigrated to Pennsylvania in 1724 with his wife and small son Christopher (1721-84). Sower worked first as a tailor, then took up farming and later bought six acres of land in Germantown, where he settled and built a large house. There, in 1738, he set up a print shop to become the first German printer and publisher in the American colonies. It is not known where he secured his training or the equipment he used-the press, the type, etc. He made his own ink and it is possible that he cast his own type, but the better fonts he used were imported from the Frankfurt foundry of Heinrich Luther. In 1744, it is believed, he also built a paper mill. Most of the Sower publications dealt with religious or educational subjects. The first to bear the Sower imprint swas Eine Ernstliche Ermahnung, an Junge und Alte (1738), followed by the first issue of his almanac (1739). In 1739 he also issued his first complete book, a collection of hymns, and the first number of the newspaper Der Hoch-Deutsch Pensylvanische Geschicht-Schreiber. Like the almanac, the newspaper continued to appear until 1777. The two publications were available in all the colonies and made Sower and his son persons of note in the German communities of Pennsylvania and Maryland. Best known of Sower's publishing efforts was the Biblia; Das ist, Die Heilige Schrift Altes und Neues Testaments, nach der Deutschen Übersetzung D. Martin Luthers (1743), the second edition of the Bible to appear in America. Two later editions were published by his son Christopher, in 1763 and 1776. The first English publication carrying Sower's imprint was Extract from the Laws of William Penn (1740). As a popular journalist Sower was outspoken in his opposition to slavery and war. His practical knowledge of contemporary handicrafts and his social zeal brought him a considerable audience and influence in his time. His son Christopher had been trained very thoroughly, and at Sower's death in 1758 was well qualified to inherit the Sower press.

SOWERBY, JAMES (1757-1832), English natural-history artist, was born in London on March 21, 1757. He became a student at the Royal academy, and subsequently taught drawing, but turned to the illustration of botanical and conchological works; and published English Botany, 36 vol. (1790-1814), and British Mineralogy, 5 vol. (1804-17). He planned and partly carried out The Mineral Conchology of Great Britain, 7 vol. (1812-46), concluded after his death by his sons.

SOWING. The scattering or depositing of seed on or in the ground so that it may grow has been practised from prehistoric to modern times. Broadcasting by hand, the most primitive method, has persisted because machinery cannot be used on newly cleared, rough or stony land or on very small fields. Even sowing requires considerable skill and experience; and, after the seed is cast, it must then be covered. Primitive agriculturists also used a dibbling stick to regulate the spacing and distribution of seed, but the hand labour entailed was still tedious. In the early 17th century, Hugh Plat and Gabriel Plattes described dibblers having metal pins to make holes and a seed-dropping device. Father Francesco Lana-Terzi, a Jesuit of Lombardy, designed a dibbler-type seeding machine in 1670. Although impracticable for sowing, dibblers were part of the average farmer's equipment until 1850.

The next improvement over hand sowing was the development of broadcast seeders. The simplest was a knapsack seeder carried by the operator who turned a hand crank geared to a distributor wheel whose vanes scattered the seed over a wide swath. Another seeder, attached to the end gate of a wagon, was similar in design but used chain drive in place of the hand crank. Primarily de-

signed for grass and clover seed, the wheelbarrow seeder was adapted for distributing grain or commercial fertilizer. Its 10–16 ft. hopper had an oscillating rope or chain in the bottom to control the rate of seeding through the outlets. The modern 2-wheel horse-drawn machine sows all kinds of seed and may be equipped with hoe-type coverers or combined with a cultivator to sow and cover simultaneously.

By contrast the evolution of the grain drill has a long history. The prototype of the modern drill is found on a cylinder seal from Tell Asmar (c. 2,000 B.C.). A later clay tablet (c. 1376 B.C.) clearly shows that the Babylonian drill was merely a rude moldboard plow with a seed pipe inserted behind the plow point. The Assyrians used a similar drill in the 7th century B.C. (Hugo Gressman, Altorientalische Bilden zum Alten Testament, 1927).

The long hiatus in the history of drilling from ancient to modern times ended with the inventon of a revolving seed-dropping mechanism by Tadeo Cavellini of Bologna in 1580 A.D., but no details concerning it are known. A widely publicized drill, invented by Joseph Locatelli of Carinthia, Austria, was demonstrated near Wien in 1662. He used a rotating drum with four rows of brass spoons to catch the seed and drop it into funnels. There were no seed pipes and an ordinary plow served as a furrow opener.

John Worlidge of England described a drill with rudimentary force feed and seed pipes (Systema Agriculturae, 1669), but there is no evidence that it was ever built. He even suggested using a fertilizer attachment. About 1701, Jethro Tull invented the first machine that would open a furrow, sow and cover in one operation. His 1733 model had three hoes, or coulters, with seed cavities behind them, a seeding device and pointed shovels for covering. The practice of drilling spread slowly, however, until 1783 when James Cooke brought out a model embodying spoon feed, seed pipes, drill shoes and spike-shaped shovels that laid the foundation for modern European drills.

In the U.S. Eliakim Spooner patented a seeder in 1799, but not until Moses and Samuel Pennock of Kennett Square, Pa, patented their hoe drill in 1841 were any noteworthy U.S. models produced. Their drill, equipped with seven hoes 9 in. apart, planted all kinds of field crops. The numerous drills patented after 1850 diverged still farther from the English by using the force feed originally proposed by Worlidge and different furrow openers. The opening of the great wheat areas caused drilling to be widely accepted, and, by 1890, disk drills for "stubbling in" directly without preparation of a seedbed were replacing shoe drills.

Current European drills are characterized by fore-steerage, cup feed and coulters; and the U.S., by pole attachment, force feed and disk furrow openers. Combined grain and fertilizer drills hitched on spring-tine cultivators, with harrows trailing behind, prepare and plant about 80-100 ac. per day, a far cry from hand sowing. Special planters have been developed in the U.S. for corn, cotton and potatoes. The check-row corn planter sows a field in a checkerboard pattern to permit cross cultivation between hills. Buttons on a guide wire stretched across the field trip the seeding mechanism as they pass through the machine. Special attachments deposit fertilizer on each side of the seed. Modern cotton planters are similar to corn planters and can be used for most field row crops because they have interchangeable seed plates. Lister planters designed to break furrows, plant and cover are used for both corn and cotton. Semimechanical potato planters still depend on the operator to feed the seed to the cups and to supply misses in the seed plate. Transplanting machines for tobacco, cabbage, tomatoes, celery, sweet potatoes, etc., simultaneously set, water and fertilize the young plants, making it possible to cover 3-4 ac. per day.

Bibliography.—Leo Rogin, The Introduction of Farm Machinery in Its Relation to the Productivity of Labor (1931); Russell H. Anderson, "Grain Drills Through Thirty-Nine Centuries," Agr. History, vol. 10, 1936; Lord Ernle, Englith Farming, Past and Present (ed. 5, 1936); U.S. Department of Agriculture, Interbureau Committee on Technology, Technology on the Farm (1940); Archie A. Stone, Farm Machinery (1942).

(H. L. E.)

SOYBEAN, also known in some countries as the soja bean and the soya bean, is a leguminous plant native to south-

eastern Asia. It has been cultivated in China and Japan since long before written records were kept, and from the standpoint of uses and value is the most important legume now grown in those countries. Although limited acreages are grown in Italy, France, southern Russia, Rumania, Netherlands Indies, South Africa and in a few countries of South America, its culture at present is largely confined to China, Manchuria, Japan, Chosen (Korea) and the United States. It is also more or less important in India, Indo China and the Malayan islands. Although first introduced into the United States in 1804, the soybean has become important only during the last 20 years. Only 8 varieties were grown in 1808. whereas at present more than 100 varieties are handled by growers and seedsmen. Previous to 1917, the soybean acreage was less than 500,000, but by 1939 it had increased to more than 8,000,000. The soybean can be grown in any climate suitable to maize or cotton, and the crop is now grown generally over the eastern half of the United States. Recent increases in acreage have been most marked in the maize belt and some of the Southern States. Introduction and breeding of improved varieties have extended the culture of the crop far beyond what were first considered its limits of profitable production, and it is destined to become a crop of great economic importance in the United States. Its principal uses are hay, pasture, silage, oil and oil meal, and human food (see SOYBEAN OIL). It can be used advantageously, either as a seed crop or a forage crop, in many systems of rotation; also as a catch crop where new seedings of grass or clover have failed. In combinations with other crops, such as corn, cow-peas, Sudan grass or sorghums, it furnishes a well-balanced ration for livestock, a large yield and a great variety of forage,

Cultivation.—The growing of soybeans is easy when ordinary precautions are followed in preparing the soil and selecting suitable varieties. Where they have not been grown previously it is advisable to inoculate the soil with soybean bacteria. The use of fertilizer is recommended in sandy soil or in soils of low fertility. Seeding is usually done with an ordinary grain drill, the rows being spaced far enough apart to allow for cultivation when the crop is grown for seed. Seeding is usually done in the Corn Belt States with the grain drill, the rows in close drills, and the fields cultivated with the harrow, weeder or rotary hoe. In the Southern States the beans are planted in rows 3 to 6 feet apart. Harvesting the seed is accomplished with the combine. (L. S. R.; X.)

SOYBEAN OIL. An oil obtained from the seeds of the leguminous plant, Soja max (L.) Piper, one of the oldest staple crops of the Far East, where for centuries both the oil and expressed cake have been used as food. Introduced about 1919 in Mid-western U.S., its cultivation now requires over 8,000,000 acres. The beans, containing 18% to 20% of oil, yield by expression in American expellers about 15%; somewhat less in hydraulic presses (see Coco-NUT OIL AND CAKE), or Chinese wedge presses. Hydrocarbon solvent extraction, which leaves about 1% of oil in the cake, is preferred in Europe, but is of secondary importance in America. The meal is high in proteins (41% to 50%), which are similar to the proteins of milk. Valuable for livestock, soybean oil meal is also prepared for human food, mostly in sausage and bakery products in the form of flour; in the Orient soy sauce and vegetable cheese are made from whole soybeans. The oil contains 84% to 87% of unsaturated glycerides, and is classed as a drying oil; for paints, lead and manganese driers are used, and for varnishes, cobalt; for salad oil, alkali refining, bleaching by fuller's earth, and steam deodorization are essential. More than half of the refined oil is hydrogenated and consumed in the manufacturing of shortening and margarine (see Hydrogenation). World production of soybeans for 1937 amounted to 12,500,000 long tons. Leading producers of soybean oil were U.S., 143,750 tons (1938); Germany, 115,584 tons (1938); Manchuria, 62,503 tons (M. M. D.)

SÓZOMEN, the name of a famous 5th-century church historian. Hermias Salamanes (Salaminius) Sozomenus (c. 400-443) came of a wealthy family of Palestine. He tells us that he was brought up under monkish influences. After studying law in Beirūt he settled down as an advocate in Constantinople, where hewrote his Ekchnotaarus Toropla about the year 440. The nine

books begin with Constantine (323) and come down to the death of Honorius (423). The work, dedicated to Theodosius II., has reached us only in a mutilated condition, at least half a book being wanting. It is a plagiarism of the ecclesiastical historian Socrates (q.v.), but Sozomen has referred to the principal sources used by Socrates (Rufinus, Eusebius, Athanasius, Sabinus, the collections of epistles, Palladius), and has not unfrequently supplemented Socrates from them. The whole of the ninth book is drawn from Olympiodorus. Sozomen wished to present a picture in which monasticism should be brought into still stronger prominence.

Sozomen also wrote an Epitome of History from the Ascension of Christ to the defeat of Licinius (323) which is not now extant. (See his

History, i. 1.)

For bibliography see the article on the church historian, Socrates. For bibliography see the article on the church historian, Socrares. Most of the editions and discussions named there cover Sozomen as well (the volume of Hussey's edition containing Sozomen appeared in 1860). The latest English translation, revised by Hartranti, is published in the Nicene and Post-Nicene Pathers, and series, vol. it. n addition see Nolte in the Thibing. Quartalschir. (1861), p. 417, spq.; C. de Boor, "Zur Kenntniss der Handschriften der Griech, Kirchenisther." in Zeitschrift fur Krichengeschichte, vi. 478, sqq.; Sarratin, "De Sozomeni historia num integra sit," in the Commentationes philologae jenenses, i. 165 sqq.; Rosenstein, "Krit. Untersuchungen über d. Verhaltnus zwischen Olympiodor, Zosimus und Sozomen" in Karock, z. deutschen Gesch. vol. 1: Bailfeld, "Sozomene" in men," in Forsch. z. deutschen Gesch., vol. i.; Batiffol, "Sozomène et Sabinos," in Byzant. Zeitschr. vii. 265 sqq.

SPA, a town in the province of Liège, Belgium, less than 20 mi. S.E. of Liège, famous for mineral springs first discovered in 1326. The springs have given the common name of "spa" to such resorts. The town is 850 ft. above sea level. In the 18th century it was the most fashionable resort in Europe for the medicinal use of such waters. In 1807 much of the town was burned down, and the principal buildings, the Casino and the Pouhon, are quite modern. Spa in ordinary times attracts about 20,000 visitors

annually. Pop. (1947) 9,002. **SPA, CONFERENCE OF** (July 5-16, 1920). This was the first occasion after the World War of 1914-18 on which the heads of the German and Allied Governments negotiated on a formal footing of equality. The crucial questions at issue were the execution of the disarmament clauses and the coal delivery clauses of the Treaty of Versailles, and in both cases the Germans were compelled to sign protocols dictated by the Allies under threat of military sanctions which were set out in the documents, and included an eventual Allied occupation of the Ruhr basin.

A German proposal for the general settlement of the reparation problem was rejected, but no general Allied counter-proposal was put forward. An inter-Allied agreement was made for the allocation of prospective German payments, an agreement which has since been modified in detail, but which still governs the situation. It was provided that France should receive 52% of sums obtained from Germany, the British Empire 22%, Italy 10% and Belgium 8%, while the remaining 8% was to be divided between the other Allied Powers. By a subsequent agreement among the several members of the British Commonwealth 86.85% of the British Empire's share was allocated to Great Britain. Another article in the Spa Agreement provided for the allocation of reparation payments from Austria, Bulgaria and Hungary, and "cost of liberation" payments from Italy, Czechoslovakia, Rumania and Yugoslavia.

At this conference the Supreme Council also came to an agreement with Germany for the trial of war criminals.

SPACE-TIME. The Theory of Relativity has brought about a fundamental change in the scientific conception of space and time, described in a famous saying of Minkowski-"From henceforth space in itself and time in itself sink to mere shadows, and only a kind of union of the two preserves an independent existence." This union, called "space-time," is the subject of the present article. As the conceptions are of considerable difficulty, most readers will probably find it best to read first the article RELATIVITY for a more elementary introduction to the subject.

All our thoughts and concepts are called up by sense-experiences and have a meaning only in reference to these sense-experiences. On the other hand, however, they are products of the spontaneous activity of our minds; they are thus in no wise logical consequences of the contents of these sense-experiences. If, therefore, we wish to grasp the essence of a complex of abstract notions we must for the one part investigate the mutual relationships between the concepts and the assertions made about them; for the other, we must investigate how they are related to the experiences.

So far as the way is concerned in which concepts are connected with one another and with the experiences there is no difference of principle between the concept-systems of science and those of daily life. The concept-systems of science have grown out of those of daily life and have been modified and completed according to the objects and purposes of the science in question.

The more universal a concept is the more frequently it enters into our thinking; and the more indirect its relation to senseexperience, the more difficult it is for us to comprehend its meaning; this is particularly the case with pre-scientific concepts that we have been accustomed to use since childhood. Consider the concepts referred to in the words "where," "when," "why," "being," to the elucidation of which innumerable volumes of philosophy have been devoted. We fare no better in our speculations than a fish which should strive to become clear as to what

In the present article we are concerned with the meaning of "where," that is, of space. It appears that there is no quality contained in our individual primitive sense-experiences that may be designated as spatial. Rather, what is spatial appears to be a sort of order of the material objects of experience. The concept "material object" must therefore be available if concepts concerning space are to be possible. It is the logically primary concept. This is easily seen if we analyse the spatial concepts for example, "next to," "touch," and so forth, that is, if we strive to become aware of their equivalents in experience. The concept "object" is a means of taking into account the persistence in time or the continuity, respectively, of certain groups of experience-complexes. The existence of objects is thus of a conceptual nature, and the meaning of the concepts of objects depends wholly on their being connected (intuitively) with groups of elementary sense-experiences. This connection is the basis of the illusion which makes primitive experience appear to inform us directly about the relation of material bodies (which exist, after all, only in so far as they are thought).

In the sense thus indicated we have (the indirect) experience of the contact of two bodies. We need do no more than call attention to this, as we gain nothing for our present purpose by singling out the individual experiences to which this assertion alludes. Many bodies can be brought into permanent contact with one another in manifold ways. We speak in this sense of the position-relationships of bodies (Lagenbeziehungen). The general laws of such position-relationships are essentially the concern of geometry. This holds, at least, if we do not wish to restrict ourselves to regarding the propositions that occur in this branch of knowledge merely as relationships between empty words that have been set up according to certain principles.

Pre-scientific Thought .- Now, what is the meaning of the concept "space" which we also encounter in pre-scientific thought? The concept of space in pre-scientific thought is characterized by the sentence: "we can think away things but not the space which they occupy." It is as if, without having had experience of any sort, we had a concept, nay even a presentation, of space and as if we ordered our sense-experiences with the help of this concept. present a priori. On the other hand, space appears as a physical reality, as a thing which exists independently of our thought, like material objects. Under the influence of this view of space the fundamental concepts of geometry: the point, the straight line, the plane, were even regarded as having a self-evident character. The fundamental principles that deal with these configurations were regarded as being necessarily valid and as having at the same time an objective content. No scruples were felt about ascribing an objective meaning to such statements as "three empirically given bodies (practically infinitely small) lie on one straight line," without demanding a physical definition for such an assertion. This blind faith in evidence and in the immediately real meaning of the concepts and propositions of geometry became uncertain only after non-Euclidean geometry had been introduced.

Reference to the Earth,-If we start from the view that all spatial concepts are related to contact-experiences of solid bodies, it is easy to understand how the concept "space" originated, namely, how a thing independent of bodies and yet embodying their position possibilities (Lagerungsmöglichkeiten) was posited. If we have a system of bodies in contact and at rest relatively to one another, some can be replaced by others. This property of allowing substitution is interpreted as "available space." Space denotes the property in virtue of which rigid bodies can occupy different positions. The view that space is something with a unity of its own is perhaps due to the circumstance that in pre-scientific thought all positions of bodies were referred to one body (reference body), namely the earth. In scientific thought the earth is represented by the co-ordinate system. The assertion that it would be possible to place an unlimited number of bodies next to one another denotes that space is infinite. In pre-scientific thought the concepts "space" and "time" and "body of reference" are scarcely differentiated at all. A place of point in space is always taken to mean a material point on a body of reference.

Euclidean Geometry.-If we consider Euclidean geometry we Searly discern that it refers to the laws regulating the positions of rigid bodies. It turns to account the ingenious thought of tracing back all relations concerning bodies and their relative positions to the very simple concept "distance" (Strecke). Distance denotes a rigid body on which two material points (marks) have been specified. The concept of the equality of distances (and angles) refers to experiments involving coincidences; the same remarks apply to the theorems on congruence. Now, Euclidean geometry, in the form in which it has been handed down to us from Euclid, uses the fundamental concepts "straight line" and "plane" which do not appear to correspond, or at any rate, not so directly, with experiences concerning the position of rigid bodies. (On this it must be remarked that the concept of the straight line may be reduced to that of the distance. A hint of this is contained in the theorem; "the straight line is the shortest connection between two points." This theorem served well as a definition of the straight line, although the definition played no part in the logical texture of the deductions.) Moreover, geometricians were less concerned with bringing out the relation of their fundamental concepts to experience than with deducing logically the geometrical propositions from a few axioms enunciated at the outset.

Let us outline briefly how perhaps the basis of Euclidean geometry may be gained from the concepts of distance. We start from the equality of distances (axiom of the equality of distances). Suppose that of two unequal distances one is always greater than the other. The same axioms are to hold for the inequality of distances as hold for the inequality of numbers. Three distances as hold for the inequality of numbers. Three distances  $\overline{AB'}$ ,  $\overline{BC'}$ ,  $\overline{CA'}$  may, if CA' be suitably chosen, have their marks BB', CC', AA' superposed on one another in such a way that a triangle ABC results. The distance CA' has an upper limit for which this construction is still just possible. The points A, (BB') and C then lie in a "straight line" (definition). This leads to the concepts: producing a distance by an amount equal to itself; dividing a distance into equal parts; expressing a distance in terms of a number by means of a measuring-rod (definition of the space-interval between two points).

When the concept of the interval between two points or the length of a distance has been gained in this way we require only the following axiom (Pythagoras' theorem) in order to arrive at Euclidean geometry analytically. To every point of space (body of reference) three numbers (co-ordinates) x, y, z may be assigned—and conversely—in such a way that for each pair of points A  $(x_1, y_1, z_1)$  and B  $(x_2, y_2, z_2)$  the theorem holds:

neasure-number  $AB = \sqrt{(x_2-x_1)^2+(y_2-y_1)^2+(z_2-z_1)^2}$ .

All further concepts and propositions of Euclidean geometry can then be built up purely logically on this basis, in particular also the propositions about the straight line and the plane. These remarks are not, of course, intended to replace the strictly

axiomatic construction of Euclidean geometry. We merely wish to indicate plausibly how all conceptions of geometry may be traced back to that of distance. We might equally well have epitomised the whole basis of Euclidean geometry in the last theorem above. The relation to the foundations of experience would then be furnished by means of a supplementary theorem. The co-ordinate may and must be chosen so that two pairs of points separated by equal intervals, as calculated by the help of Pythagoras' theorem, may be made to coincide with one and the same suitably chosen distance (on a solid). The concepts and propositions of Euclidean geometry may be derived from Pythagoras' proposition without the introduction of rigid bodies; but these concepts and propositions would not then have contents that could be tested. They are not "true" propositions but only logically correct propositions fo purely formal content.

Difficulties.—A serious difficulty is encountered in the above represented interpretation of geometry in that the rigid—body of experience does not correspond exactly with the geometrical body. There are no absolutely definite marks and, moreover, temperature, pressure and other circumstances modify the laws relating to position. It is also to be recollected that the structural constituents of matter (such as atom and electron, q.v.) assumed by physics are not in principle commensurate with rigid bodies, but that nevertheless the concepts of geometry are applied to them and to their parts. For this reason consistent thinkers have been disinclined to allow real contents of facts (reale Taisachenbestände) to correspond to geometry alone. They considered it preferable to allow the content of experience (Erjahrungsbestände) to correspond to geometry and physics conjointly.

This view is certainly less open to attack than the one represented above; as opposed to the atomic theory it is the only one that can be consistently carried through. Nevertheless it would not be advisable to give up the first view, from which geometry derives its origin. This connection is essentially founded on the belief that the ideal rigid body is an abstraction that is well

rooted in the laws of nature.

Foundations of Geometry.—We come now to the question: what is a priori certain or necessary, respectively in geometry (doctrine of space) or its foundations? Formerly we thought everything; nowadays we think—nothing. Already the distance-concept is logically arbitrary; there need be no things that correspond to it, even approximately. Something similar may be said of the concepts straight line, plane, of three-dimensionality and of the validity of Pythagoras' theorem. Even the continuum-doctrine is in no wise given with the nature of human thought, so that from the epistemological point of view no greater authority attaches to the purely topological relations than to the others.

Earlier Physical Concepts.—We have yet to deal with those modifications in the space-concept which have accompanied the advent of the theory of relativity. For this purpose we must consider the space-concept of the earlier physics from a point of view different from that above. If we apply the theorem of Pythagoras to infinitely near points, it reads

 $ds^2 = dx^2 + dy^2 + dz^2$ ,

where ds denotes the measurable interval between them. For an empirically-given ds the co-ordinate system is not yet fully determined for every combination of points by this equation. Besides being translated, a co-ordinate system may also be rotated. This signifies analytically: the relations of Euclidean geometry are covariant with respect to linear orthogonal transformations of the co-ordinates.

In applying Euclidean geometry to pre-relativistic mechanics a further indeterminateness enters through the choice of the coordinate system: the state of motion of the co-ordinate system is arbitrary to a certain degree, namely, in that substitutions of the co-ordinates of the form x'=x-vt

y' = y z' = z

also appear possible. On the other hand, earlier mechanics did

not allow co-ordinate systems to be applied of which the states sum is to be taken over the indices for all combinations 11, 12, of motion were different from those expressed in these equations. In this sense we speak of "inertial systems." In these favouredinertial systems we are confronted with a new property of space so far as geometrical relations are concerned. Regarded more accurately, this is not a property of space alone but of the fourdimensional continuum consisting of time and space conjointly.

Appearance of Time.—At this point time enters explicitly into our discussion for the first time. In their applications space (place) and time always occur together. Every event that happens in the world is determined by the space-co-ordinates x, y, z, and the time-co-ordinate t. Thus the physical description was four-dimensional right from the beginning. But this four-dimensional continuum seemed to resolve itself into the three-dimensional continuum of space and the one-dimensional continuum of time. This apparent resolution owed its origin to the illusion that the meaning of the concept "simultaneity" is self-evident. and this illusion arises from the fact that we receive news of near events almost instantaneously owing to the agency of light.

This faith in the absolute significance of simultaneity was destroyed by the law regulating the propagation of light in empty space or, respectively, by the Maxwell-Lorentz electro-dynamics. Two infinitely near points can be connected by means of a lightsignal if the relation

$$ds^2 = c^2 dt^2 - dx^2 - dy^2 - dz^2 = 0$$

holds for them. It further follows that ds has a value which, for arbitrarily chosen infinitely near space-time points, is independent of the particular inertial system selected. In agreement with this we find that for passing from one inertial system to another, linear equations of transformation hold which do not in general leave the time-values of the events unchanged. It thus became manifest that the four-dimensional continuum of space cannot be split up into a time-continuum and a space-continuum except in an arbitrary way. This invariant quantity ds may be measured by means of measuring-rods and clocks.

Four-dimensional Geometry.—On the invariant ds a fourdimensional geometry may be built up which is in a large measure analogous to Euclidean geometry in three dimensions. In this way physics becomes a sort of statics in a four-dimensional continuum. Apart from the difference in the number of dimensions the latter continuum is distinguished from that of Euclidean geometry in that ds<sup>2</sup> may be greater or less than zero. Corresponding to this we differentiate between time-like and space-like line-elements. The boundary between them is marked out by the element of the "light-cone"  $ds^2=0$  which starts out from every point. If we consider only elements which belong to the same time-value, we have

$$-ds^2 = dx^2 + dv^2 + dz^2$$
.

These elements ds may have real counterparts in distances at rest and, as before, Euclidean geometry holds for these elements. Effect of Relativity, Special and General.-This is the

modification which the doctrine of space and time has undergone through the restricted theory of relativity. The doctrine of space has been still further modified by the general theory of relativity, because this theory denies that the three-dimensional spatial section of the space-time continuum is Euclidean in character. Therefore it asserts that Euclidean geometry does not hold for the relative positions of bodies that are continuously in contact.

For the empirical law of the equality of inertial and gravitational mass led us to interpret the state of the continuum, in so far as it manifests itself with reference to a non-inertial system, as a gravitational field and to treat non-inertial systems as equivalent to inertial systems. Referred to such a system, which is connected with the inertial system by a non-linear transformation of the co-ordinates, the metrical invariant ds2 assumes the general form:

$$ds^2 = \sum g_{\mu\nu} dx_\mu dx_\nu,$$

where the gm 's are functions of the co-ordinates and where the

... 44. The variability of the  $g_{\mu\nu}$ 's is equivalent to the existence of a gravitational field. If the gravitational field is sufficiently general it is not possible at all to find an inertial system, that is, a co-ordinate system with reference to which ds2 may be expressed in the simple form given above:

$$ds^2 = c^2 dt^2 - dx^2 - dy^2 - dz^2$$
;

but in this case, too, there is in the infinitesimal neighbourhood of a soace-time point a local system of reference for which the last-mentioned simple form for ds holds This state of the facts leads to a type of geometry which Riemann's genius created more than half a century before the advent of the general theory of relativity of which Riemann divined the high importance for physics.

Riemann's Geometry.-Riemann's geometry of an n-dimensional space bears the same relation to Euclidean geometry of an n-dimensional space as the general geometry of curved surfaces bears to the geometry of the plane. For the infinitesimal neighbourhood of a point on a curved surface there is a local coordinate system in which the distance ds between two infinitely near points is given by the equation

$$ds^2 = dx^2 + dy^2$$
.

For any arbitrary (Gaussian) co-ordinate-system, however, an expression of the form

## $ds^2 = g_{11}dx^2 + 2g_{12}dx_1dx_2 + g_{22}dx_2^2$

holds in a finite region of the curved surface. If the  $g\mu\nu$ 's are given as functions of  $z_1$  and  $z_2$  the surface is then fully determined geometrically. For from this formula we can calculate for every combination of two infinitely near points on the surface the length ds of the minute rod connecting them; and with the help of this formula all networks that can be constructed on the surface with these little rods can be calculated. In particular, the "curvature" at every point of the surface can be calculated; this is the quantity that expresses to what extent and in what way the laws regulating the positions of the minute rods in the immediate vicinity of the point under consid-

eration deviate from those of the geometry of the plane.

This theory of surfaces by Gauss has been extended by Riemann to continua of any arbitrary number of dimensions and has thus paved the way for the general theory of relativity. For it was shown above that corresponding to two infinitely near space-time points there is that corresponding to two infinitely near space-time points there is a number ds which can be obtained by measurement with rigid measuring-rods and clocks (in the case of time-like elements, indeed, with a clock alone). This quantity occurs in the mathematical theory in place of the length of the minute rods in three-dimensional geometry. The curves for which \( \int d \) as has stationary values determine the paths of material points and rays of light in the gravitational field, and the "curvature" of space is dependent on the matter distributed over space.

Just as in Euclidean geometry the space-concept refers to the position-possibilities of rigid bodies, so in the general theory of relativity the space-time-concept refers to the behaviour of rigid bodies tivity the space-time-concept refers to the behaviour or ngid bodies and clocks. The space-time-continuum however differs from the space-continuum in that the laws regulating the behaviour of these objects (clocks and measuring-rods) depend on where they happen to be. The continuum (or the quantities that describe it) enters explicitly into the laws of nature, and conversely these properties of the continuum are determined by physical factors. The relations that connect space and time can no longer be kept distinct from physics proper. Nothing certain is known of what the properties of the space-time-continuum may be as a whole. Through the general theory of relativity, however, the view that the continuum is infinite in its time-like extent but finite in its space-like extent has gained in probability.

#### TIME

The physical time-concept answers to the time-concept of the extra-scientific mind. Now, the latter has its root in the time-order of the experiences of the individual, and this order we must accept as some-thing primarily given. One experiences the moment "'now," or, exed more accurately, the present sense-experience (Sinnen-Erlebnis) combined with the recollection of (earlier) sense-experiences. combined with the recollection of (earner) sense-experiences. That is why the sense-experiences seem to form a series, namely the time-series indicated by "earlier" and "later." The experience-series is thought of as a one-dimensional continuum. Experience-series can repeat themselves and can then be recognized. They can also be repeated inexactly, wherein some events are replaced by others without the character of the repetition becoming lost for us. In this way we form the time-concept as a one-dimensional frame which can be filled to be arrestored to the repetitions becoming the control of the co in by experiences in various ways. The same series of experiences answer to the same subjective time-intervals.

The transition from this "subjective" time (Ich-Zeit) to the time-concept of pre-scientific thought is connected with the formation of ea that there is a real external world independent of the subject. In this sense the (objective) event is made to correspond with the subjective experience. In the same sense there is attributed to the "subjective" time of the experience a "time" of the corresponding "objective" event. In contrast with experiences external events and their order in time claim validity for all subjects.

This process of objectification would encounter no difficulties were the time-order of the experiences corresponding to a series of external events the same for all individuals. In the case of the immediate visual perceptions of our daily lives, this correspondence is exact. That is why the idea that there is an objective time-order became established to an extraordinary extent. In working out the idea of an objective world of external events in greater detail, it was found necessary to make events and experiences depend on each other in a necessary to make events and experiences depend on earn other in a more complicated way This was at first done by means of rules and modes of thought instinctively gained, in which the conception of space plays a particularly prominent part. This process of refinement leads ultimately to natural science.

The measurement of time is effected by means of clocks. A clock is a thing which automatically passes in succession through a (practically) equal series of events (period). The number of periods (clocktime) elapsed serves as a measure of time. The meaning of this defi-nition is at once clear if the event occurs in the immediate vicinity of intended is a concern the event occurs in the inhibition of the clock in space; for all observers then observe the same clock-time simultaneously with the event (by means of the eye) independently of their position Until the theory of cleativity was propounded it was assumed that the conception of simultaneity had an absolute objective

assumed that the conception of simultaneity had an absolute objective meaning also for events separated in space.

This assumption was demolished by the discovery of the law of propagation of light. For if the velocity of light in empty space is to be a quantity that is independent of the choice (or, respectively, of the state of motion) of the inertial system to which it is referred, no absolute meaning can be assigned to the conception of the simultaneity of events that occur at points separated by a distance in space. Rather, a special time must be allocated to every inertial system. If no co-ordinate system (inertial system) is used as a basis of reference there is no sense in asserting that events at different points in space occur simultaneously. It is in consequence of this that space and time are welded together into a uniform four-dimensional continuum. See RELATIVITY.

Recent Developments.-The concepts of space and time which lie at the basis of the Newtonian natural philosophy, and which have provided a general background for the understanding of the external world during the last three centuries, are now known to be untenable, as a result of the progress of theoretical physics in the present

The concepts in question may be said to have originated with Pierre Gassendi (1592-1655), who, opposing Descartes' representation of space as a plenum, revived the doctrines of the ancient atomists of space as a plentum, revived the doctrines of the ancient atomists regarding the void. This implied making a distinction between matter and extension, asserting that while space has extension, matter has solidity as well, and occupies only a part of space, Gassendi's ideas were adopted by Newton, and thus was evolved the portrayal of space and time which became finally established in classical physics. Its fundamental postulate is that all the phenomena of the external world can be described in terms of the location and motion in space of entities, each of which has some degree of persistence and continof entities, each of which has some degree of persistence and continuous identity in time: so that whatever happens, happens in space: space, the stage on which the drama of physics is to be played, is the dominating conception of the whole system. Thus, with Newton, space is regarded as having a positive, objective existence, which is not attached in any way to subjective necessities of the human mind. "Absolute space," he says, "in its own nature, without regard to anything external, remains always similar and immovable," and "All things are placed in space, as regards order of situation." (Principia, Schol. ad Defin.). It is a real entity, subsisting prior to, and independently of, the bodies which it contains: and all events in nature can be represented by movements within it. Every point of space can be represented by movements within it. Every point of space persists throughout an infinite succession of instants of time, and the notion of public simultaneity is valid, with all the implications which it carries in classical physics. In the Gassendi-Newton scheme it is not considered necessary to account for the existence of entities which are permanent over appreciable durations of time, such as particles of matter: these are postulated, and the aim of science is to explain the changing phenomena of the universe in terms of their motions. Persistence of bodies in time, and their displacement in space are the concepts to which everything in the external world is

It was, however, necessary to account for the fact that gravita-tional, optical and electrical influences could be transmitted across donal, optical and electrical inductions could be transmitted across space which was void of ordinary matter: and for this purpose the ether was invented—an invisible medium filling all space, whose stresses and vibrations constituted the influences in question. The effect of this introduction was to endow space with practically all the qualities of an ordinary solid body, except visibility. A meaning could now be attached to the concept of absolute position in space, since

this was interpreted as position relative to points fixed in the ether. The existence of the ether, the Newtonian idea of public simultaneity, and the possibility of a complete separation of space from time, were all rejected after 1905, as a result of the theory of Special Relativity; and the discovery of General Relativity in 1915 made it necessary to abandon also the doctrine of the homogeneity of spacetime. The theory of the Expanding Universe, which was developed about 1930, destroyed still more of the old framework, by showing that the world contains only a finite number of cubic miles, and that this number varies with the time. Very little was left of the Newtonian ideas now, beyond the general understanding that nature could tonian ideas now, beyond the general understanding that nature could be interpreted by the existence and motion of entities in space and time; and this also was destined to perish. In the latter part of the roth century all the optical phenomena then known had been explained by the undulatory theory, i.e., the hypothesis that light consists essentially of waves. Now waves propagated outwards from a source of disturbance have the property of spreading, so that the energy of the disturbance becomes diffused over a progressively larger water. But could not be the control that the control of the latter and the latter and the control of the latter and the latter region; but early in the 20th century it was found (see LIGHT) that in some types of experiment there is no spreading; the luminous energy travels in a compact bundle, as in the old corpuscular theory of light. It was realized eventually that the undulatory and corpuscular theories are, in a sense, both true—light is both a wave and a particle, but this cannot be understood in terms of the classical idea of space, and is incompatible with it.

This conclusion was confirmed in another way, starting from the exploration given by Niels Bohr in 1913 of the emission of spectra. In Bohr's theory, the electrons in an atom move in orbits around the nucleus, like the orbits of the planets around the sun. Sometimes an electron falls from one orbit into another orbit nearer the nucleus, and the energy so lost is radiated outwards as light. (See Atom; QUANTUM MECHANICS; SPECTROSCOPY.) Bohr was, however, unable to explain how the electron moved from the one orbit to the other. At the time this was regarded as an imperfection in his theory, but ultimately it came to be regarded as one of the most valuable of its features; for it introduced the idea of a change which was later shown to be, even in principle, incapable of description in terms of space and time. The electron, in fact, like light, has two aspects, particle and wave, and the same was found to be true of all the ultimate constituents of the universe. It is not possible to assign to them a definite location in space combined with a definite velocity, and they cannot be represented by any picture which is based on classical ideas. At De represented by any picture which is based on classical ideas. At present there is no known way of expressing them except by mathematical formulae; but, as these formulae enable us to predict future events, they are sufficient for the purposes of science. The hope of forming an intuitive notion of what is going on around us has been

The concept of time has also been the subject of fruitful investigations in recent years, the most striking new ideas being those of Edward A. Milne. The system of time-measurement in common use is based on the principle that the angle through which the earth has 10tated on its axis (measured with reference to the fixed stars, whose small proper motions we can for this purpose neglect) in the interval between two events, measures the time elapsed between the events in question: this angular measure being convertible into the ordinary measure in terms of mean solar hours at the rate of 360° to 24 x 2 man of the convertible into the measure in terms of mean solar hours at the rate of 360° to 24 x 2 man of the convertible into the convertible mamical principles, such as pendulum clocks, give indications in accordance with this system, which Milne calls dynamical time. He points out, however, that it is possible to conceive of a totally different system of time-measurement, based not on molar dynamics, but on atomic phenomena. For instance, atoms of radium are continually disintegrating, by the emission of alpha and beta particles, into atoms disintegrating, by the consistent of applies and occasionate of arother radio-active element known as radon; the number of atoms which disintegrate in a given interval of time is a definite fraction of the number of non-disintegrated atoms which were present at the beginning of the interval. Evidently this property will serve for the construction (in principle) of a radio-active clock. Time as measured by radio-active clocks or by other means depending on changes in the atom (such as emission of light of definite frequency) is called the atom (such as emission of light of definite frequency) is called by Milne kinematic time. For phenomena taking place at the present moment, dynamical time and kinematic time keep pace with each other; but over long stretches of time they differ greatly. Measured in dynamical time, the frequency of atomic vibrations is always increasing, so that light reaching us now from distant nebulae, and emitted a long time ago, has a lower frequency than light emitted by similar atoms here and now: and this is Milne's explanation of the red-shift of the spectral lines of the remotest objects in the cosmos. The mathematical relation between the two kinds of time is

 $\tau = t_0 \log \frac{t}{t_0} + t_0$ 

where  $\tau$  is dynamical time, t is kinematic time, and to is the present value of t, i.e., the age of the universe reckoned in t-time from the Creation. Evidently the zero value of t corresponds to an infinite Creation. Evidently the zero value of r corresponds to an immune negative value of r; so that in Milne's theory, whether we say that the Creation took place a finite number of years ago, or is infinitely remote, depends on the arbitrary choice of our scale of time. (E. Wr.)

SPADEFISH (Chaetodipterus faber), a very deep-bodied, of the earth's surface which is included between latitudes 43° almost circular fish of the family Ephippidae, 2 to 3 ft. long, common in Atlantic waters from Massachusetts to Brazil and much prized for food. It has a small mouth, with brushlike teeth. The lateral line follows the humped curve of the body. In colour it is grayish, with four dark bands running from the top of the back down the body. It is also called angelfish.

SPADE GUINEA, the name by which the guinea coined in the reign of George III came to be known. It was so called because the reverse of the coin was designed with a shield pointed at the base after the fashion of a spade. See GUINEA.

SPADINI, ARMANDO (1883-1925), Italian painter, was born in Florence July 19, 1883. Not until the International exhibition at Venice in 1924 where 48 of his paintings were displayed was he assured of a definite place in modern Italian art. In 1010 he went to Rome where he died on March 31, 1925. He painted a number of notable pastoral scenes and a few portraits but his best subjects are domestic scenes.

SPAGHETTI: see MACARONI.

SPAGNA, LO (d. after 1530), the usual designation (because of his Spanish origin) of the Italian painter Giovanni di Pietro, a pupil and assistant of Perugino. Nothing is known of his early life. The chief of his numerous panel paintings are the "Nativity, in the Vatican, and the "Adoration of the Magi," at Berlin. Lo Spagna's frescoes reach a higher standard of merit than his panel pictures. The museum of the Capitol in Rome possesses a very beautiful series of life-sized fresco figures by him, representing Apollo and the nine muses from la Magliana, formerly ascribed to Raphael.

SPAHIS, originally the holders of fiefs in central Asia who yielded personal military service to their superior chief (in Persian sipari, meaning warriors, and synonymous with sepoy). In time the term came to be applied to the soldiery furnished in their own stead. A similar institution existed in Turkey, and the "Spahis" were the light irregular cavalry which from the time of Sultan Murad I (1362) down to the beginning of the 19th century formed the flower of the Turkish army; at one period they are estimated to have numbered 130,000. "Spahis" is the term now applied to certain native cavalry regiments in Algiers and Tunis, officered by Frenchmen.

SPAHLINGER, HENRY (1882-), Swiss bacteriologist, was born at Geneva, Switz., on Aug. 8, 1882. He produced his first tuberculosis serum in 1912, and in 1913-14 treated a number of patients at London hospitals, with good results. During World War I, being unable to continue the production of his serum, he manufactured large quantities of tetanus serum for the Allied armies. In 1916 he began to reproduce his antituberculous serum. which was in almost complete form in 1919. The Spahlinger treatment was based on two different therapeutic principles, according to the disease: passive immunization, or serum treatment, and active immunization, or vaccine treatment. He later studied the endocrine glands and their relation to disease resistance and longevity.

SPAIN, in its own language España, a state in the southwest of Europe, comprising eleven-thirteenths (190,115 sq.mi.) of the Iberian peninsula and in addition the Balearic Islands (1,936 sq.mi.), the Canary Islands (2,894 sq.mi.) and certain towns on the Mediterranean coast of Morocco (Ceuta, Peñón de Vélez, Alhucemas and Melilla), with the Chafarinas Islands.

The Spanish protectorate of Morocco extends over a northern and a southern zone (see Morocco), with capitals at Tetuán and Cabo Juby (Villa Bens) respectively. The colonial possessions of Spain are: Ifni territory (741 sq.mi.; capital, Sidi Ifni); Spanish Sahara (Río de Oro, 73,362 sq.mi., and Saguia el Hamra, 32,047 sq.mi.; capital, Villa Cisneros); and Spanish Guinea (Río Muni and the islands of Fernando Po, Elobey, Annobón and Corisco, in all 10,852 sq.mi.; capital Santa Isabel, on Fernando Po).

This article is concerned with Spain proper; i.e., with the Spain of the Iberian peninsula.

### PHYSIOGRAPHY

The Iberian peninsula covers the major portion of that section

47' N. (Estaca de Vares) and 36° o' N. (Isleta de Tarifa) and between the meridians of 3° 19' E. (Cape de Creus) and 9° 30' W. (Cape da Roca). Of its area of about 223,000 sq.mi., approximately 85% is Spanish. It has been thought proper, therefore, to treat here of the physical geography and geology of the peninsula as a whole rather than to confine the treatment to Spain.

The peninsula is the least European in appearance of the three great Mediterranean peninsulas. Its massif character, the great central Meseta, the narrow Strait of Gibraltar by which it is separated from Africa and the high barrier of the Pyrenees by which it is separated from the rest of Europe all give it the physical appearance of a disconnected outlier of the Moroccan Meseta rather than that of a part of Europe. Moreover, it is separated from the Mediterranean by coastal ranges which leave between themselves and the sea only narrow and discontinuous strips of coastal plain that alone, of all the peninsula, have a Mediterranean history.

At first glance it would seem that the peninsula should serve to unite Africa and Europe; instead, its ranges of east-and-west mountains serve to separate them. Moreover, the peninsula furnishes no natural traffic routes between the Mediterranean and the Atlantic or between the Mediterranean and northwestern Europe. The closer physical connection with Africa than with the rest of Europe had the consequence of the Islamic invasion and the 500-year struggle with Islam which is accountable in large part for the slow development of Spain along European lines. The physical character of the peninsula likewise resulted in the separation of Portugal from Spain and the 700-year separation of the kingdoms of Castile and Aragon. So sharply defined are the natural regions occupied by these two states that even now their peoples differ sharply in physical type, customs and social organization.

The Coasts.-Seven-eighths of the border of the peninsula are washed by the sea; yet the peninsula as a whole has relatively little access to the sea and comparatively few good harbours. The Portuguese seaboard is 500 mi. long and, as compared with the rest of the peninsula, relatively low. On the southern half of the coast, however, mountain masses and spurs terminate in a number of high rocky headlands like Capes Mondego, Carvoeiro, da Roca, Espichel, de Sines and St. Vincent. The lagoon of Aveiro and the estuaries of the Minho, Douro, Mondego, Tagus, Sado and Guadiana rivers deeply indent the coast and furnish the principal harbours. The high continental mass which forms the greater part of Spain has practically no navigable rivers and a coast line that is for the most part steep and rocky, with relatively few indentations that are easily approached from the interior. The northern coast has numerous indentations that form convenient harbours for small craft, although the current that flows eastward along it frequently builds bars at their mouths. The best harbours are found in the rias or fjordlike indentations of the coast of Galicia. There are the fine natural harbours of Pontevedra, Vigo, Corunna and Ferrol. Bilbao, on the Nervión river, has been since mediaeval times the principal maritime outlet of the Basque provinces. Santander and San Sebastián, likewise on the northern coast, are secondary centres of overseas shipping.

Along the Gulf of Cádiz is the broadest coastal plain of the whole peninsula. Eastward as far as the marshes at the mouth of the Guadalquivir (Las Marismas) it is lined by a series of sand dunes and bordered in part by a line of low, wave-built islands. Eastward from the mouth of the Guadalquivir the coast is more varied and includes the excellent harbour of the Bay of Cádiz.

The Mediterranean coast is bold and rocky from the Strait of Gibraltar almost to Cape Palos but is broken by the British-owned harbour of Gibraltar and the fine harbour of Cartagena. North of Cape Palos the coastal ranges again recede, leaving a narrow coastal plain; but in the northern part of the province of Alicante the mountains again advance to the sea and form the lofty headland of Cape de la Nao. The whole coast of the Bay of Valencia is low and swampy and lined with lagoons, furnishing little in the way of good harbours. All this coast is built of sediments brought down from the Meseta. This sedimentary character IO8 SPAIN

culminates in the great delta of the Ebro river. North of the mouth of the Ebro the coast alternates between playas and rocky headlands. The Liobregat river also forms a considerable delta just south of the harbour of Barcelona From Barcelona a long monotonous sand beach extends to the mouth of the Tordera river. There begins the famous Costa Brava, divided into two sections by the Gulf of Rosas and presenting a rough varied coast line of

deep coves and steep, rocky bluffs.

Inland Configuration .- The surface of the peninsula is noted for its contrasts and its vast expanses of dreary uniformity. There are mountains rising with alpine grandeur above the snow line, but often sheltering rich and beautiful valleys at their base. Naked walls of white limestone tower above dark woods of cork and olive. In other parts, as in the Basque country, in Galicia, in the Serranía de Cuenca (between the headwaters of the Tagus and those of the Júcar), in the Sierra de Albarracín (between the headwaters of the Tagus and those of the Guadalquivir), there are extensive tracts of undulating forest-clad hill country. Almost contiguous to these there are broad plains of level tableland, some almost uninhabitable and some with a network of irrigation canals and richly cultivated like the Requena of Valencia. Continuous mountain ranges and broad tablelands give the prevailing character to the scenery; but there are, in addition, lofty isolated mountain peaks such as Monseny, Montserrat and Mont Sant in Catalonia, the Peña Golosa in Valencia and Moncavo on the border of Aragon and Old Castile, as well as many small secluded valleys such as those of Vich and Olot among the Catalan Pyrenees.

The Meseta and Its Borders.—More than half the peninsula is occupied by the Meseta, an ancient earth block consisting mostly of flat-lying strata. broken and eroded and reduced in large part to a state of peneplanation. The Meseta slopes gradually from north to south and from west to east, its average altitude being about 2,000 ft. On the north it is bordered by the Cantabrian mountains and on the northeast by the Iberian ranges, which separate the Meseta from the deep tectonic depression in which flows the Ebro river and terminate near the Gulf of Valencia. On the south the Meseta is bordered by the Sierra Morena, which is actually only the sceep southern edge of the Meseta along the Baetic depression, and the Sierra de Alcaraz between the headwaters of the Guadalquivir and Segura rivers.

The Cantabrian mountains are divided into two sections-the Cantabro-Asturian section on the northern border of the Meseta and the Galician section which extends into Portugal as far as the Douro river. The Cantabro-Asturian section runs sensibly parallel to the north coast and culminates in the Peña de Cerredo (8,786 ft.), the highest point in the ranges of the Meseta. A characteristic of these mountains is the many parameras or isolated plateaus surrounded by steep mountains or walls of sheer cliff. On account of the diversity of their origin and their many interruptions the Iberian ranges can be characterized better as the upturned northeastern corner of the Meseta than as a true mountain system. This corner reaches its highest point in the Sierra de Moncavo (7,595 ft.). South of the Jalon river it divides into two sections: one, which borders on the Meseta, forms the broken and picturesque Serranía de Cuenca: the other, which lies nearer the Ebro depression, forms the coast ranges that border the low, lagoonstrewn Bay of Valencia.

The Meseta is divided by a central cordillera into northern and southern submesetas, representing the ancient regions of Old Castile and New Castile. This central cordillera consists of a series of crust-block mountains formed by successive fractures and vertical movements and extending en échelon northeastward from the Atlantic coast near Lisbon to the Nudo de Albarracin, where it connects with the Iberian ranges. It divides the basin of the Douro river from that of the Tagus. There are lofty peaks reaching above the line of perpetual snow in the sierras of this central cordillera. The highest peak, the Plaza del Moro Almanzor (8,504 ft.) in the Sierra de Gredos, is only a little lower than the highest of the Cantabrian peaks, while the Pico de Pefialara in the Sierra de Gudarrama reaches 7,972 ft. Even these highest crests are, however, only about 5,000 ft. above the general level

of the Meseta. Between the Sierra de Guadarrama and the Sierra de Gredos and between the latter and the Sierra de Gata are high irregular surfaces filled with hills and paramerus.

Parallel to the western part of the central cordillera between the basins of the Tagus and Guadiana rivers are the Montes de Toledo, a shorter series of sierras that form a denuded highland of relatively low elevation and are separated from the Iberian ranges by the section of the Meseta known as La Mancha. Their highest point is Las Villuercas (4,734 ft.) in the Sierra de Guadalupe. Their westward extension into Portugal is known as the Montanhas do Alentejo. The Sierra Morena is an even less continuous range than the central cordillera or the Montes de Toledo. Its westerly extension into Portugal ends at the rocky headland of Cape St. Vincent.

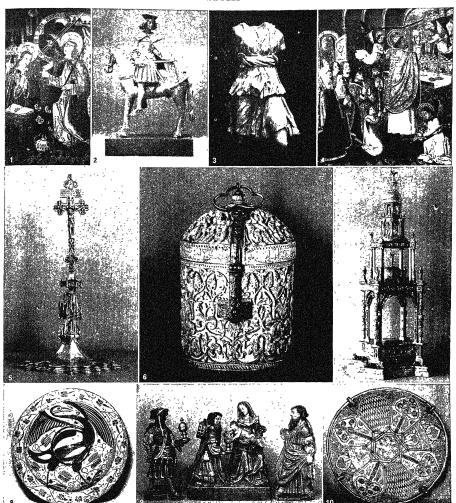
Geologically, geographically and politically the Meseta is the true Spain. On all sides it is in general remarkably isolated from the coast so that the passes on its border and the river valleys that lead from it to the coast and to the Ebro and Guadalquivir depressions have been from earliest time geographical features of the highest importance. On the northwest, communication between León and Galicia is furnished by the Sil river which at an early date was followed by military roads and in modern times became part of the route of the railway to the port of Corunna. In the Cantabrian mountains the passes are fairly numerous and over them lie the routes of several railways connecting the interior with the ports of the Bay of Biscay. The two most remarkable passes in these mountains are the Pass of Pajares, which carries the railway from León to Oviedo and the port of Gijón, and that of Reinosa which leads down to the deep valley of the Besaya and is crossed by the railway from Valladolid to Santander. The eastern part of the range is crossed by railways from Burgos to Bilbao and San Sebastián, the latter following the picturesque gorge of Pancorvo and crossing the range at Idiazabal.

On the northeast the valley of the Jalon affords the most important communication between Madrid and the Ebro,depression. At an early date an important military road followed this depression. It is now traversed by the Madrid-Saragossa railway. Farther south the southerly extension of the Iberian ranges long made direct communication between Madrid and Valencia difficult, and even now, although a branch line connects the Jalon valley with the coastal railway a short distance north of Valencia, the main communications between Madrid and the eastern and southeastern coasts are across the southeastern part of the Meseta and the hill country between the Meseta and the Mediterranean.

The descent from the Meseta to the depression of the Guadalquivir is comparatively gradual; but passes through the eastern part of the Sierra Morena are few, the principal one being the Puerto de Despeñaperros where the Magaña river, a tributary of the Guadalimar, has cut a deep gorge that the railway from Andalusia to Madrid follows in its ascent to the Meseta.

The central cordillera also offers considerable obstruction to easy communication between the northern and southern sumesetas, although the hilly intervals between the sierras afford comparatively easy routes. Carriage roads cross the three main passes in the Sierra de Guadarrama (the passes of Somosierra in the northeast, Novacerrada near the Pico de Peñalara and Guadarrama a few miles south and west), while the railway from Madrid to Segovia passes through a tunnel close to the Guadarrama pass and that from Madrid to Ávila crosses the southwestern portion of the same sierra by a remarkable series of tunnels and cuts. The Sierra de Gredos has a road across it connecting Avila with Talavera de la Reina by way of the Puerto del Pico; but for the most part there are only bridle paths across this sierra and the Sierra de Gata and no railway crosses either.

The Meseta is bordered on the northeast and on the south by two great transverse depressions. That on the south is known as the Baetic depression, now deeply eroded by the bed of the Guadalquivir. It is a gigantic fracture that has cut like a knife across all the strata of the Meseta and stands out with remarkable clearness from Cape St. Vincent to the eastern end of the Sierra Morena. The present Baetic depression is believed to be the remains of a strait which, up to the Tertiary period, connected the Mediter-

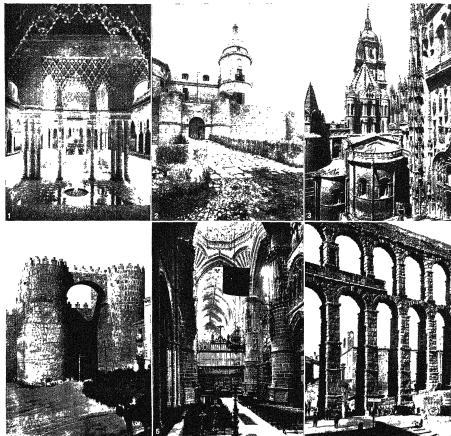


PHOTOGRAPHS COURTESY OF THE HISPANIC SOCIETY OF AMERICA

EXAMPLES OF SPANISH ART

- "The Annunciation." Panel from a 15th-century Castilian retable
   "Saint Martin." Wood carving, 15th-16th-century Castilian statue
- 3. "Artemis." Hispano-Roman statue from Itálica
- 4. "The Mass of Saint Martin." Panel from a 15th-century Aragonese retablo
- 5. Enamelled altar crucifix, 14th century

- 6. Hispano-Moresque avory box, 10th century
- 7. Silver custodia by Cristóbal Becerril, 1585
- 8. Valencian glazed plate, 15th century
- 9. "The Adoration of the Magi." Wood carving, 15th-16th century
- 10. Hispano-Moresque bowl, 15th century



SPANISH SCENES

- Stucce decorations in the Lions' court of the Alhambra, 14th-century palace of the ancient Moorish kings
   The citadel at Simancas, near Valladolid, where the national archives have been kept since 1563
   The old 12th-century cathedral at Salamanca, built in late Romanesque style, and the adjoining new cathedral (right), begun three cen-
- turies later
- 4. Puerta del Alcazar. Part of the dark granite fortifications walling the town of Ávila
- 5. Central transept within the Gothic cathedral at Burgos (1221-1567)
- 6. The aqueduct at Segovia, a late Roman structure

ranean with the Atlantic.

Later, on account of movements that produced the Cordillera Penibética by which the present depression is bounded on the south and southeast, this strait was reduced to a gulf opening only to the Atlantic and was in time converted, whether by further uplift or by sedimentation alone, to the present valley. The sedimentary deposits of the Guadalquivir, which flows along the most abrupt border of the depression at the foot of the Meseta, have been built up on the materials worn off from the Meseta during the period of submergence and the sediments of marine origin to form the present fertile valley of Andalusia.

The Ebro depression forms a deep ravine between the northeastern corner of the Meseta and the Pyrenees. Its bordering walls converge to form an angle at the point where the depression is shut off from the Mediterranean by the Catalan coastal range, through which the Ebro river has cut a tortuous gorge. At one time the depression was occupied by the sea, which penetrated by way of the Gulf of Rosas but did not extend to the Bay of Biscay. When the Catalan coastal range emerged the depression was converted into a closed lake. The definition of the Ebro river and the successive terraces which characterize both sides of the depression were brought about by the later uplift from which resulted the present architecture of the Pyrenees.

The Ebro valley is divided into two sections by spurs from the Pyrenees on the one side and from the Sierra del Moncayo of the Ebrian ranges on the other. The uppermost of these, a plateau of between 1,000 and 1,300 ft. above sea level, is only about one-fourth the size of the lower portion. The valley of the Guadalquivir is also divided into an upper and a lower section as indicated by the change in the course of the river from a due west to a more southwest direction. The small upper valley is of considerable elevation while the much larger lower valley is mainly lowland and, from Seville to the sea, is composed of a perfectly level and marshy alluvum (Las Marismas).

Mountains Outside the Meseta Border.—The Pyrenees (q.v.) form a wall between Spain and France with an average altitude higher than that of the Alps. Their snow-capped crests reach their highest point in the Pico de Aneto (11,168 ft.) in the central massif of granitic rocks that forms the range's core. Railroads pierce the Pyrenees over two routes (Jaca-Pau and Ripoll-Foix). The Catalan coastal range that borders the Ebro depression is the youngest range of the pennsula and all evidence indicates that the region suffered movements in the Quaternary period. It represents the upper portions of a land mass now in large part submerged beneath the Mediterranean. The peaks Monseny (5,713 ft.) and Montserrat (4,076 ft.) are the outstanding crests. Erosion has moulded them into picturesque forms. Nearer the coast a series of hills of low elevation borders the Catalan range throughout its whole length.

The Baetic system of the southeastern part of the peninsula has been said to be the result of a series of thrusts that had their focus farther south and forced up against the rigid mass of the Meseta the land mass located in front of it. It is generally accepted that a long longitudinal fault which extends from the lower course of the Segura river to the Genil river divides the system into two groups. The mountains to the south of this fracture are known as the Cordillera Penibética. They lie near the Mediterranean coast and are considered to be prolonged across the Strait of Gibraltar by the mountains of the Rif. The great block of the Sierra Nevada of the Cordillera Penibética contains the highest crests of the peninsula and reaches its greatest altitude in Cerro Mulhacén (11,414 ft.). It is completely alpine in character with glacial cirques, lakes and moraines. The Cordillera Penibética includes at its eastern end the volcanic zone that forms the Cape de Gata. The extension westward from the Sierra Nevada to Point Marroquí appears to be cut by a series of transverse faults. The mountains north of the Penibaetic fault, though not exhibiting the high crests of the Cordillera Penibética, have a much broader area of high altitudes. They close the eastern end of the Baetic depression and extend eastward to form the Cape de la Nao. The dividing line between them and the Iberian ranges is generally placed at the Júcar river.

Rivers and Lakes.-The main water divide of the peninsula follows rather closely, in the north, east and south, the border of the Meseta and the greater part of the drainage is westward by four large rivers, the Tagus (Spanish Tajo, Portuguese Tejo), Douro (Spanish Duero), Guadiana and Guadalquivir. Only a limited part of the northeastern corner of the Meseta is drained by the Ebro on account of the barrier of the Iberian ranges, and all the remaining rivers which drain to the Mediterranean are short as compared with those draining to the Atlantic. All the large rivers of the Atlantic slope rise in Spanish territory. The Tagus and the Douro have their lower reaches in Portugal and the lower Guadiana is partly in Portugal and partly on the boundary. Only the Guadalquivir and the Ebro, of the larger rivers, are entirely in Spanish territory. The longest of the rivers is the Ebro (575 mi.). The rest in order of their length are the Tagus (565 mi.), the Guadiana (510 mi.), the Douro (480 mi.) and the Guadalquivir (350 mi.). The Minho, which divides the Cantabrian from the Galician mountains, and its tributary, the Sil, which rises in the northwestern corner of the Meseta, are much shorter.

The mouths of the Minho, Douro and Tagus form estuaries which provide good harbours for shipping, but all rapidly become unnavigable toward the interior. In fact only the Guadalquivir can really be classed as navigable for any appreciable distance from the sea, ships being able to ascend it as far as Seville. The others flow in deep rocky valleys which they have cut across the Meseta. Their water supply is scanty, their deeply cut valleys are difficult to cross and the river beds so far below the level as to make them useless for irrigation. The Ebro makes its way to the Mediterranean by way of a tortuous gorge and so affords no means of river transportation to the sea. Its great importance lies in its plentiful waters for irrigation purposes derived from both the Pyrenees and the Cantabrian mountains. Lakes of any considerable size are few, the only important ones being two coastal lagoons near the Mediterranean-the Albufera de Valencia, the Mar Menor in Murcia-and the Laguna de Janda in Cádiz behind Cape Trafalgar. There are many small alpine lakes and small salt lakes are to be found in every steppe region.

#### GEOLOGY

Geologically the Iberian peninsula consists of a great massif (the Meseta) which has been composed by Archaean, Palaeozoic and eruptive rocks partly concealed by a covering of Tertiary strata but characterized by the absence, excepting in its margins, of any marine deposits of Mesozoic age and bordered on the north, east and south by zones of folding in which the Mesozoic and early Tertiary beds are involved.

The Meseta is a fragment only of the great Hercynian mountain system which was formed across Europe at the close of the Carboniferous period. The earth block which forms the Meseta was individualized at the close of the Palaeozoic era. During the Mesozoic era the Hercynian system of which it is a part was shattered and large portions of it sank beneath the sea and were covered by Mesozoic and Tertiary strata. But other portions remained above the sea and of these the Meseta was one. Around it the deposits of the Jurassic and Cretaceous seas were laid down. During the Tertiary era these deposits, together with the earlier Tertiary beds, were crushed against the old massif, thus forming the folded zones of the Baetic ranges on the south, the hills of southern Aragon in the east and the Pyrenees on the north.

There are clear evidences of earlier (Huronian and Caledonian) movements on the Meseta, but worn folds of Carboniferous formations embedded in the Hercynian structure may represent in places an older discordant structure resulting from earlier movements.

Tertiary movements soldered to the Meseta the formations of the northeast, where the folding action lay within the early (Palaeogene) Tertiary period, and of the southeast, where the folding was most intense, in the later Neogene period before the Tortonian epoch. The Tertiary pressures also caused many important movements in the Hercynian massif itself; ancient fractures were rejuvenated, large interior basins were formed and the strata were folded and crushed with great violence in the borders of the massif. During the Pliocene period the Meseta was given a general tilt westward. Later differential Tertiary movements modified the central cordillera system and accentuated the separation of the northern from the southern submeseta.

The areas of regional metamorphism on the Meseta are formed of plutonic rocks, broadly granites, which pass upward into an Archaean or strata-crystalline series in Galicia, Portugal and the central cordillera system. They appear elsewhere aligned with the Palaeozoic series, principally along a line from Alcántara to Andújar. This series shows these levels: the lowest, augen-gneiss; the intermediate, micaceous gneiss with schists and crystalline limestones intercalated; and the uppermost, lustrous schists and phylltes These materials appear now at the surface among granitic rocks in the massif of Galicia and northern Portugal and the central sierras, in the Montes de Toledo and in southern Portugal on the plateau of Évora and Beja which extends eastward by the Sierra de Aracena to the Sierra Morena at a point north of Seville.

Palaeozoic.—The oldest Palaeozoic strata are referred, from their included fossils, to the Cambrian, Ordovician and Silurian systems. They range through a vast region of Andalusia, Estremadura, Castile, Salamanca, León and Asturias and along the peaks of the Pyrenees and the Cantabrian mountains. In eastern Galicia and Asturias and in western León the Cambrian and Silurian trend lines swing round a quarter circle following the outline of Galicia and northern Portugal. The Silurian of the sierras (Ocejón, Alto Rey) lying to the northeast of the Sierra de Guadarrama trends south-southwest, south and, finally, southwest. Round the gneissic vestiges of the Toledan massif the Cambrian and Silurian, partly metamorphosed in the neighbourhood of the granites, trend westward and then northwestward in the Montes de Toledo and the Sierra de Altamira. From the Sierra Morena front the trend lines, running at first parallel to the line of front, swing to the west and west-northwest round the strata-crystalline of southern Portugal. Farther east they run freely to the northwest in the great belt of Palaeozoic which stretches from La Mancha to beyond the Portuguese frontier. The older Palaeozoic of the north culminates in the Teleno (7,181 ft.) belonging to the Montañas de León. In the south the Sierra Morena is the scarped southern edge of the main mass of the Palaeozoic, cut by a series of faults partly of Permian and partly of Pliocene date. The Palaeozoic also formed the two plateaus to the south of the Sierra Morena and a low plateau in the east notable for the complex lead-silver zone of Linares and La Carolina; and a broad plateau in the west extending from the Andévalo district south of the Sierra de Cuacena to the western shores of Portugal.

In the hinterland the Palaeozoic sierras trend finally to the northwest, washing the Hercynian axial lines which curve into this direction from both the Sierra de Toledo and the Sierra Morena. At Montoro the course of the Guadalquivir has been imposed on the Palaeozoic by the removal of overlying Tertiany formations. East of Almadén the Palaeozoic is pierced by Quaternary basalts of the Campo de Calatrava beyond which tongues of Mesozoic projecting from La Mancha bring the Guadiana drainage into the Palaeozoic area,

Mesozoic.—In Portugal the Mesozoic series consists of deposits laid down in the geosyncline which existed to the west of the latesta during that era and which disappeared at its close after retreating north of the present Tagus river draining the Upper Cretaceous. Geosynclinal conditions were most marked during the Jurassic whose "Tusitanian" stage has a thickness of 5,000 ft. in the Törres Vedras area. Jurassic limestones sketch the structural skeleton of the Mesozoic fringe of the Meseta. In the Mondego region a Jurassic upfold, flanked on two sides by Turmian formations, runs west-southwest to Soure and then west-northwest to Cape Mondego by Verride and Buarcos.

This axis delimits on the south an area of worn Cretaceous reliefs above which stands out the Jurassic of Cantanhede, separated from the sea by a broad belt of high dunes. The Cretaceous, which appears in depressions along the principal axis as well as on the flanks of the Jurassic zone, is widely developed in the Cintra region where the Jurassic scarcely emerges. South of the Tagus

river movements of Alpine date have brought up the Jurassic to form the higher parts of the complicated Serra da Arrábida which runs west-southwest to Cape Espichel. In Algarve the Lias and Jurassic, with a fringe of Cretaceous toward the littoral, are folded against the southern edge of the plateau and contribute granite and limestones to the complexity of the zone.

The Lower Carboniferous rocks of Spain consist partly of limestones and partly of sandstones and conglomerates like the culm of Devonshire. It is in the culm of the province of Huelva that the celebrated copper mines of Rio Tinto are worked. The Upper Carboniferous is formed, to a large extent, of sandstones and shales, with seams of coal; but beds of massive limestones are often intercalated, and some of these contain Fusulina and other fossils like those of the Russian Fusulina limestone. In the Cambrian and Silurian areas of the northwest, Tertiary movements have probably compressed the strata in the arc of the western Asturnas, but not in the Carboniferous area to the east where the Carboniferous has its most extensive development in Spain, covering a considerable section of the eastern Asturias and stretching more or less continuously through the provinces of León, Valencia and Santander.

The blue-gray mountain limestone of the Lower Carboniferous forms the triple massif of the Picos de Europa and the crests of many sierras. The culm, which also forms mountains, especially along the upper Deva, marks the transition to the continental conditions in which originated the sandstones and slates of the middle Carboniferous, with their intercalated beds of coal, principally the beds of the Tangres and Mieres basins. Tertiary movements raised the Carboniferous along an east-west axis to form the Cantabrian chain.

To the north of the Carboniferous of the central Asturias lies an area of Mesozoic marine invasion with deposits in a belt trending east and west behind the Palaeozoic "island" by the Cape de Peñas district. From Peña Prieta eastward the altitude of the summits of the Cantabrian chain declines and the Gretaceous is rapidly substituted for the Carboniferous. In the half circle between Peña Tabra and the Sierra de Alcaraz the Meseta is bordered by highlands principally of Mesozoic formations. The tectonic relations between these highlands and the Cantabrian system, which continues eastward in the Cretaceous to the Pyrenean front, are not clear.

The Permian is probably represented by some of the red sand-stones, conglomerates and slates in the Pyrenees, in the Sernain de Cuenca and in Andalusia. The Triassic system is well developed in the north of the peninsula along the Cantabrian chain and eastward to the Mediterranean. It is composed of red and variegated sandstones, dolomites and marl, and contains deposits of gypsum, aragonite and rock salt. The Jurassic overlies these strata and is especially important in the eastern part of the peninsula between Castile and Aragon, along the Mediterranean border, in Andalusia and on the flanks of the Pyrenees. The early Jurassic conglomerates and grits are followed by limestones, some dolomitic variegated marl and overlying spongy limestones or dolomites. The neritic Lias and Jurassic are important only on borders of New Castile.

The Cretaceous forms the broad plateau of La Lora on the southern front of the Cantabrian mountains northwest of Burgos and extends southward and westyward into a Cretaceous isthmus in the northern side of the Miocene "Straits of Burgos." An upfold brings it to the surface again in the islandlike Sierra de Atapuerca on the south side of the "straits" toward the Montes de Oca. From the scarp of the Urbión the Cretaceous dips gently southward and Upper Cretaceous limestones form small, bare, fault-bounded plateaus sharply contrasting with the pine-clad slopes of the Lower Cretaceous and appearing at the surface not only on the margin of the zone but in the upfolds of small radius among the Tertiaries of the Douro, at El Burgo de Osma. Soria and elsewhere.

South of the Jalón river beyond the Parameras de Molina the border of the Meseta is formed principally of Jurassic limestones and marl commonly capped by horizontal limestones of the Cretaceous and forming a series of high plains rather than mountains in which the *muela* or molar-tooth summit is typical. The dif-

ferent alineations, however, are known as the Serranía de Cuenca, the Montes Universales and the Sierra de Albarracín.

Tertiary.—Deposits of Tertiary age cover rather more than a third of Spain. On the Meseta the Tertiary formations were laid down in the basins of Old and New Castile and in the minor systems of Castelo Branco (Beira Baixa), Badajoz and others of the Tagus and Guadiana valleys. In the west arkose grits of Lutetian date form a broad, monotonous plain in the provinces of Zamora and Salamanca, and the old Tertiary (Palaeogene) beds appear also in the east near Lerma and in the plateau of Soria. Elsewhere the outer deposits of Palaeogene are insignificant. The continental Miocene, unconformable on the Palaeogene, consists of fine-grained materials laid down within the basins of the Palaeogene; and the Cretaceous to which it is unconformable had been folded in the margins of the basins, by rivers (Tortonian), brackish ponds (Sarmatian) and the marshy ponds (Pontian). In spite of stratigraphic discontinuity the forms of the Miocene relief are constant and characteristic.

The type form is the tableland (mesa), with its flat upper surface of the limestone cap (páramo), its slope of marl (cuesta) and its sands or clays of the lower slopes forming plains (lamass, campiñas, campos). As the erosion advances the worn tablelands appear as truncated pyramids or form low mesas capped by the beds of harder marl. Finally great stretches of plain are formed on the level of the Tortonian on lower Sarmatian. Elsewhere, the Eocene marine strata are developed in the basin of the Ebro, and Miocene deposits occupy some small tracts especially on the coast of Valencia, although most of the sandy Tertiary rocks of the latter district are Pliocene. In the Baetic depression the marls of the Tertiary rocks of whatever level are of great importance, supplying the rich soil of the Cijarafe olive groves west of Seville and of the vineyards of Jerez.

Other Features.—Quaternary deposits spread over about a tenth of the country. The largest tract of them is to be seen to the south of the Cantabrian mountains. Another flanks the Sierra de Guadarrama and spreads out over the great plain from Madrid to Cacers.

From the rivers Douro, Tagus, Guadalquivir and Ebro, E. Hernández-Pacheco described four fundamental terraces at heights of 30, 100, 200 and 330 ft., which are fairly constant within limits of 4-33 ft. from the higher terraces, and he commented on the absence of terraces on the Spanish section of the Guadiana river. The highest terrace is of late Pliocene date, and to it are referred the famous rañas, extensive platforms of coarse detritus high on the northern front of the Montes de Toledo. The others seem to be related to the terminal moraines of the Pleistocene glaciation with which, in some cases at least, they are continuous. These moraines are found as low as 2,300 ft. on the Serra da Estrêla (one of the westernmost sierras of the central cordillera); and the topography of the Picos de Europa (of the Cantabrian mountains), the Sierra de Guadarrama and the Sierra de Gredos (of the central cordilleras), the Sierra Nevada and the Iberian ranges from the Demanda to Moncayo has been modified to some degree by glaciation. But the centres of glaciation in each of these cases were relatively small, and the action local. Only in the Pyrenees are the glacial phenomena of real topographical importance. The terraces, however, are of first importance, making irrigation possible in areas otherwise arid.

# CLIMATE AND SOILS

Looking at Spain, as a whole, for the year as a whole, we can distinguish, in respect of temperature, the very different climates of the equable Biscayan and northern Atlantic coasts; of the interior, with extremes of temperature always, but with a winter that varies from the traditional nine months of the higher parts of Old Castile to the short two months' winter of the lowlands of Estremadura; of the Mediterranean coast with its very short winter and rather hot summer; and of the subtropical south and southeast, where winter, in the popular sense, hardly exists.

More important is the distinction in respect of rainfall between Spain of the northwest and north (roughly as far south as the line León-Pamplona-Huesca), with a mean annual rainfall of 24 in.

and more, fairly well distributed over the year; and the rest of the country, arid Spain, with rains insufficient in quantity or badly distributed or, more commonly, both. There is a general decline in the mean annual rainfall from northwest (Santiago, 66 fh.) to southeast (Almería, c. 10 in.), but this is interrupted by the mınımal rainfall of the basin of Old Castule, where. Salamanca and Zamora, like Saragossa in the Ebro basin, lie within an Isohyet of 12 in, and by the orographic rainfalls, which are sometimes remarkable. Thus, in the Baetic calcareous zone, in spite of a rainless summer season, the annual rainfall may be 80 in, on the outskirts of the Serranía de Ronda.

The rains of arid Spain are spasmodic, Mediterranean rains falling in large drops for a few hours of a few days of the year. They are also irregular in amount from year to year, the rainfall records of 95 years for San Fernando, near Cádiz, for example, show a mean deviation, from the mean, of 26%. (Annual records from 48 stations are practically complete from 1920 on, and a few are much older.)

Irregularity of the seasonal rain supply and the entrenched courses of the rivers of the interior prevent much use being made of their waters for irrigation. To overcome both of these difficulties for the rivers of the Ebro system immense engineering works were planned. (See Aracon.) On the lower courses of the rivers of the short eastern slope the relief is, by exception, highly favourable to the establishment of important irrigation systems. (See VALENCIA)

Properly conserved, arid soils, although they are inevitably exposed to the sterility resulting from sequences of years of drought, have, nevertheless, certain advantages of chemical composition because of the smaller degree to which plant foods are lost by leaching, which enable them to maintain a standard of productivity lower than that of more humid regions and requiring a greater output of labour, but more independent of artificial fertilization, especially if natural manure is supplied by pasturing. Dry farming, the cultivo de secano, is the third and most widespread of the geographical institutions of arid Spain.

Subsoils include the Andalusian black earths and new soils, chestnut or red in colour. An extreme type is the calvero soils. In the calveros, which arise commonly from attempts to extend cultivation beyond its proper limits, the soil cap is discontinuous and the native rock conspicuous on the surface; tufts of permanent vegetation depend on and protect the small patches of soil; in the open spaces lichens are the chief covering, with occasionally transitory grasses.

Saline soils occur locally, in the more arid, parts of Old and, especially, of New Castile and of the Ebro basin and elsewhere; but the extension of the saline area is greatly modified by human agency. In eastern Spain, in general, and in Andalusia, red soils, the Mediterranean red earths, are commoner than chestnut, and in the dry southeastern corner tawny or gray soils are commoner than red; the precise significance of the colour is not known.

## FLORA AND FAUNA

Flora.—Because of the extraordinary variety of climates, altitudes, exposures and soils, there are more botanic species in Spain than in any other European district of the same size. The number of endemic species, particularly on the tablelands and the mountain ranges, is exceptional. Spain may be divided botanically into four zones.

In the humid north and northwest the flora is mesophytic, of the same type as that found in central and western Europe. A great part of the country once covered with forest is now barren. Deciduous trees flourish only in the north and northwest or on damp mountain slopes and along watercourses. Typical of these are oaks, beech, birch, ash and sweet chestmut. In the Pyrenees they ascend to about 5,000 ft., above which level grow birches and conifers such as silver fir (Abies alba), mountain pine (Pinus anugo) and Scotch pine (Pinus sylvestris). Higher up are alpine meadows and heaths, rich in alpine flora. Westward from the Pyrenees, through the Basque country and the Cantabrian mountains to Galicia, the lower slopes are well wooded. Higher up, heath moors contain box, blackberry, gorse and heather; while

apples are cultivated in the open meadows and maize, oranges, lemons and other fruits near the coast.

The central tableland or Meseta and the steppe lands carry xerophytic types. Typical trees are pines and evergreen oaks (Quercus ilex and Q. suber), though poplar and ash grow by the streams. On the deforested areas above 7,000 ft. thin matorral, mainly broom heath, is found. Matorral consists of a scrub of evergreen bushes and herbaceous plants belonging mainly to the Cistaceae, Labiatae, Leguminosae and Ericaceae families. flourishes where there is plenty of sunshine, low rainfall and high evaporation. Myrtle (Myrtus communis), mastic bush (Pistacia lentiscus), sage (Salvia officinalis), sweet marjoram (Origanum majorana), wormwood (Artemisia absinthium) and tree heath (Erica arborea) are common in mattoral. As the soil becomes more arid this changes into steppe which consists chiefly of bare ground sparsely covered with small bushes and tufts of grasses. Spanish broom (Spartium junceum) and gorse are common northeast of the Sierra de Gredos, on the southern side of which olives, figs and vines are cultivated, while on the rocky western slopes are huge areas of woody labiates.

On the Montes de Toledo and Sierra Morena are matorrales of broom heath and cistus. Those dominated by cistus are known as jarales. On the vast plains of La Mancha the matorral is of aromatic labiates such as thyme, lavender and rosemary (these are known as tomillares). Sometimes the scrub is very dense and may be 10-15 ft. high, though typically it is about 6 ft. high. In the Sierra Morena evergreen oaks are the dominant trees with ash, alder, black poplar and others along the river banks. There is a great deal of cork oak (Quercus suber) in the southwest and sweet chestnut (Castanea sativa) in the west. Steppe lands occur mainly in the high southeastern plains where the climate is dry and the soil sandy or salt. There is a large variety of plants, but esparto

grass (Stipa tenacissima) is dominant.

In the dry Andalusian plain of the southeast, African and semidesert plants are found. Much land is under cereals and legumes, though there are many vineyards and groves of oranges and olives. Along the streams grow patches of dwarf palms (Chamaerops humilis), prickly pears and oleanders. In the Andalusian mountains evergreen oaks grow everywhere, pinewoods in the hollows, and olives are common. The matorral is chiefly of cistus and labiates. On the Sierra Nevada typical Mediterranean fruits grow about 5,000 ft. up, below the matorral of gorse and aromatic shrubs. In irrigated parts cultivated fruit trees form gardens called vegas or huertas. The flat marshy expanse of Las Marismas, near the mouth of the Guadalquivir, supports reeds and salt-marsh plants.

The lush, green, almost tropical vegetation of the southern coastal strip is the result of irrigation. Date palms, bananas, sugar, rice and cotton are grown in vegas. On the hills grow pines, oaks and carob, along the coastal areas jujube, almonds, figs. olives and pomegranates and on the lowlands mastic bush and sweet

laurel.

On Spain's Mediterranean coast line Catalonia has the densest vegetation. South of Barcelona are woods of pine and cork oak as well as typical matorral. Oleanders grow in the Ebro valley. North of Barcelona cork flourishes. The rainfall is higher there and so eucalyptus, pines, cypresses and poplars are common. Farther north the deciduous trees are found and the Mediterranean

flora merges with the Pyrenean.

Fauna. Cut off from Europe by the Pyrenees and formerly joined to Africa, Spain has two clearly distinguished groups of animals. The first group includes both species found in the temperate forests of central Europe and occurring in the north of Spain and also isolated colonies of alpine forms occurring in the higher mountain ranges—for instance, deer, ibex, eagle, vulture. The second group is typically Mediterranean and is found in Spain in the dry southeastern regions; there are many indigenous forms and many North African species.

Almost everywhere are found the rabbit, various dormice and squirrels, the rat (Rattus norvegicus) which was probably brought into Spain by Napoleon's armies in the 19th century, bats (21 kinds, including the only tropical species found in Europe) and red

deer. Indigenous to the country are the Spanish hare (Lepus granatensis), the water vole (Arvicola terrestris sapidus), the squirrel (Sciurus vulgaris segurae) found in the Sierra de Segura, the red deer (Cervus elaphus hispanicus) and the Spanish ibex (Capra pyrenaica).

In the region of the Pyrenees the fauna is similar to that of France. There live the squirrel, mole, chamois, hare (Lepus europaeus) and bear (Ursus arctos). In the Cantabrian mountains the fauna is of the European type and includes the chamois, gray dormouse, squirrel, bear, yellow marten and ermine. The typical animals of Galicia are the Galician hare and the ibex.

In the central placeau of Spain indigenous species of squirrel, mole, muskrat and roebuck are found. In the Sierra de Guadarrama live species of wolf, lynx, genet (an African animal), stone marten, badger, weasel and fox. In the central strip between the Tagus and Guadiana rivers there is a predominance of African species. Among the indigenous animals of the southeastern regions are peculiar species of jackal, wolf, squirrel and rabbit. In the lower Guadalquivir valley lives the wild boar.

In Andalusia are a species of dormouse, the Egyptian mongoose (Herpestes ichneumon widdringtoni), which is not found in Europe except in the Iberian peninsula, the Andalusian weasel and the hedgehog, while the ibex inhabits the mountains inland from the Mediterranean. At Gibraltar are the famous Barbary apes, probably introduced from Africa. There are no squirrels in the Mediterranean regions.

As Spain is on the route of bird migration between northern Europe and Africa, many species, such as ducks, wild geese and wading birds, winter there on their way south. Others such as flamingos, snipe (by the Guadalquivir), two sorts of quail and the southern shearwater (in the south) stop in the spring, on their way north from Africa.

Birds of prey are numerous and varied, the most common being the buzzard. There are many kinds of vultures, hawks and eagles. The imperial eagle (Aquila heliaca adalberti), also found in North Africa, is indigenous and so are some owls, the royal cuckoo (Cuculus canorus minor) and, in central Spain and the Sierra Morena, the azure-winged magpie (Cyanopolius cooki), otherwise only found in northeastern Asia. Common on the steppes is the red-legged partridge, and the great bustard feeds in flocks in the cornfields of the Meseta.

Amphibians and reptiles are particularly numerous in the south. There are many lizards, chameleons in the Guadalquivir valley, salamanders in the mountains, tortoises and, everywhere, frogs and toads. Trout abound in the mountain streams and lakes, and barbel, carp and tench are common fresh-water fish.

The insect life is quite varied and contains African and European species. Those in the rainy northwest are different from those in the arid zones, where the praying mantis and locusts are

BIBLIOGRAPHY.--Maps published by the Instituto Geográfico y Catastral, by the Depósito de la Guerra, by the Instituto Geológico Gestand and by the Portuguese Directo Geral dos Trabalhos Geodésicos e Topográphicos and Commissão do Servico Geológico Max Sorre, Espagne—Portugal, vol. 7 of Geographic universelle, ed. by L. Gallois and P. Vidal de La Blache (Paris, 1934); L. Martine Echeverris, Geográfic de España, 3 vol., 3rd ed. (Barcelona, 1937–38); E. H. del Villat, El Valor geográfico de España (Madrid, 1921); J. Doporto, Geografia general de España, 3rd ed. (Seville, 1930); L. Mallada, Explicación del mapa geológico de España, 7 vol. (Madrid, 1893–1911); Museo Nacional de Ciencias Naturales, Serti geológico: Trabajos (Madrid, 1912); J. Sistituto Geografico Y Catastral, Oficina Central Meteorológica, Resumen (annual), and Memorias; E. H. del Villat, España en el mapa internacional de suelos (Madrid, 1921); Comisión de Investigaciones Paleontológicas Problemistóricas, Memorias (Madrid, 1927); M. Wilkomm and J. Lange, Prodromus Florae Hispanicae, 3 vol. (Stuttgart, 1861–80., with supplement, 1893); E. Fodor (ed.), Spaña and Portugal in 1952 (1952); Doré Ogrizek (ed.), L'Espagne (Paris, 1951). de España and by the Portuguese Direcção Geral dos Trabalhos

It is impossible to introduce any accurate chronology into the prehistory of Spain. Before the Roman pacification in the 2nd century B.C. with its certain dates and events lie a couple of centuries of Punic penetration from Carthage; still earlier we know

SPAIN II3

of the coasting voyages of Greek traders along the Mediterranean shore and catch some glimpse of the Iberian civilization with which these Greeks came into contact; but all this brings us only into the 7th century B.C. Perhaps for several hundred years before the advent of the Greek ships there had been Phoenicians, mainly from Tyre and Sidon, who had maintained trading posts along the southern shore of Spain and had sailed through the Gibraltar straits to Cádiz on the Atlantic. Then the perspective of years lengthens out immeasurably and we step back, not by centuries but by thousands of years, through neolithic into palaeolithic times, when some type of men—we cannot guess to what race they belonged or what form of language they knew—hunted the beasts of those early days and decorated with marvellously fine likenesses of these animals the inner walls and roofs of deep caverns.

Palaeolithic Spain.—These cave paintings rank among the most impressive discoveries of the past. There can be no doubt of their vast antiquity, since they certainly represent animals of the late Quaternary geological period and are engraved upon bones which are identifiable as those of animals now long extinct. Nor can there be much dispute about the extraordinary veracity and vivacity with which wild horse and bison, hind and stag, ibex and ox and boar are delineated with little save their outline and with no visible hesitation of stroke.

The best-known of the Spanish caverns and one of the first to be discovered is Altamira near Santander. The publication of its contents by Edouard Cartailhac and the abbé Henri Breuil (Monaco, 1906) is the best introduction to the study of palaeolithic Spanish archaeology. Other important sites are Hornos de la Peña, Pasiega and Castillo in the province of Santander; Basondo in the province of Biscay; and Pindal, Buxu and La Peña in Asturias. Palaeolithic decorated caverns are largely confined to the small mountainous area in the north which extends from the westernmost Pyrenees through the coastal hills beyond Santander. They may therefore be justly termed Cantabrian. Elsewhere, however, beyond the Spanish border, the same type recurs, chiefly on the northern slopes of the Pyrenees and in the region of the Dordogne in southwestern France. These three districts—the one in northern Spain, the two others in southern France-are inseparably allied and were products of contemporary cultures. In other parts of Spain, where caves are little more than open rock shelters, a distinctively different art has been found.

Prehistorians therefore speak of "cave art" and "rock-shelter art," and distinguish sharply between Cantabrian and east Spanish palaeolithic. Beginning in the early 1920s there was great activity in the exploration and elucidation of this second group. Except that the fauna of the paintings there implies a slightly warmer climate, much the same series of animals are rendered in much the same style; but intimately combined with them appear weirdly represented men and women-a subject almost completely neglected by the Cantabrian cave artists. Often the men are armed with bow and arrow and shown in pursuit of their quarry; but whereas the beasts are naturalistically correct in the surprising palaeolithic manner, some of the huntsmen with threadlike limbs more nearly resemble the praying mantis, while others with sudden protuberances of calf or thigh suggest unevenly inflated rubber toys. The women, in long flounced petticoats very remotely suggestive of the elegant ladies of Minoan Crete, seem to take part in dances and conversations, poorly visualized and crudely rendered. This striking combination of a naturalistic animal art with geometrically conventionalized, highly primitive human representations is a phenomenon of great significance, since the groupings and actions of the men and women are almost as clearly allied to palaeolithic rock drawings in North Africa as the ibexes and stags, horses and oxen and bulls are allied to the cave paintings of Cantabria. As in historic, so in prehistoric times, the destiny of Spain must have been a succession of invasions, now from the north, pouring round or over the Pyrenees, now from the south out of Morocco and Algeria. The most important sites of the east Spanish group are Cogul by Lérida, Valltorta in Castellón. Albarracin by Teruel, Alpera and Minateda in Albacete and Cantos de la Visera in Murcia-all characteristically within two or three days' journey afoot from the sea.

Neolithic and Bronze-Age Spain.—The Neolithic Age in Spain testifies to a wholly different condition of mankind. Perhaps it is too ingenuously simple to ascribe the naturalism of palaeolithic art to a race of hunters and the geometric conventionalism of the neolithic to a race that tilled the soil. A fairly uniform culture spread over the entire peninsula; for the rock shelters with neolithic drawings have a very wide distribution and show a striking similarity. They have almost no pictorial attraction and often resemble picture script rather than actual illustration. The pottery finds are the great archaeological aid to neolithic chronogy; and the occurrence of some of the conventionalized devices of the rock paintings upon pottery which can with certainty be assigned to the transition from the Neolithic to the early Bronze Age puts the general epoch of this culture beyond doubt.

A closer comparison of ceramic types shows that beneath this superficial uniformity there lies sufficient diversity to warrant many subdivisions. Chief among these is the clear distinction between the more indigenous central and the southeastern or Almería culture which was probably under African influence and may actually have been the nucleus from which the true Iberian culture developed. In late neolithic times the more extensive central culture exhibits a distinctive and striking bell-shaped (the so-called campaniform) pottery. At this time it is likely that there was some exportation of copper and silver from Spain to the nearest of the Mediterranean islands, since there are ceramic affinities with finds of the Aeneolithic Age (or Stone and Copper Age, lasting in Spain from about 3000 to 2500 B.C.) in the Balearics and in Sardinia and Sicily. The peculiar megalithic structures in these parts, such as the talayots of the Balearics, the nuraghi of Sardinia, the underground chambers of Malta, are fairly well paralleled by megalithic grave structures in Portugal and Spain. But there is as yet no certain proof of intercourse between the eastern and western basins of the Mediterranean for these early times.

Somewhat after 2500 B.C. the Bronze Age displaced the Åëneoithic without apparent interruption; but still the Aegean influence, which can be proved to have reached Sicily and southern Italy, failed to extend as far as Spain. If anything, the Bronze Age marks a retrogression in the civilization of Spain, where at midcentury there had been no archaeological discovery to indicate a powerful or wealthy Bronze Age culture even remotely comparable to that of Crete or the eastern Mediterranean lands.

Tartessus.—Herodotus (iv, 152) narrates the adventurous voyage of a Greek sailing ship from Samos, which was driven by storm past the Pillars of Hercules and "at last reached Tartessus. This trading-town was in those days a virgin port unfrequented by merchants, and the Samians in consequence made a greater profit than any Greeks before their day." This event supposedly took place about 630 B.C. During the century thereafter, Tartessus was certainly frequented by trading vessels of the Ionian Greeks of Phocaea in the Bay of Smyrna. It has been maintained that this rich Spanish city on the Atlantic was the Tarshish of the Old Testament, which "with silver, iron, tin and lead" traded in the fairs of Tyre (Ezekiel xxvii, 12).

Yet the modern search for Tarshish-Tarsis-Tartessus failed. The German archaeologist Adolf Schulten after several campaigns regretfully admitted in 1926 that the mysterious city must lie deep underriver and below the ground-water level.

## THE IBERIANS

The whole of the Hispano-Lusitanian peninsula was sometimes called Iberia by ancient writers; but the true focus of the Iberian civilization was the southeastern corner of the land. There, a stock out of northern Africa (Oran?) and therefore probably Hamitic (Berber?) may have been infiltrating ever since the aëneolithic days of the Almería culture (c. 3000 B.C.). They were probably racially akin to the Tartessians, who would therefore have also been African invaders. We become completely certain of their presence toward the end of the Bronze Age and, several centuries later, can trace the diffusion and inland penetration of their culture until it was finally absorbed by the Roman civilization almost as late as the time of Christ. Roman writers describe the typical Iberians as dark complexioned, with unkernot hair, small

of face but with the cheekbones emphasized and the lower lip prominent, small framed, alert and wiry. Iberian bronzes display them as nders of horses, and we know what their swords and daggers, spears and other weapons were like. The women are represented sometimes as wearing a single-piece cloak drawn up over the head from the shoulders like a mantilla or shawl, and sometimes with a short, hooded garment which flares out below the waist and often has swallow-tailed sleeves. We may judge of their jewellery and their headdresses from the famous sculptured bust, the "Lady of Elche." Iberian art was rude but vigorous, with a leaning toward sculptured animals of stone and human figurines in bronze. The pottery was decorated with simple linear themes, artistically of no particular distinction, until Greek examples offered more sophisticated decorative motives to copy. The best Iberian art comes from the provinces of Murcia and Albacete in the southeast, where the Greek influence was strongest. The Iberians lived in walled towns. The cyclopean masonry in the bottom courses of the great walls of Tarragona is indubitably a remnant of an old Iberian stronghold. Tartessus and Massia (now Cartagena) were similarly enclosed; but the Carthaginians completely destroyed both of these cities, making Gades (now Cádiz) take the commercial place of the former and refounding the latter as Carthago Nova. Behind this seaboard fringe of Tartesso-Iberians the high-lying interior was in the possession of a variety of indigenous peoples of whom we have no clear knowledge except that, along with Catalonia, they passed through an early Iron Age (or Hallstatt phase) associated with the invasion of Celtic tribes who, in the 7th and 6th centuries B.C., poured through the Pyrenees by the western passes and gained possession of large areas of the peninsula, submerging the previous inhabitants. The chief Celtic zones today are Galicia and Portugal. This Celtic invasion may justly be called a historical event. We can date its successive waves within a few decades, define its sources, follow its spread and perceive its results. In the extreme northern mountain lands the earlier inhabitants managed to preserve their individuality in the face of the irruption. It has even been argued that the Basques, who maintain customs and a language whose isolation is a mark of extreme antiquity, are ultimate descendants of the palaeolithic Cantabrian folk which produced the cave art so many thousand years earlier. Elsewhere, during the pre-Roman times, we find Celtic tribes (Beribraces, Sefes, Cempsos) in possession of the land.

Such is the ethnic picture during the 6th and 5th centuries B.C. With such a Spain the Ionic Greeks now came into contact, in rivalry with the Carthaginians who had fallen heirs to the centuries-old Phoenician exploitation of these western marts. Neither the Phoenicians nor the Carthaginians left any very permanent mark upon the land, while the Greeks influenced it profoundly. Ships from Tyre and Sidon may have traded beyond the straits and in Cádiz at least as early as the 9th century B.C.; yet modern archaeology, which has located and excavated Greek, Iberian and Roman towns, has not laid bare a single Phoenician settlement or found more important Phoenician remains than the odds and ends of trinkets and jewels and similar articles of barter. The inference is clear that, except perhaps at Cádiz, the Phoenicians built no towns, but had mere trading posts and points of call.

The Phocaean Greeks, on the other hand, whose western focus was Massilia (Marseilles; founded 600 s.c.), founded true colonies along the east and south coasts where unmistakable traces of their settlements have survived. The sites of Hemeroskopeion (near the modern Denia) and Mainake (at the mouth of the Río de Vélez near Málaga) have been identified, though not yet excavated; and Emporion (now Ampurias, on the Pyrenean east coast near the French frontier) has been systematically dug, revealing a fortified town with strong gates and walls, streets more or less at right angles, remains of houses and a shrine of Aesculapius with a cult statue of the god.

While there is almost nothing in Iberian art ascribable to Phoenician or Punic influence, the art of the Greeks had indisputably a revolutionary effect. A collection of sculptures found at Cerro de los Santos in the province of Murcia is a hybrid of archaic Greek and Iberian art. Fragments of ibericized Ionic Greek architectural mouldings were discovered in the same region; and the pottery from Elche and the surrounding districts is full of unmistakable borrowings from the ornamental repertory of Greek vases. The earliest Iberian money was coined in direct imitation of Greek types of the 4th century BC. Archaic Greek bronzes discovered in many parts of Murcia and Alicante and the actual material traces of the Phocaean colonies tell us that the Greeks were once in this part of Spain.

Elsewhere in the Mediterranean this period is covered by written chronicles of the ancient historians; but the records for Spain are extraordinarily meagre. We hear no more about Tartessus after the 6th century B.C. Instead, Greek sources of the 5th century begin to speak of the whole Tartesso-Iberian region as Iberia; and recent archaeological exploration has confirmed this emphasis upon the Iberians and established them as the great civilizing force of that time in ancient Spain.

During the 4th century B c. the Carthaginian encroachment reached most of the Iberian homeland, the Greek contact was broken and the Graeco-Iberian culture in Murcia waned. But in recompense, and probably under the pressure of this Punic expansion, the Iberian penetration of the interior gathered great headway. During the 3rd century B.c. the most flourishing Iberian centre in Spain was the valley of the Ebro, where in the 5th century there had been no Iberian settlements whatever; and Greek writers of the time no longer refer to the Castilian uplands as Celtic but as Celtiberian. Excavation confirmed this gradual iberianization of almost the whole of pre-Roman Spain. Largely as a result of the careful and systematic work of Schulten in laying bare the sites of the Roman and Celtiberian encampments there, an extensive insight into this iberianized Celtic culture of the 3rd and and centuries B.C., in particular that of Numantia, has been gained.

Thus, when the Romans began their efforts to latinize the land after the close of the Second Punic War (201 B.C.), they found not a Celtic civilization like that of Gaul but an Iberian culture of the general type which the Greeks had encountered and influenced before them. Archaeological evidence shows that the Iberian and the Roman civilizations must have co-existed side by side for more than a century. The latest sculptures from Cerro de los Santos, though still Iberian in style, borrow Roman statuary motives. In other regions true Iberian pottery is often found mixed with thoroughly Roman ware (terra sigillata). Iberian jewellery and gold have been found amid Roman surroundings; and most of the coinage bearing in Iberian script the names of Iberian towns dates from after the Roman conquest.

(R. C.; X.)

## THE ROMANS

Carthage, defeated by Rome in the First Punic War, turned to Spain as a natural treasure house to furnish reparations, to finance new offensives and to supply auxiliary troops. Hamilcar's activities after 237 B.C., followed by those of Hasdrubal (including the founding of the fortress at Carthago Nova) and Hannibal, forced upon Rome a difficult, distant and costly war for which it had no desire and which ushered in many decades of stubborn effort to subdue a rich, proud and brave country. Victory in the Second Punic War left Rome with two embryonic Spanish provinces: Hispania Citerior, the eastern coastal strip based on Tarraco (Tarragona) and Carthago Nova; and Hispania Ulterior, comprising the southern coast and the valley of the Baetis (Guadalquivir). Thereafter the task of deepening the provinces by advance inland was bitterly pursued. Year by year, with each province under its proconsul, Roman soldiers and Roman money were poured in, until Scipio Africanus' epic capture of Numantia in 133 B.C. allowed advance northward to the Durius (Douro) and westward to the middle Tagus. Administration, though usually opportunist, was not always merely oppressive or self-interested; and although annual tribute was imposed on native communities they received certain advantages-security, peace, safe communications, new opportunities of production and commerce, employment under Roman arms and acquaintance with Roman civil law. Agriculture, viticulture and fisheries flourished in the south and east, as the local coin types attest, even if these activities were controlled by

SPAIN II5

Pyrenees to Carthago Nova) and coinage developed from the proceeds of the innumerable mines, of which Rome claimed the gold while leasing out the silver, lead and (probably) copper.

When in 80-70 B.C. the Roman Quintus Sertorius used Spanish supporters against Roman political rivals, he did so as the leader of an already half-romanized army. Julius Caesar's governorship of Hispania Ulterior (61-60 B.C.) saw the frontiers extended up to the mouth of the Durius. Later, as dictator, he initiated a new colonial and municipal policy, bringing Italian settlers to Spain and granting Latin rights to certain indigenous communities. Gades became a fully fledged Roman municipium. Roman peace was swiftly followed by Roman political consciousness: language. religion and public life were henceforth moulded and unified by the central Roman model.

Augustus' first task was to undertake, by bloody and savage warfare, the conquest of the northwestern (Asturio-Cantabrian) corner of Spain-not complete until 19 BC. Now, with the whole peninsula tamed, he effected its total reorganization, though the precise date (in any case earlier than 2 B.C.) is uncertain. Baetica (roughly the Guadalquivir valley with the southern coast) became a "public" province, without regular troops, under senatorial proconsular administration; Lusitania (a new province roughly coextensive with modern Portugal south of the Durius) and Tarraconensis (comprising all the rest of the peninsula) were imperially administered under propraetors with three legions as a permanent garrison in the latter. Major regional towns or cities became centres of government and local jurisdiction. Emerita Augusta (Mérida), a pattern of Augustus' many newly founded watchdog colonies of veteran soldiers, typifies, by the wealth of its remains today, their imposing character. Colonies and full municipia, formed ex hypothesi of Roman citizens, were selfgoverning and subject only to citizens' taxes. Unprivileged communities were administered by the provincial governor and subject still to payment of tribute. Although Augustus was chary in extending the Roman franchise, his work for Spain was enormously beneficial and widely recognized as such. The building of roads and bridges, the encouragement of local enterprise, the unification of sentiment and the establishment of profound peace, while raising the standard of living everywhere, were not imposed at the cost of rigid conformity. Political, religious and financial anomalies were tolerated. Rome's principal reward consisted of the vast output (perhaps unequalled elsewhere) of gold, silver, copper, iron, tin and lead from Spanish mines.

The Augustan model was faithfully preserved. Claudius reduced the garrison to two legions, Vespasian to one. The road complex was developed swiftly. Spanish wine, by its cheapness, and oil, by its quality, disturbed the previous pattern of world markets. Vespasian imposed stricter regulations for the control of all the principal Spanish mines, the revenue of which afterward flowed into the imperial treasury. But early in his reign he recognized a century of astonishing progress by simultaneously promoting about 350 unprivileged communities to Latin rights. Spain could not now deny the presence of the golden age, marked by security, a high and well-diversified culture and a balanced and critical civilization, which, if it produced only few statesmen, gave Rome the younger Seneca, Lucan, Martial, Quintilian, Columella and Pomponius Mela as literary or academic ornaments. The 3rd and 4th centuries saw initiative, if not prosperity, declining. City walls crumbled in neglect, through excessive dependence on Rome; and when the barbarians burst the Rhine frontier in A.D. 406-407 and flooded Gaul and Spain, there could be neither resistance nor (C. H. V. S.) hope of recovery.

With the irruption of the Vandals, the Suebi (Sueves, Suevi) and the Alani (Alans), the history of Spain enters on a long period of division and confusion. The Vandals and their associates, who plundered far and wide, were not numerous enough to establish a rule of their own. When in 428 their king Gaiseric passed out of Spain to found the Vandal kingdom of Carthage, his whole horde numbered only 80,000 persons, including old men, women and children and runaway slaves. Salvian says that many of the subjects of the empire preferred poverty among the barbarians to the

Roman capital; trunk roads were constructed (e.g., that from the tyranny of the imperial tax collectors. The great landowners had, moreover, almost as much to fear from the agrarian insurgents known as Bagaudae, who are found acting with the Suebi, as from the barbarians. In the north the Asturians and Basques, the least romanized part of the population, appear from the beginning of the age of barbarization as acting for themselves. In the mountain country of Cuenca, Albacete and the Sierra Nevada the native Orospedans were entirely independent in the middle of the 6th century. Spain was thrown back into the state of division from which it had been drawn by the Romans-with the vital difference that the country now possessed the tradition of the Roman law, the municipalities and one great organization in the Christian Church.

No help was to be expected from the empire. Unable to aid itself it had recourse to the Visigoths (see Goths). Ataulphus (q.v.), the successor of Alaric I and husband of Placidia, whom he had married against the wish of her brother the emperor Honorius, entered Spain in 414 but was murdered in 415. After the speedily ensuing murder of his murderer and successor Sigeric. Wallia (415-419), who was elected to the kingdom, continued Ataulphus' work. He destroyed the Alani and drove the Vandals and Suebi into the northwest. But then he handed Spain back to the imperial officials, that is to say, to weakness and corruption, and marched with all his people into Aquitania Secunda, which had been assigned to them by Honorius.

### THE VISIGOTHS

The Visigothic rulers of Aquitaine began to intervene in Spanish affairs early in the 5th century but it was not until 404, during the reign of Alaric II (484-507), that large-scale migration to Spain began. The migrants, who certainly did not number more than 200,000, included peasants as well as warriors and clergy and established their overlordship without serious opposition (497). In the areas where they elected to settle, the Hispano-Roman landowners (hospites) were compelled to surrender to the newcomers two-thirds of their cultivated land (sortes Gothicae), but there was no general expropriation even in Old Castile, where Visigothic settlement was densest. The political capital of the Visigothic monarchy was transferred from France to Toledo in the reign of Athanagild (551-567).

Though the invaders were both politically weak and already highly romanized, powerful influences at first prevented any rapid assimilation to the native population. The Visigoths were followers of the Arian heresy and remained subject to their own legal codes, while the Hispano-Romans were Catholics and continued to be governed by Roman law. Intermarriage between the two races was prohibited. Instability was to be the outstanding feature of the state set up by the Visigoths in Spain. Because of the ambitious Visigothic nobility's strict insistence on the principle of elective monarchy, the crown was constantly menaced by political intrigue, and the removal of the sovereign by deposition or assassination was frequent. Leovigild (568-586)-one of the few effective Visigothic kings-finally destroyed (585) the remnant of the Germanic kingdom set up by the Suebi in northwestern Spain about 175 years before and managed to bring the ever-rebellious Basques under his control; he also dealt successfully with a Catholic rebellion against the state religion. But the next king, Reccared (586-601), was baptized a Catholic soon after his accession, and the third council of Toledo then proclaimed the conversion of the whole kingdom (589).

The removal of the religious barrier allowed the assimilation of the two races to progress more rapidly, and the councils of Toledo, where nobles as well as clergy were represented, now began to dominate the crown. The reign of Swintila (621-631) saw the final expulsion of the Byzantine prefecture set up in southern Spain in Athanagild's time. In the time of Sisenand (631-636), the fourth council of Toledo-presided over by St. Isidore-completed the subjection of king and government to ecclesiastical authority. An event of great significance for the subsequent history of mediaeval Spain was the promulgation by Reccessinth (640-672) of the Liber judiciorum as the sole legal code for both races. This was a new compilation, drawn up by order of the king c. 654,

in which Germanic customary law predominated over Roman legal traditions.

It is probable, however, that the extent of the assimilation between the two races brought about by Reccared and Reccesswinth has been somewhat exaggerated. Even after their reforms only nobles of pure Visigothic descent could be elected to the throne, and the Germanic nobility was thus encouraged to maintain its racial purity up to (and after) the final fall of the monarchy.

Wamba (672-680), the last king of any stature, attempted to reorganize the decadent military institutions of his kingdom but was deposed by a trick; and the energies of the next three kings were chiefly concerned with holding their thrones against the intrigues of their political enemies. By the time of Roderick (710-711) the disintegration of the state was complete. Apparently as a result of an invitation from Roderick's opponents, Tarik, the Arab governor of Tangier, crossed the Strait of Gibraltar with an invading Arab and Berber army in 711. Roderick called for national unity against this grave threat, but even then the Visigothic nobles declined to abandon their suicidal partisanship. Defeatism was deliberately encouraged by some of them in the army that Roderick had assembled; in consequence it was routed by Tarik south of Medina-Sidonia on July 19, 711, the king himself disappearing from history.

The collapse of the Visigothic monarchy in Spain followed at once. A substantial number of members of the large slave population abjured Christianity to improve their social position. The Spanish Jews, subjected to fierce persecution since the reign of Sisebut (612-621), welcomed the tolerant invaders as liberators. A number of high Visigothic nobles accepted Arab suzerainty. Toledo fell without resistance and the invaders speedily completed the occupation of almost the whole peninsula. Though the Arabs took one-fifth of the land for themselves the Christian communities were left with their religious and legal independence intact and

were protected by Koranic law.

The social system of the Visigothic monarchy had consisted broadly of an aristocracy of nobles (primates) and clergy; a large class of freemen (mgenui) of mixed racial origin; and a numerous slave class (servi). The aula regia was made up of palace officials (palatini), who held the title of count by virtue of their offices. Provinces were governed by duces or comites and subdivided into areas ruled by judices. This stratified society without clear political ideals proved incapable of creating any sense of national cohesion during the two centuries of Visigothic rule in Spain. Though they were by no means without creative capacity in letters and the visual arts, it was as lawgivers that the Visigoths exercised their greatest influence on the history of Spain. Reccessinth's Liber judiciorum remained the basic legal code of Christian Spain for centuries after the disappearance of the last Visigothic king; and, by a curious paradox, memories of the feeble Visigothic state were now to prove strong enough to sustain the small Christian states of the north in their long and desperate resistance to Islamic military (P. E. R.) and cultural power.

## MOORISH SPAIN TO 1031

During the reign in Spain of the Visigothic king Witiza (701-709) Arab forces of the caliphate (q.v.) had conquered northern Morocco and laid siege to Ceuta, the last remnant of the Byzantine possessions. It seems certain that Julian, the imperial count or governor of Ceuta, incited the Arab viceroy in North Africa, Musa ibn Nusair, to attack Spain, possibly by arrangement with the sons of Witiza. After a successful preliminary raid by the Berber Tarif in 710, Musa ordered his governor at Tangier, Tarik ibn Ziyad, to make a descent in force. In 711 Tarik crossed with 7,000 men, mostly Berbers, and, after reinforcement by 5,000 more, awaited Roderick's advance near the Laguna de Janda, south of Vejer de la Frontera. There, on July 19, Roderick was defeated, and probably killed. The sons and partisans of Witiza, who had withdrawn during the battle, now joined Tarik and encouraged him to advance northward to seize Toledo, while a detached force occupied Córdova. In June 712 Musa crossed with an army of 18,000, mostly Arabs, captured Seville and Mérida (after a siege lasting over the winter) and dispatched his son 'Abd al-Aziz to

the southwest, before himself joining Tarik at Talavera. After wintering at Toledo, he resumed his advance in 714, captured Saragossa and made with Tarik a two-pronged expedition into León and Galicia before returning to Damascus at the caliph's command. His son 'Abd al-Aziz, after occupying Portugal, completed the conquest of Granada and Murcia, where the duke Theodomir (called Tudmir by the Arabs) became tributary. Other Arab forces pushed northeast into Septimania; and later governors continued to raid into Gaul, where, although defeated by Charles Martel at Poitiers in 732, they maintained an advanced base at Narbonne until its capture by Pepin in 751.

The invaders met little opposition on the whole. The sons of Witiza and other great Visigothic families, whether converted to Islam or not, compounded by payment of tribute for extensive domains. The Jews, freed from persecution, were eager allies, and the serfs gained a measure of freedom. Conversions were on a large scale, and the Spanish converts (muwallads) became an active and turbulent element in the general Moorish population. The unconverted, called mustaribs (Mozarabs), did not suffer much from interference and, like the Jews, formed prosperous communities in the Moslem cities. The Arabs, in spite of continuous immigration, were too few to colonize the country; they formed the administrative and military cadres, maintained by the allotment of fiefs in the region of Saragossa, the eastern and southern coasts and the Guadalquivir valley. The Berbers settled mainly in the centre and in mountainous regions which resembled their native land and favoured their anarchical tendencies. Berber revolt in Morocco in 740 produced a parallel outbreak in Spain, and Berber risings, large and small, continued for the next two centuries. Among the Arabs, also, the intertribal feud between Kais and Kalb (see CALIPHATE) was reflected in Spain, complicated by rivalries between the early immigrants (baladis) and the Syrian contingents (shamis) which came in from 741 onward. In this patchwork of racial and tribal discords, rebellion was almost endemic, and the resulting lack of unity remained a permanent characteristic of al-Andalus, as Moorish Spain was called.

The Omayyad Dynasty.—In 755 the Omayyad prince 'Abdar-Rahman ibn Mu'awiya, escaping from the massacre of his relatives in Syria, landed at Almuñécar, and with Kalbite support captured Córdova (756). He waged pitiless warfare against internal disorder for more than 30 years and established a centralized power based upon an imperial guard of Berbers and European slaves (Slavonians). The pious Hisham I (788-796) tried to stem the expansion of the Asturian kingdom. A series of muwallad revolts, at Saragossa, at Toledo, at Mérida and in Córdova, threatened to dislodge his successor, al-Hakam I (796-822), who, however, by his implacable resolution reaffirmed the Omayyad power and laid the foundations of the material and literary culture which developed under the urbane 'Abd-ar-Rahman II (822-852). The peace was again broken under Mohammed I (852-886) by successive muwallad and Berber revolts, often with Asturian support, notably those of the "Visigothic" Beni Kasi at Tudela and Saragossa and of Omar ibn Hafsun in the Sierra de Ronda. General disintegration and civil war among and between Arabs, Berbers and muwallads in all quarters forced his son 'Abdallah (888-912) to adopt a temporizing and defensive strategy.

'Abdallah's grandson 'Abd-ar-Rahman III (912–961) by resolute and far-sighted leadership lifted the kingdom from this morass to an apoge of power, culture and magnificence. Within ten years he mastered Ibn Hafsun (d. 917) and his sons, and in ten more he reunited Moorish Spain. He proclaimed himself caliph in 929, taking the title of al-Nasir (the Victorious). In spite of occasional reverses, he forced the Christian princes to pay tribute to Córdova, now a metropolis enjoying immense reputation and prestige in all Europe. He greatly enlarged the Slavonian guard, whose officers acquired increasing power at the expense of the old Arab aristocracy. The reign of his son al-Hakam II (961–976) was no less brilliant. The weakness of Hakam's son Hisham II (976–1013) favoured the rise of a military dictator, the Arab Ibn Abi Amir, later entitled al-Mansur (Almanzor) (981–1002), under whom, as under his son 'Abd al-Malik al-Muzaffar (1002–08), the military

SPAIN II7

power of the caliphate, now recruited mainly from Morocco, was at its height. But beneath the surface the old antagonisms and social discontents were still alive. In roog they broke out in a political crisis which temporarily reduced Moorish Spain to chaos and from which it never fully recovered. While Slavonians and Berbers turn by turn occupied Gordova and made and unmade caliphs, the rest of al-Andalus threw off all allegiance to the Omayyads and was dissected among a host of petty rulers (muluk al-tawaif). After Córdova itself had been occupied by the Moroccan Arab house of Hammuda (1016-27), the last Omayyad prince was dethroned in 1031 and replaced by a republic

## (H. A. R. G.)

## CHRISTIAN SPAIN TO 1479

The history of Christian Spain during the period 711-1479 is dominated by the interplay of two opposed forces: the idea of an ultimate Christian reconquest of the whole peninsula; and the inescapable fact that, both culturally and economically, the Islamic and Christian peoples of Spain had become irretrievably associated with each other. The urge to reconquer, based partly on religious belief, partly on the Visigothic tradition of Spanish unity and partly, too, on economic pressures, did not express itself predominantly through the forms of militant Christianity until four centuries after the Moorish occupation. Then, when religious fanaticism had made its appearance, among both Moors and Christians, at the end of the 11th century, the Christian conquest of Andalusia was undertaken in a spirit of intolerance that brought ruin to southern Spain and severely damaged the economy of the conquering power, Castile. Once again, however, the fact of the convivencia between the two Spains asserted itself, and fanaticism had to be moderated. Thus, in 1238, Ferdinand III, the conqueror of Andalusia, was compelled to acquiesce in the foundation of the new Moorish kingdom of Granada and to give it his protection because it was recognized that without Moorish tribute, the economic structure of Castile could not survive while it digested the newly reconquered territories. For the same reason the Christian kings had to continue to accept the existence within their frontiers of communities of Islamic vassals (Mudéjares) to whom they also gave protection.

The Kingdom of Asturias.-Before the tide of Arab and Berber invasion a number of Visigothic nobles and their retinues withdrew to the mountains of Asturias and there elected a Visigothic prince, Pelayo (?718-737), as their king. The Berber revolt in Morocco and Spain and the consequent withdrawal of the Berber garrison in Galicia (750) led to the attachment of Galicia to the new kingdom by Alphonso I (Alfonso; 739-757). Under Alphonso II (792-842) the Asturian capital was moved from Cangas de Onís to Oviedo. Later kings pushed forward from the mountains to the central plain and their armies operated with success far to the south. The supposed discovery of the tomb of St. James at Compostela in Galicia (c. 830) made the Asturian kingdom guardian of a shrine of European significance and gave it a symbol of national unity. Alphonso III (866-910), the greatest of the Asturian kings, expanded his domains as far as Coimbra in the southwest and Burgos in the southeast. By now the situation was stable enough for his successor, García I (909-914), to move the capital from the Asturian mountains to the city of León.

The Asturian kings, like their Leonese successors, regarded themselves as direct heirs to the traditions of the fallen Visigothic monarchy; and, for this reason, the historical writings of Alphonso III's reign emphasized their obligation to undertake the reconquest of all Spain. The Asturian administration followed Toledan models as closely as circumstances permitted. Yet the organization, social and political, inherited from the Visigoths was already being changed by the immigration of a free Mozarabic peasantry from the south, while Frankish political ideas also exerted some influence on Asturian society. In general, however, it can be said that the Asturian kings handed on to the kings of León a tradition of isolation, not only from Moorish Spain but also from the rest of Christian Europe, which experience was to show could not be sustained.

The Kingdom of Leon.—The transfer of the Christian capital pendent history.

from Oviedo to León coincided with the establishment of the caliphate of Córdova and, until the early 11th century, the balance of power in the peninsula swung strongly in favour of the Moors. That the Leonese kingdom survived at all was the result of the generalship of Ordono II (914-924) and Ramiro II (932-950) who, in unfavourable circumstances, secured important victories against the caliph's armies. Ramiro was, however, unable to prevent the breakaway from his kingdom of the Christian county of Castile. This district, partly recolonized by immigrants from the north, had rejected the Visigothic Forum judicum in favour of Castilian customary law and showed itself hostile in other ways to the Visigothic traditions of León until, under Count Fernán González (923-970), it achieved de facto independence. Henceforth clashes between the innovating tendencies of Castile and the conservative traditions of León were to weaken the Christians. Ordoño III of León (951-956) acknowledged the hegemony of the caliphate, and the later attempts of Bermudo II (984-999) to assert his independence of Córdova brought disaster on the kingdem. Almanzor's armies occupied and destroyed León (988) and sacked Santiago de Compostela itself (997), sparing only the Apostle's tomb. Under Alphonso V (999-1027) the capital was repopulated and recovery began. However, early in the reign of Bermudo III (1027-37), a new threat to the independence of León materialized when Sancho III the Great of Navarre, after seizing the county of Castile (1028), occupied the eastern part of the Leonese kingdom. Later he entered the capital (1034) and there assumed the title of "emperor of Spain," Bermudo fleeing to Galicia. León was never wholly to recover its supremacy again.

The Rise of Catalonia and Navarre.-During the reign of Charlemagne the Franks succeeded in capturing Barcelona (801) and in driving the Moors out of the northeastern corner of the peninsula. This area, later known as the Marca Hispanica, was then occupied by a number of Visigothic counts under Frankish suzerainty. In the time of Count Wilfred (865-898) the county of Barcelona became independent and established its hegemony over the other counties of the Marca Hispanica. Under Borrell II (954-992) Almanzor's armies devastated Catalonia and burned Barcelona (985); but the region recovered during the rule of Raymund Borrell (Ramón; 992-1018). Under Berengar-Raymund I (Berenguer Ramón, 1018-35) it began to flourish. Because of the influence of the Franks it had already developed political and social institutions different from those of the rest of Christian Spain. The 10th century also saw the dramatic rise of the Basque kingdom of Navarre, which has little history before this period. Sancho I Garcés (905-926) added the small county of Aragon to his dominions but suffered severely at the hands of 'Abd-ar-Rahman III's armies. A period of subordination to the caliphate followed, but Sancho II Garcés (970-995) was spared the worst of Almanzor's attacks and devoted himself to the political organization of his kingdom. There was, however, nothing to indicate that, under Saucho III the Great (1000-35), Navarre was to become, for a brief period, the dominant power in Christian Spain.

The Mediaeval Spanish Empire.—Though Sancho the Great had assumed the imperial title in León, his political ideas were hostile to the old Visigothic-Leonese tradition of peninsular unity, and his empire was largely built on a simple desire for personal aggrandiscment. It included Navarre, Castile, León, Sobrarbe and Ribagorza while Berengar-Raymund I of Barcelona became his vassal. Sancho deliberately encouraged contacts between his dominions and the rest of Christian Europe and probably did much to make the Spanish nobles aware of the feudal aspirations of their class north of the Pyrenees. He regarded his empire as his personal property and distributed it among his four sons in his will. The eldest, García Sánchez III (1035-54), inherited an enlarged Navarre. Castile was made a kingdom and given to his second son, Ferdinand; Sobrarbe and Ribagorza were united in a separate kingdom and given to another son, while the small county of Aragon was also erected into a kingdom for his fourth son, Ramiro I (1033-65). Ramico soon incorporated Sobrarbe and Ribagorza into his new kingdom (1037), and Aragon thus began its indeII8 SPAIN

Sancho's will provided for the return of León to Bermudo III on his death, but this restoration was overthrown by Ferdinand I of Castile (1037-65), who speedily annexed León and reoccupied (1054) the Castilian territories given in his father's will to his eldest brother, García of Navarre. Ferdinand also took the imperial title and by virtue of this claimed suzerainty over his brothers. He achieved great successes against the Moors, pushing his frontiers to the Tagus in the south and the Mondego in the west and making the taifa kings of Saragossa, Seville and Toledo his tributaries. On his death Ferdinand, as his father had done, divided his dominions among his sons, and there was a period of violent strife before the second of them, the brilliant Alphonso VI (1065-1109), succeeded to the whole inheritance. His reign brought great changes to Spain. Toledo was permanently reoccupied (1085); and soon afterward the Cid Campeador took possession of Valencia (1094). All the tasfa kingdoms paid tribute to Alphonso. There was no attempt to expel the newly conquered Moorish populations, who were promised royal protection and the preservation of their religion and customs. To give formal expression to his tolerant policy, Alphonso changed the imperial title by styling himself "emperor of the two religions." It seemed for a brief time as if these ideas might produce a genuine Hispano-Moorish civilization under Christian political control, Unfortunately the Almorávides' invasion of Andalusia (1086) soon removed the taifa kingdoms from Alphonso's control and replaced the tolerant spirit of the Spanish Moors by one of bigoted fanaticism. Meanwhile, under the influence of his wife Constance of Burgundy, the emperor allowed French Cluniac monks to get complete control of the Spanish church. The Spanish tradition of convivencia was wholly repugnant to these ardent disciples of Gregory VII's doctrine of the universal church. They forced Alphonso to modify his promises of toleration toward the conquered Mudéjares, compelled him to replace the old Mozarabic missal by the Roman and contrived to have the ancient Visigothic script of Spain replaced by the Carolingian hand in use in the rest of western Europe. These innovations brought into Christian relations with the Moors something of the crusading zeal which the French monks had found deplorably lacking and ensured that mediaeval Spain would in the future belong much more definitely to the common political and cultural pattern of mediaeval Europe. This uprooting of the traditions of the past was, however, partly responsible for the backwardness of Spanish culture for the next 150 years, while the new determination to regard the reconquest as a crusade rather than a recovery of territorial dominion in the end wrecked the Spanish economy, both Moorish and Christian.

Alphonso was followed by his daughter Urraca (1109-25), widow of Count Raymund of Burgundy; her turbulent reign cannot be followed here. She was succeeded by her son, Alphonso VII (1126-57), who gave new meaning to the imperial title by extending his influence over the county of Barcelona and by forcing Ramiro II of Aragon and García Ramírez of Navarre to accept his suzerainty. The counts of Gascony and Provence also accepted him as overlord and, at a ceremony at León (1135), attended by his new Christian and Moorish vassals, he assumed the title "emperor of all Spain." He also achieved resounding, if inconclusive, successes against the Moors, and the European prestige of the Spanish imperial court was recognized when Louis VII visited Alphonso at Toledo (1150). Nevertheless separatist tendencies in the peninsula secured another ominous victory when the count of Portugal, Alphonso Henriques, extracted from the emperor recognition of Portugal's status as an independent kingdom (1139). On his death, Alphonso VII, too, divided his realm among his sons, leaving Castile to the elder, Sancho III, and León to Ferdinand II. This new partition proved the deathblow to any future revival of the imperial idea originally inherited from the Visigoths. Castile and León now remained separated for 73 years, during which the magnates began to display in a marked degree that anarchical partisanship and resistance to royal authority which were to plague Spanish life for the next three centuries. Some important successes were nevertheless achieved against the Moors during this time. In 1212 Alphonso VIII of Castile (1158-1214), Sancho's son, supported by the armies of Aragon, Navarre and Portugal, routed the

Almohade amir of Morocco, Mohammed III, at Navas de Tolosa and so removed the last really serious Islamic threat to Christian hegemony in Spain. In an atmosphere of ever-mounting religious fanaticism the way was now open to the conquest of Andalusia.

The Rise of Aragon.-The kingdom of Aragon was brought into existence (1035) by a testamentary act of Sancho the Great of Navarre. During the rest of the 11th century it gradually encroached on Moorish territory north of the Ebro. Saragossa was captured (1118) by Alphonso I (1104-34) who, in spite of his entanglements in the internal affairs of Castile, was able to follow up this important success by occupying a large area southwest of the former Moorish capital. In 1137 Petronilla, the infant daughter of Ramiro II (accession 1134; death 1154), was betrothed to Raymund-Berengar IV, count of Barcelona, to whom Ramiro thereupon handed over the government of Aragon (1137-62). The son of the marriage, which was solemnized in 1150. Alphonso II (1162-96), formally initiated the personal union of both countries under the house of Barcelona which was to last until 1410. In 1170 an important step for the future of Aragon was taken when Alphonso made an agreement with Castile whereby the task of reconquering the Moorish kingdom of Valencia was reserved to the Aragonese crown. In exchange Aragon relinquished any claims to any other Moorish-held territory in the peninsula. During this reign, too, Aragon developed political interests north of the Pyrenees; Provence and Roussillon fell to Alphonso by inheritance. This preoccupation with French affairs proved fatal to Alphonso's son, Peter II (1196-1213) who, having added Montpellier to his dominions by marriage, became involved in the Albigensian war and was killed by Simon de Montfort at the battle of Muret (1213). His death put an end to major Aragonese political pretensions north of the Pyrenees. It is to be noted that, from 1137 to 1412, Catalonia was the dominant partner in the association of the two countries. Economically and culturally Catalonia was much in advance of isolationist and conservative Aragon, whose nobility often found itself more in sympathy with the politics of the Castilian magnates than with the bourgeois ideas of the nationalistic Catalans. Catalan was the language of the court of Aragon during the whole of this period.

During the reign of Ramiro II Navarre seceded (1134) from the Aragonese crown to which it had been united since 1076. Sancho VII of Navarre (1194-1234) tried to nominate James I of Aragon as his successor and to reunite the two kingdoms, but the Navarrese preferred Thibaut (Theobald) IV of Champagne as king (1234-53), and Navarre was thereafter ruled mostly by a succession of French princes. The little mountain kingdom nevertheless retained

most of its distinctively Spanish institutions. End of the Reconquest.—The last king of León, Alphonso IX (II88-I230), was succeeded, on his death, by his son, who was already king of Castile. Castile and León were thus finally united. The new sovereign, Ferdinand III the Saint (1217-52), at once embarked on a great series of campaigns to subdue Andalusia. These began with the capture of Córdova (1236) and culminated in the surrender of Seville (1248). Influenced by the crusading zeal instilled into the Spanish church by the Cluniac and Cistercian orders, Ferdinand at first expelled the Moorish inhabitants of the Andalusian cities en masse but was later forced to modify his policy by the collapse of the Andalusian economy that inevitably ensued. He also assented, chiefly for financial reasons, to the establishment of the new Moorish kingdom of Granada under Castilian suzerainty. The Granadine Moors were forced to create, by hard work, a high degree of productivity in their new state in order to pay to Castile a large annual tribute, which probably became essential to the well-being of Castile's finances. This reviving tendency toward a renewal of the older tolerance toward the Moors was also reflected in the cultural field; Toledo now became famous throughout Europe as a centre where Moorish philosophy and science were, under the stimulus of successive archbishops, made available in translation to European scholars. During the same period James I of Aragon (1213-76), Peter II's son, who was legislator and littérateur as well as warrior, completed Aragon's part in the reconquest. After occupying the Balearics (1235) he captured Valencia (1238) and so established the final peninsular

frontiers of Aragon. By these Castilian and Aragonese achievements the reconquest was, for all practical purposes, brought to an end. Both countries now gave themselves up to internal social and constitutional struggles.

Castile and León From 1252 to 1479.—The reign of the cultured Alphonso X the Wise (1252-84) was politically ill-fated. Alphonso involved himself in wars with Portugal, Aragon and Navarre and, having got himself elected to the German throne (1257), devoted much effort and treasure to an unsuccessful attempt to make good his claims against papal opposition. At home a constitutional struggle developed over the rival claims to the succession of Ferdinand of La Cerda and of Sancho, respectively the grandson and the brother of the king. This ended in an attempt by a junta of prelates and nobles, supporters of Sancho, to denose Alphonso (1282) and saw the beginning of an acute phase in the violent clash between the magnates and the crown which was to dominate Castilian politics for 200 years. Alphonso's legal works, based on the renascent doctrines of Roman and canon law, laid the theoretical foundations for monarchical supremacy; but the king was too inept a politician to succeed in enforcing them. The troubled reign of Sancho IV (1284-95) was complicated by war with Aragon, which supported the succession of the house of La Cerda; and Castile did not emerge from continuous civil strife until the end of the minority of Sancho's grandson Alphonso XI (1312-50). This Alphonso, aided by the armies of the autonomous municipalities (concejos), sternly repressed the magnates and succeeded in establishing a measure of absolutism which found expression in the legal and political reforms promulgated at Alcalá (1348). He also took up arms successfully against a threat from Morocco, defeating the invaders at Salado (1340).

The trend toward strong central government would probably have continued under his son Peter I the Cruel (1350-69) without major trouble, had not Alphonso left a number of powerful bastard sons to contest his legitimate heir's inheritance. The eldest, Henry of Trastamara, posing as the defender of the magnates against royal attempts to limit their ancient privileges, began a struggle to seize his half-brother's throne which lasted about 10 years. Meanwhile Aragonese designs on Murcia-Castile's only outlet to the Mediterranean-and Castilian ambitions in western Aragon plunged the two countries into a ferocious war (1356-66) which became even more embittered when Peter IV of Aragon espoused the Trastamaran cause in Castile. It was not, however, until France intervened actively in support of Peter IV and Henry of Trastamara that Peter of Castile's victories in Aragon were checked. Both France and England believed that the support of the powerful Castilian fleet might prove decisive in settling the outcome of the Hundred Years' War. Peter I's alliance with England (1362) therefore led to the dispatch of the free companies to Castile, financed by France and the pope (1365). Peter fled to Gascony and secured the military intervention of the Black Prince. who routed Henry's supporters at Nájera (1367). Peter was restored but quarrelled with his English ally, who then began negotiations with Aragon, Navarre and Portugal for a quadripartite partition of Castile. In 1369 Henry of Trastamara, again with French help, defeated and killed the Castilian king at Montiel and finally seized the kingdom (1371).

To counteract this French success John of Gaunt married Peter's daughter and heiress Constance (1371) and thus became pretender to the Castilian throne (1372–87). He was, however, mable to invade Castile during the reign of his rival Henry II (1369–79), who succeeded in consolidating his position against strong loyalist opposition. For several decades to come a close political and military alliance with France dominated Castilian foreign policy, and Castilian sea power menaced the English south coast. In spite of the conservative and class-conscious ideas of the Trastamaran monarchy, the constant wars in which they were involved compelled Henry and his son John I (1379–90) repeatedly to seek financial aid from the third estate, which thus in the latter's reign secured a considerable measure of control over the government. John brought military and financial ruin to his kingdom, partly because of new Lancastrian attempts to conquer Castile and partly because of his own ambitions to add Portugal to his

crown. His crushing defeat by the Portuguese at Aljubarrota (1385) was followed by the landing of John of Gaunt in Galicia with a large army (1386). French support and John of Gaunt's military ineptitude, however, saved the Trastamaran dynasty and the dynastic dispute was finally settled (1388) by the marriage of Catherine of Lancaster. Peter I's granddaughter, to John I's heir, Henry III (1390-1406). Violent outbreaks against the Jews marked Henry's accession. In his short reign the crown reverted with success to the policies of Alphonso XI and Peter I and reduced the magnates to order by stern measures. At this time, too, the occupation and colonization of the Canary Islands was begun. The long reign of the weak John II (1406-54) saw a continuance of the political disintegration of Castile as a result of a renewal of the struggle of the magnates with the crown. Civil war was now frequently accompanied by armed Aragonese and Navarrese interventions. John, a politically inept lover of the arts, left the government in the hands of his favourite, Alvaro de Luna. Luna's power was not broken until 1453, when the king, acceding to the demands of the nobles and of the queen, ordered his execution.

Under the impotent Henry IV (1454-74) the Trastamaran dynasty reached its lowest ebb. Civil strife continued unabated and was now accompanied by a collapse of the moral standards of the court. The king had married Joan (Juana) of Portugal (1455), but their daughter and heiress, also called Joan, was alleged to be the child of an adulterous relationship of the queen's. Opponents of the court accordingly favoured the adoption of the king's sister Isabella (Isabel) as heiress to the throne. The magnates formed a league in support of Isabella though popular opinion tended, as usual in such circumstances, to support the king. Joan's marriage to Alphonso V of Portugal and his active support of her claims led, on Henry's death, to five years of civil war before Isabella triumphed and was acknowledged to be queen of Castile by the peace of Trujillo (1479). Ten years before she had married Ferdinand, son and heir of John II of Aragon. Thus, on John II's death (also in 1479), the crowns of Castile and Aragon became associated though not yet formally united. The 15th century had so far been an age of political, financial and moral decay in Castile. There was nothing to hint, in 1474, that the central kingdom would, within a few years, become the heart of a world

Aragon and Catalonia, 1276-1479.—The conquest of Valencia having ended Aragonese participation in the reconquest, it became necessary for the eastern kingdom to expand outside the peninsula if it was to avoid becoming subordinate to the hegemony of Castile. Under Peter III (1276-85) Aragon therefore began political and military intervention in Italy. As husband of Constance, daughter of the emperor Frederick II's bastard son Manfred (see SICILY), Peter accepted the throne of Sicily and promised to free his new subjects from the rule of Charles of Anjou. In pursuit of this aim Aragonese troops and Catalan ships secured substantial successes against French military power and papal diplomacy and made Aragon a major factor in Italian politics. Papal pressure on Peter III's sons Alphonso III (1285-91) and James II (1291-1327) resulted in Aragonese undertakings to abandon Sicily; but these were not accepted by the Sicilians, and James's brother Frederick (Fadrique) was eventually recognized as king of the island of Sicily for life (see FREDERICK III). James also secured the grant of Sardinia to Aragon as a papal fief (1297), though the island was not completely subjugated until the 15th century and Aragonese claims to it led to prolonged hostilities with Genoa. Aragonese power in the Mediterranean was further strengthened by the activities of the Catalan company in Asia Minor and Greece, which eventually brought about the establishment of the Catalan duchy of Athens, first under Sicilian and then under Aragonese suzerainty. The Aragonese dynasty in Sicily remained closely associated with the Aragonese crown, and both countries were united when Martin L of Aragon (1395-1410) succeeded his son Martin 1 of Sicily in 1409. The reign of Alphonso V (1416-58) saw a further dramatic extension of Aragonese power in Italy when after a long struggle, Alphonso finally became the undisputed ruler of the kingdom of Naples (1443) and transferred his capital there

I20 SPAIN

These events reacted unfavourably on the political situation in the parent kingdom, where Aragonese and Catalan particularism grew apace and reached its climax under John II (1458-79), when Catalonia was in revolt against the crown for 11 years. The discontent of the Catalans dated back to the compromise of Caspa (1412), which had placed Alphonso V's father, the Trastamaran prince Ferdinand I (1412-76), on the Aragonese throne when the male line of the house of Barcelona had become extinct. Since 1164 Catalonia had been the dominant partner in the Aragonese union. Now the Catalans feared, with some reason, that the Castilian dynasty would favour Aragonese interests at their expense.

The preoccupation of successive kings with Italian affairs weakened the crown at home. In 1283 the nobles and municipalities of Aragon formed an union and extorted a General Privilege granting them special privileges and immunities. These were increased substantially in 1287 and remained in force throughout the reigns of James II (1291-1327) and Alphonso IV (1327-35). But in 1348 Peter IV (1336-87), who had strong absolutist leanings, routed the army of the union at Epila and put an end to an intolerable constitutional situation. Peter's reign represents something of a break with the general policy of Aragon during this period. Having annexed the kingdom of Majorca (1344), he challenged the peninsular hegemony of Castile (1356); but, in the 11 years' war which followed, a large part of his kingdom was overrun and occupied by the armies of Peter I of Castile. He saved himself by joining in the French effort to dethrone his Castilian rival and replace him by Henry of Trastamara. Henry promised to cede the whole of eastern Castile to Aragon in exchange for Aragonese support but declined to fulfil his promise when he had secured the Castilian throne. Long years of negotiation for an Anglo-Aragonese alliance against Castile followed, during which Peter IV sought to play off French and English interests in the peninsula for his own ends without finally committing himself to either side. In the last years of his reign the common problems with which the schism in the papacy faced the peninsular kingdoms led him to try to form a peninsular bloc that would be neutral in both religious and military affairs; but French pressure prevented the success of this far-sighted plan. Peter's son John I (1387-95), elder brother and predecessor of Martin I, left the conduct of diplomacy largely to his French wife Yolande of Bar, and Aragonese foreign policy became largely subservient to that of France. The accession of a Castilian prince to the Aragonese throne as Ferdinand I in 1412 had already foreshadowed the union of the two largest peninsular states, and this was made certain in 1469, during the reign of Ferdinand I's second son John II, when Ferdinand, the heir to the throne (born 1452), married the Castilian heiress Isabella (born 1452). The same year which saw Isabella undisputed ruler of Castile (1479) brought her husband to the Aragonese throne as Ferdinand II. The destinies of the two countries were thereafter bound together.

Mediaeval Institutions: Asturias, León, Castile.—The Asturo-Leonese kingdom inherited from the Visigoths the principle of elective monarchy; but in practice its sovereigns were always chosen from the same family. By the 11th century primogeniture was accepted, though the elective tradition was never formally abandoned. In accordance with their declared policy, the first Asturian kings sought to re-establish at Oviedo the civil and ecclesiastical administration which had existed at Toledo. Outlying regions were governed by comites in the king's name, and the officers of the royal household were the direct successors of the Visigothic palatini. The steward (maiordomus) and the standard-bearer (armiger regis or dapifer) eventually emerged as the chief civil and military officers of the court. By the 13th century the governorship of the larger provinces was usually held by an adelantado, who exercised regional military and judicial authority on behalf of the king. In some areas similar duties were carried out by the merino mayor. The merino menor, who was appointed by either of these two officers, acted as their deputy in matters of criminal jurisdiction reserved to the crown (voz de rey). The traditional military organization of the country was overhauled by John I of Castile in 1383 when, following

French practice, a constable aided by two marshals took over the duties previously performed in the king's name by his afférez. The office of admiral of Castile was created by Ferdinand III. The cancellarius rarely appears before the 12th century. By the time of Alphonso X, however, the chancellor was recognized to be the chief civil officer of the household. The cancilleria, like the court itself, remained ambulatory until the end of the mediaeval period. The employment by the king of a privy seal (sello de la poridad), independent of the chancery and held in the custody of its own canciller, was well established by the end of the 13th century. As elsewhere in Europe the privy seal was evidently used by Alphonso XI and Peter I to further the direct control of the king over the government since, in the political reaction brought about by the accession of Henry of Trastamara, attempts were made to restrict its use. The treasury, whose officials were largely Jewish, was headed by the almogarife mayor, later known as the tesorero mayor. Peter I created several contadores reales to supervise the work of local tax collectors.

In theory feudalism did not exist in Castile or León, the magnates (ricoshombres) holding their territorial possessions, from which their rank derived, by virtue of an individual grant for life only from the king. Vassalage was not tenurial, and lands were not held for military service. In practice, however, feudal grants did occur and, from the 10th century onward, the magnates constantly attempted to usurp feudal rights for themselves. The ambiguity of their status may, indeed, have been partly responsible for their determination to control the crown. The lesser nobles (infanzones and hijos d'algo) could be vassals of the crown or of a lord. The free peasants paid tribute for permission to till the soil either to the king on royal lands (realengos) or to a lord on seigneurial lands (señorios). On the behetrias the peasants were semifree, having the theoretical right to change their lord at will. This institution was chiefly found in those areas of Castile and León proper which had been repopulated by Mozarabic immigration during the reconquest. The serfs (solarjegos) were chiefly found on the lands of the magnates, of the military orders and of the church (abadengos). The status of the Mudejares (Moslems living under Christian protection) varied according to political conditions and to locality. The Jewish communities in the towns (aljamas) enjoyed royal protection until the end of the 14th century, when an outburst of popular fanaticism led to great massacres of Jews in Seville, Córdova, Toledo and other cities (1391) and Jewish communal life was irreparably damaged.

and Jewish communal life was irreparably damaged. The most notable institution of mediaeval Castile was the semi-autonomous municipality (concejo) comprising a town (villa) and its surrounding comarca. The rise of the concejos dates from the rith century, and they were largely brought into being by the need to attract settlers, by special privileges, to newly reconquered areas. This was achieved by the royal grant of a franchise (fuero) giving the concejo in perpetuity a large measure of control over its own affairs and its own legal code. The concejos raised their own militia and formed military associations with each other (hermandades) in defense of their interests. They were invaluable allies of the crown in its struggles with the nobles, particularly during the 14th century, when their deputies (procuradores) to the Castilian parliament (Cortes) dominated that body. The appearance of the third estate in the Cortes dates from the end of the 12th century.

In the later middle ages the king depended on the vote of the procuradores for the grant of financial aid (servicio) necessary to cover civil and military expenditure. The beavy costs of the wars of Henry II and John I increased the dependence of the king on the third estate. John I was forced to meet the severe criticisms of his policy voiced by the procuradores by creating the royal council (1386). At the beginning four representatives of each estate were appointed to the new body, and the king delegated to it (theoretically at least) many of his powers. In the 15th century the concejos themselves fell victims to the growth of the royal power and had to accept royal officials known as corregidores. A hint of impending decay had already appeared during the reign of Henry III (1390–1406) when, against the wishes of the Cortes, the king succeeded in making permanent the alcabala, a highly

SPAIN I2I

main sources of royal revenue.

Mediaeval Institutions: Aragon, Catalonia, Valencia,-In spite of their union under the Aragonese crown, these three regions retained their own separate institutions and parliaments. There was a strong tendency toward feudalism in Aragon from the beginning and grants of fiefs for military service were frequent, After the union with Catalonia, where feudalism was fully developed, the Aragonese nobility intensified its efforts to obtain full feudal rights. The smaller municipalities (universidades): were less important than in Castile partly because of the dominant position of Saragossa, Barcelona and Valencia respectively in the parliamentary representation of the popular arm. The Aragonese nobility consisted of four classes, ricoshombres de natura, ricoshombres de la mesnada (created by James 1), caballeros and infanzones. These, like the representatives of the universidades, attended parliamentary sessions by right. In Catalonia there were three classes of magnates (comtes, vescomtes and valvassors). The Aragonese Cortes, which consisted of four estates (brazos) because of the separate representation of the greater and lesser nobles, was governed by complicated rules of procedure. Redress preceded supply, and unanimity was in theory required for the approval of any measure. The Cortes also claimed the right to declare war. The most important political office in the country was that of the justicia de Aragón, whose presence at sessions of the Cortes, to which he was responsible, was indispensable. He was arbitrator between king and nobles or people when disputes arose with the crown, and his decisions were virtually final. A permanent parliamentary commission (diputación del reyno) existed to deal with finance, observance of the fueros and matters pertaining to the peace of the realm. The organization of the Catalan and Valencian corts was somewhat similar, though the former asserted a right to control all legislation. A diputació general in Catalonia performed functions like those of the Aragonese permanent parliamentary commission. In spite of the many restrictions on their powers it has been suggested that the Aragonese kings had greater de facto authority than the kings of Castile, except perhaps during the domination of the union of 1283-1348. The appointment of the justicia was made by the crown, and only the crown could initiate legislation.

A peculiar feature of Aragonese administration was the absence of intermediate authorities between the central government and purely local officials. In Catalonia, land belonging to the king was ruled on his behalf by the veguers, with subordinates known as sots-veguers or battles; both were crown appointments. The importance of Barcelona gave that city a dominant place in the life of Catalonia. It was ruled by the concell de cent though, in practice, this body's authority was normally delegated to a small concell of five persons with whom were associated the veguer and the battle. Catalan law was based on the Usatges (c. 1060), the oldest written feudal code. The kingdom of Valencia was governed by the constitution (Furs) granted to it by James I in 1239. There were wide variations in the conditions of the unprivileged classes under the Aragonese crown. The legal and economic position of the Catalan serfs (pagesos de remença) was worse than that of serfs anywhere else in the peninsula. On the other hand the Mudéjares were comparatively well treated in Aragon proper where, until the 15th century, crown and nobles appreciated their economic importance and allowed them freedom of worship and their own tribunals. The Jews, vassals of the king, were favourably treated until the 15th century when, as in Castile, their (P. E. R.) position rapidly deteriorated.

## THE "CATHOLIC KINGS"

The accession of Isabella has long been traditionally regarded as the final stage of Spanish mediaeval history. When Ferdinand succeeded to the crown of Aragon (1479), which possessed also Catalonia and Valencia as well as the Balearic Islands, the married pair ruled a larger area of the peninsula than had been united for many centuries. Though Castile remained a sovereign and independent state completely separated from the states of the crown of Aragon, the combined power of the devout and energetic

unpopular sales tax of one-tenth, which then became one of the Isabella and the subtle and unscrupulous Ferdinand (V of Castile and II of Aragon) soon sufficed to make Spain one of the leading powers of Europe.

In Castile aristocratic anarchy, rapacity and violence had reduced the whole land to poverty and taught the people to look to the crown for strong government. Ferdinand and Isabella, to whom Innocent VIII gave and Alexander VI confirmed the title of "Catholic kings," responded to the demands of their subjects by a series of measures directed to the weakening of the overmighty nobility. The rebellious nobles were first defeated in a series of battles in many parts of Castile, and all castles not entirely necessary for the defense of the kingdom were destroyed. Soon the private jurisdictions of the nobility were considerably limited and their most pretentious imitations of royal customs forbidden: The administration of the great military orders, hitherto the exclusive preserve of the nobility, was progressively taken over, with their revenues, by the crown. The feature of the royal policy that contributed most toward establishing an efficient bureaucracy was, however, the principle of depriving the nobles of their influence on the royal council, replacing them by letrados (trained civil servants steeped in the absolutist traditions of Roman law) or by ecclesiastics (owing their position to royal patronage). The nobles were also attracted to the court, where they tended to lose their local influence, to dissipate their wealth in ostentatious living and to change from powerful chieftains to obsequious courtiers under the jealous vigilance of the crown, which was indeed their only source of employment and honours. They continued too to be excluded from the Cortes, in accordance with the 15th-century custom of regarding the superior estates as no longer essential thereto. Meanwhile the number of towns represented in the Cortes, which had once been as many as 50, sank to 18; and any further enfranchisement was opposed by the privileged towns (Cortes of Valladolid, 1505). Henceforth a meeting of the Cortes of Castile consisted merely of 36 procuradores, two from each town-a number conveniently small for the exercise of royal influence. These procuradores never succeeded in asserting the principle that redress precedes supply; and the old custom whereby every procurador was bound by detailed instructions (poderes) from his town was abrogated at least as early as 1505 (probably much earlier). Henceforth they were plenipotentiaries, free to consent to any proposal of the crown. Even their legislative power was not complete, since one of the 83 laws to which the Cortes of Toledo of 1502 agreed recognized that kings possessed the power "to make fueros and laws and to interpret and amend them whereinsoever they shall think it convenient to do so." The Laws of Toro (1505) did much to remedy the diversity of laws from which Castile suffered.

In the states of the crown of Aragon the Catholic kings were unable to make any large direct increase in their power. The greater nobles of Aragon enjoyed feudal liberties and privileges almost unequalled elsewhere in Europe and kept the peasantry in abject servitude. The Aragonese Cortes with its four estates was so powerful as to reduce royal power to a mere shadow-a shadow still further diminished by the overwhelming power of the justicia mayor, who, sitting in a chair, crowned the kneeling king with the formula: "We who are as good as you swear to you who are no better than we, to accept you as our king and sovereign lord, provided you accept all our liberties and laws; but if not, The Corts of Catalonia and that of Valencia were only a degree less powerful than that of Aragon. It was only by skilful use of the church and of the Inquisition that royal power could be increased in these eastern regions of the peninsula.

The Spanish Inquisition .- The Spanish church was wealthy and powerful because the people were intensely religious and because it was largely a national institution in which no foreigner might hold office and in which the crown was supreme (papal power having been reduced almost to the vanishing point). It was, consequently, a fact of serious political importance that during the anarchy of Henry IV's reign (1454-75) the Jews gained great power and influence. They might compel-sometimes by means of their usury-their debtors to renounce the Christian religion: and Marranos (baptized Jews) often preserved their old religious faith SPAIN SPAIN

in secret. At the same time the power of the Moriscos (baptized Moors) had increased, and they were reviving ancient heresies such as the half-forgotten Manichaeism. The Catholic kings consequently consulted Pope Sixtus IV, who thereupon issued a bull (Nov. 1, 1478) authorizing them to choose two or three inquisitors notable for their virtue and learning, to whom he granted jurisdiction. The bull was put into force by a royal cédula (decree) issued in Medina del Campo (Sept. 17, 1480) ordering the establishment of the Holy Office in Castile.

As a royal instrument for the strengthening of the monarchy and the unification of the peninsula the value of the Inquisition would be difficult to exaggerate. The whole organization was completely under royal control, papal sanction being little more than a matter of form. The suprema, which controlled it, was merely one of the royal councils; and the officials of the Inquisition, from the inquisitor general downward, were the paid servants of the crown, who could appoint them or dismiss them at its pleasure Also, except for one brief period (1507–17), there was to be but one Inquisition and one inquisitor general for the whole of Spain. As far as the Inquisition was concerned the political divisions between Castile and Aragon, Valencia and Catalonia soon ceased to exist.

Furthermore the Inquisition took no account of those privileges of the nobility and those extensive liberties and franchises that had been a ceaseless embarrassment to the crown. Indeed, it was used by the crown to achieve secular aims in cases where the ordinary courts were difficult to move, or where the laws and customs of the country were used to place obstacles in the path of the advancing monarchy. The familiars of the Inquisition, exercising ceaseless vigilance in the remotest corners of Spain, may be fittingly compared with the justices of the peace who did so much to uphold the throne of Tudor England. Though frequently popular among Spaniards of pure Old Christian descent, the new inquisitorial activities met with strong protest in Aragon, where it was established in 1484. The inquisitor of Saragossa, Pedro de Arbués (1441-85), was murdered—probably at the instigation of rich Marranos (baptized Jews). Throughout the centuries the chief victims of the Inquisition were men of Morisco or Marrano ancestry. It cannot be denied that the Inquisition was guilty of abuses and cruelties in the course of its long history, but it was no more unjust or inhumane than most other courts of the Europe of its day. The traditional exaggerations about it were derived from propaganda against Spain at the time of its greatness and from the works of Juan Antonio Llorente (1756-1823), 19th-century liberals and a number of historical novelists and dramatists.1

The Inquisition was abolished by Joseph Bonaparte in 1808, restored by Ferdinand VII in 1814, abolished and restored again (1820 and 1823) and finally abolished by Maria Cristina in 1834.

The Conquest of Granada.—After a hard-fought war of more than ten years (1481-92) the last of the Mohammedan kingdoms of the peninsula fell (Jan. 2, 1492) to the Catholic kings. The long process of reconquest had occupied the energies of the many provinces of Spain and thus made itself a unifying influence. It also created the Spanish military tradition which was to dominate the battlefields of Europe for the subsequent 150 years. At the conquest of Granada the Moors were granted by treaty the most liberal rights for the exercise of their religion. But the efforts of Christian missionaries, prompted by Francisco Jiménez (Ximénez) de Cisneros, the queen's confessor, stirred the Moors to a revolt (1501) which was put down after fierce fighting and was regarded as having invalidated their treaty. They were, consequently, ordered by a pragmática (Feb. 12, 1502) to leave the peninsula under conditions so difficult that they accepted the only feasible alternative, Christian baptism. Thus all the Moors of Granada

À

became Moriscos and therefore subject, as Christians, to the Inquisition. But their Christianity became only nominal, since the overwhelming majority had neither the opportunity aor the desire to understand the Catholic faith. Attempts to instruct them failed for lack of money and for lack of priests and other missionaries able to speak to them in the Arabic language. They consequently remained an anti-Catholic and, therefore, anti-Spanish population in possession of the southeastern corner of the peninsula—of the region, that is to say, most liable to invasion from the African Moors or from the Turk.

The Expulsion of the Jews .- The tide of national enthusiasm. religious fanaticism and indignation at Jewish financial operations reached its high-water mark about three months after the fall of Granada, in a decree of March 31, 1492, which offered all the Jews in Spain the alternatives of Christian baptism or exile within three months. The emigrants were allowed to sell or take with them their goods, except that a law forbade the export of gold or silver (an exception which use of the credit system made less cruel than it would otherwise have been). The number of those who preferred exile to the renunciation of their religion has been credibly estimated at 165,000. They spread over Portugal, Italy, Greece, Turkey and North Africa, where they still speak the Spanish current in Castile at the time of their expulsion. By the middle of the 20th century their descendants (Sephardim), more than 2,000,000 in number, were spread widely over both hemispheres.

Spain in the New World .- The discovery of America (Oct. 12, 1492) was the result largely of the enterprise of Isabella, and upon her fell the responsibilities inseparable from her position as proprietress of half the world. She immediately laid down certain principles of policy that endured for centuries. The most important of these was the limitation of American trade to a single portat first Cádiz, but from 1503 Seville-which maintained a virtual monopoly, in spite of its inaccessibility, till 1717. Secondly, the control of all American trade was exercised by the Casa de Contratación (House of Trade), which rapidly developed into a huge organization for the fulfilment of three important functions: as a ministry of commerce it carried out all the ordinances about the lading of ships, the registering of cargoes, smuggling and unlicensed emigration to America; as a school of navigation it formed itself into a kind of nautical university, one of the greatest centres of mathematical and scientific research in Europe (its books were translated into many languages and used by navigators throughout the world); and as a court of law it had an extensive jurisdiction over everything that happened on its ships and over most matters connected with American trade.

The exploration of America (known always to Spaniards as lar. Indias, "the Indies") was pushed on with great speed immediately after its discovery. Diego Velázquez conquered Venezuela (1499-1500) and Cuba (1511). The famous conquest of Mexico by Hernan Cortes took place between 1517 and 1524. During the opening decades of the 16th century settlements were founded in Paraguay and Colombia. In 1513 Vasco de Balboa reached the Pacific. The Philippines were discovered in 1521 and formally occupied (1565) during the reign of Philip II, after whom they were named. The expeditions of Pánfilo de Narváez and Ferdinando de Soto (1528-42) brought the Spaniards to Fforida. In 1539 the Mississippi was discovered, and during the same year Ecuador, Bolivia and Chile were added to the possessions of the Spanish crown. Buenos Aires was founded in 1535. After nearly 20 years of war Francisco Pizarro won his victory over the Inca state of Peru (1543).

As the conquest went on, it followed the traditions of the reconquest of Spain from the Moors in the middle ages. As a consequence the natives were granted a certain amount of protection and self-government. But the grant of great estates (encomiendas) to Spaniards by the crown led to the use of native labour under conditions that often amounted to cruel exploitation, which the Spanish priest Bartolomé de las Casas exerted himself to the utmost to check. Among other measures designed to mitigate the hardships of the natives he introduced the importation (1512) of Negro slaves from Africa. The policy of Isabella, Charles V and

<sup>&</sup>quot;Thus, for example, Llorente states that the tribunal of Seville alone, in 1481, tried 21,000 accused persons and burned 2,000 of them alive and as many in edigr. He obtained these fantastic figures by adding those pardoned under an edict of grace to those accused of heresy. Carrell investigation points to the cities of the control of

Philip II toward the natives was distinguished by its humanitarianism and enlightenment. Yet it must be admitted that the good intentions of Spanish kings rarely did much more than pave the colonial hell.

The energies of the first colonists were largely absorbed in one industry: the production of precious metals. Though all mines were regarded as royal property, Spaniards were allowed quite freely to discover and to operate them, provided that they went through certain formalities such as the registering of their claims before royal officials and the swearing of an oath to bring all the precious metals they obtained to be taxed and stamped at the royal offices. The royal share, at first a large one, was fixed in 1504 at one-fifth. This royal quinto, which was rarely varied in certain parts of America, amounted to 22,000,000 maravedis (about £28,000) in 1505 and had risen to more than double that amount by 1518. These modest sums were the earnest of that vast and dazzling wealth which was soon to lure Spain on to attempt world domination. The precious metals imported into Spain before 1530 were mostly gold; after that date they were from 85% to more than 99% silver. They rose in quantity steeply till the closing years of the 16th century, reaching a yearly average of about £4,000,000. In the earlier half of the 17th century they declined almost as steeply as they had arisen.

Joanna the Mad and Philip L-On the death of Isabella (Nov. 29, 1504) her eldest surviving daughter Joanna (Juana; 1479-1555) succeeded to the throne of Castile, her father Ferdinand continuing to rule the states of the crown of Aragon till his death in 1516. Since Joanna's mental derangement (she is known as la Loca, "the Mad") had become apparent even before her accession, her Habsburg-Burgundian husband Philip the Handsome, son of the emperor Maximilian I and archduke of Austria, ruled in her stead as Philip I of Castile till his sudden death (Sept. 25, 1506). Thereafter Castile was governed by Jiménez (who became a cardinal and inquisitor general in 1507) and by Ferdinand, Joanna having been persuaded to retire to a life of seclusion at Tordesillas. On the death of Ferdinand (1516) the whole of Spain, which now included Ferdinand's recent acquisitions-Cerdana (Cerdagne) and Roussillon (1493) and Spanish Navarre (invaded 1512; incorporated with Castile 1515)—came under the governance of Charles I, better known as the emperor Charles V. This eldest son of Joanna the Mad, who ruled in her name, inherited not only the Aragonese and Italian possessions of his grandfather Ferdinand but also the great possessions in the Netherlands and central Europe of his Habsburg grandfather Maximilian.

### THE HOUSE OF AUSTRIA

Charles V (1516-56) .- Charles arrived in Spain an unprepossessing youth (Sept. 19, 1517) surrounded by grasping Flemish favourites and unable to speak Spanish. By his reckless promotion of Flemings he offended the Spanish nobility; and by his demands for money he offended the common people, who were also alarmed at his obvious intention of ruling Spain as an absentee. The general discontent found expression in the revolt of the comuneros-a rising chiefly interesting for its constitutional not to say democratic character. Fortunately for Charles a rift soon showed itself between the common people and the nobles, whose support he was able to attract. As a consequence the royalists were able to win the battle of Villalar (April 23, 1521), a small fight that had great results. The comunero movement, which had once looked so formidable, collapsed at once, and the king of Castile emerged with fewer constitutional limitations than ever before.

Charles was compelled by the geography of his vast European dominions to be the enemy of France, a state which, though apparently weaker, had the advantage of fighting on interior lines while Charles's government was almost overwhelmed by such serious preoccupations as the Lutheran revolution in the empire and the powerful onslaughts of the Turk. Nonetheless, Charles's invincible Spanish soldiers won resounding victories, such as that at Pavia (1528); and the Spanish people, when they saw Francis I of France brought a prisoner to Madrid, were almost reconciled to their king's international outlook. What lay nearer to their hearts

was Charles's successful expedition against Tunis (1535) and his attempt, though unsuccessful, to take Algiers (1541). Before his abdication in 1556 Charles had taught the Spaniards to regard his interests as their own and to pour out their wealth with almost reckless prodigality for his purposes. It has been well said of him that he was born a Fleming and grew up to be a Spaniard.

Philip II (1556-98) .- Philip II, having inherited all his father Charles's dominions except the empire, which went to his uncle Ferdinand, was able to be a more truly Spanish king than Charles had ever been. The main purpose to which he devoted his life was the unification of the whole of the peninsula under his rule and the establishment of social justice among all his subjects. To say that he strove for the supremacy of the Catholic faith is only to say that he was a typical 16th-century statesman in his belief that political unity could not exist apart from unity in religion. In pursuance of these purposes he strengthened the Inquisition to enable it to stamp out the first sparks of Protestantism, which appeared in Valladolid and Seville (1559); he managed to get possession of the kingdom of Portugal (1580)-by far the greatest success of his reign, bringing indeed not only the whole Iberian peninsula under a single sceptre for the first time in nine centuries but also the second largest colonial empire in the world into union with the largest of them all, as well as securing to Spain the Atlantic harbours of Portugal and fleets manned by crews of unequalled experience; and he took advantage of a rebellion on behalf of his treacherous secretary, Antonio Pérez (q.v.), to reduce the liberties of Aragon (1592) so that that kingdom became hardly less monarchical than the other states of the peninsula.

Many modern writers repeated the views of L. von Ranke (The Ottoman and the Spanish Empires in the Sixteenth and Seventeenth Centuries, Eng. trans., London, 1843) that these changes converted Aragon into a virtual despotism. It is necessary, therefore, to point out that the changes made, though numerous, were comparatively small. Philip was too much a Spaniard to harbour the design of levelling out all local independence; he merely desired to give the central government enough power to do away with the most glaring social injustices. Among the chief acts of Philip II's Cortes of Tarazona (June 15, 1592) were the change of the office of justicia from a life appointment to one terminable at royal pleasure; and the increase in the royal share in the appointment of the justicia's lieutenants. In the Cortes itself the constitutional theory that all members of every estate (brazo) must be unanimous before a measure could become law-a theory that had long been circumvented in practice, since otherwise it would have required a miracle to pass any law whatsoever-was now definitely abrogated. The time that might be spent on statements of grievances (grueges), which had previously been theoretically infinite-to the great delay of public business-was now brought within tolerable limits. The right to seats in the Cortes was also considered. Henceforth only eight of the higher nobles were allowed to claim as a right their summons to the Cortes, and lesser nobles could only sit when the king chose to summon them; and in the same way certain towns were recognized as having the prescriptive right to send representatives, while the king was given the right, after the manner of the Tudors in England, to choose as many others as he thought fit. Such changes as these were obviously moderate and reasonable. They left Aragon with the bulk of its constitution and its ancient rights, liberties and fueros only slightly restricted in favour of the crown.

There is little doubt that the mass of the Aragonese benefited greatly from these changes in the customs of their country. They were often hideously oppressed by the aristocratic possessors of liberties and fueros. Subsequent experience would lead one to regret that Philip had not been more radical in his demand for their suppression. Thus, for example, Aragonese serfs were frequently put to death at the mere arbitrary orders of their masters; and when the crown, with characteristic zeal for social justice, inquired into these incidents the council of Aragon pointed out that there was nothing to be done, as the killing of peasants by nobles was quite in accordance with the much-prized fueros of the kingdom.

But Philip's responsibilities outside Spain were world-wide in

extent and virtually limitless in the expenditure that they demanded. Charles V's unhappy decision to attach the Netherlands to the Spanish monarchy involved his son in a rebellion that he was unable to quell after 30 years' continuous effort. The war with France, which had lasted from his father's reign, was ended at the peace of Cateau-Cambrésis (April 2, 1559), but the wars of religion gradually induced him to come to terms with his former enemies the Guises and to help them with men and money; and finally to attempt to win the crown of France for his daughter Isabella Clara Eugenia. In these plans for France he was foiled by the more able and less scrupulous Henry IV. With England Philip tried to continue under Elizabeth I the friendship that had existed under his wife Mary 1 Tudor. But the raids of English pirates upon Spanish trade with America and Elizabeth's persecution of Roman Catholic missionaries and her assistance to the rebels in the Netherlands caused strained relations between Eugland and Spain and the consequent sending of the Armada (q.v.)

Philip's position in the Mediterranean demanded ceaseless war against the Turks. But it was not till 1567 that, recognizing the grave danger present in the pro-Islamic sympathies of the lately converted populations of the south, he issued the severe pragmatica that forbade all Moorish or Mohammedan practices under pain of the heaviest penalties. The 3½ years of fierce rebellion that followed resulted in a fearful outpouring of blood and treasure and in the transportation of the entire Morisco population of Granada to northern Spain, where the Moriscos were forced to live only in houses sandwiched between those of Old Christians. Then Philip's bastard half-brother Don John of Austria defeated

the Turks at Lepanto (Oct. 7, 1571).

Lepanto has been condemned as a barren victory, yet it was regarded throughout Europe as the finest feat of arms of the century, Miguel de Cervantes says of one of the spurious continuators of Don Quixote "what I cannot forbear resenting is that he upbraids me with being maimed . . . as if my wound had been got in some drunken quarrel in a tavern and not on the noblest occasion that past or present ages have seen or future ones may hope to see"

(introduction to the second part of Don Quixote).

The expenses of Spain's great enterprises were, however, beyond anything that even the vast silver imports from America could defray; and the industries of Castile were by now being taxed out of existence. At the same time the great imports of silver from America were causing Spanish prices to rise so steeply as to destroy the export market. Hence the economic decline of Spain was far advanced before the end of Philip's reign, during which there were three virtual declarations of bankruptcy upon debts to foreign bankers: one at the beginning, one in 1576 and one in the last year (1598). Yet in Spanish historical tradition the reign of Philip II passes for an era of great successes and glory. enemies of Spain-notably Elizabeth I of England-quailed before this strength. The growth, moreover, of literature, art and science in many forms under Philip II gave Spain for a time the cultural and intellectual hegemony of the world. This growth owed at least a little to Philip's patronage and interest and may fairly be regarded as a compensation for his failures.

Philip III (1598-1621) .- In territorial extent Philip III's empire was the greatest in recorded history. Philip, born April 14, 1578, was the fourth son of Philip II's fourth marriage. He departed from the traditions of his father by employing a chief minister to carry on the government and by giving much of his confidence to members of the high nobility. The chief minister, Francisco Gómez de Sandoval y Rojas (1552-1623), duke of Lerma, was loudly and probably not without some measure of justice accused by his enemies of piling up a vast fortune for himself and his own favourites at the expense of his overtaxed country. Lerma not only found that Philip II had left an enormous debt and almost all the revenue pledged in advance to moneylenders but also had two major wars upon his hands. He was therefore driven to the last resort of destitute statesmanship, the debasement of the coinage, a measure that drove the silver currency out of the country. In one respect Lerma deserves credit: by his able diplomacy he secured peace with England (1604), the 12 years' truce with

the Netherlands (April 9, 1609) and the friendship of the French government after the assassination of Henry IV (1610). An act of more doubtful statesmanship was the expulsion of the Moriscos (1609-14). The Moriscos, however, though treated not without consideration after the resettlement under Philip II, had remained Mohammedan at heart; and it is probable that their hostility to the state was so deep-rooted and their relations with foreign powers so dangerous as to leave no feasible alternative except expulsion. The fall of Lerma (Oct. 4, 1618) was an event of no advantage to Spain, for his son and successor, Cristóbal Gómez de Sandoval y Rojas, duke of Uceda, took the fatal step, through Ambrose Spinola's campaign in the Palatinate, of involving his country in the Thirty Years' War, a step which destroyed all possibility of economic recovery.

Philip IV (1621-65).—As a patron of dramatic art and painting Philip IV was one of the most successful kings in recorded history. The plays and pictures that owe their existence dargely to his encouragement are among the world's most precious possessions. Yet from the military and economic point of view his region is to be regarded as one of the most disastrous in Spanish history,

Having come to the throne at the age of 16, Philip appointed as his chief minister Gaspar de Guzman (b. 1587), count of Olivares (q.v.) and first duke of San Lucar, known as the countduke (conde duque). An energetic, patriotic and truculent-looking man, Olivares set to work to restore Spain to its former powerful position in the world by curbing extravagant living and idleness and by changing the country from a bundle of independent states into one centralized Castilian monarchy, a plan not uninfluenced by the example of Richelieu's work in France. "You should not be content," he advised Philip IV, "to be king of Portugal, of Aragon and of Valencia and count of Barcelona, but you should direct all your work and thought . . . to reduce these realms to the same order and legal system as Castile. If your majesty succeeds in this you will be the most powerful prince in the world." an aim was unfortunate in coming at a time when Castile, the centre of gravity in the Spanish monarchy, was growing weaker in comparison with the other states, which had centrifugal tendencies. When, therefore, Olivares pushed his centralizing policy on with his habitual tactlessness and violence he was to be met with a crop of revolts of which the French were not slow to take advantage.

The early years of Spain's participation in the Thirty Years' War were marked by military successes that recalled the great days of Spanish victories. Don Fadrique de Toledo destroyed the Dutch fleet off Gibraltar; and more important still was Spinola's capture of Breda aften a ten months' siege (1624-25)—an achievement made immortal by the painting of Velazquez. The Dutch were overcome in South America and expelled from Guavaquil and Puerto Rico; and at the same time Moorish pirates were almost swept from the Mediterranean. The fever of glory and conquest had laid hold of Spain, and the name of the king became "Philip the Great"; but the demand for money followed in the footsteps of war. Olivares felt that the eastern states of the peninsula, Aragon, Catalonia and Valencia, used their three close-fisted Cortes to evade their fair shares of the burdens of the empire while loyal Castile bore all, including the greater part of the fighting. He therefore went out of his way to show them the scant respect that he considered their due.

The three Cortes were convened for Jan. 1626; and the king promised to be present at each and to take the oath as sovereign to respect their rights. The Valencians, however, resented the summoning of their Cortes at Monzón, a place outside the kingdom of Valencia, and were ready to take offense before the meeting. When the king asked them at Monzón to grant him 2,000 paid troops to be used as he pleased, as well as a money vote, they refused. It would, they said, be the same as the conscription in Castile, and that was against their liberties. Olivares alternately threatened and bribed and the king himself tried persuasion. At last he formally said that they must vote the supplies without more ado. But the noble estate of the Cortes continued to hold out against stronger pressure.

At last the king called them traitors and gave them one day in

which to do his bidding. It was necessary that the vote should he unanimous, and under this pressure all the members gave way except one-Don Francisco Millan. When, however, a hint was given that the garrotte would probably be the recompense for his obstinacy, he acquiesced in the vote. Even so the nobles still cavilled about the amount of their quota and only after much deliberation settled that the vote of money should be reduced to 1,080,000 livres in 15 years, half the sum paid by Aragon, not in coin, but in kind. The king was forced to accept, but the Cortes was discontented and would not formally ratify the vote. At length the king sent it a message that he gave it half an hour in which to vote the supply, as he was leaving at once. He then took out his watch and said that the half-hour had already begun. The Cortes, thrown into consternation by such a course, deliberated all night. But at last, at 6 A.M., the king sent a message to say that he had determined to abolish the privilege of némine discrepante (unanimity). The astonished and indignant Valencian Cortes then allowed all its resistance to collapse. The king met the Catalan Cortes at Lérida and sought to dazzle it by feasts and splendour, but the Catalans insisted on the repayment of former loans by the king before they would grant a ducat. As they would not yield to threats, Olivares, fearing mischief, suddenly and without warning carried the king back to Castile. The Catalans thereupon voted all that was required of them in the hope of getting the king to come back. The reply was a threat of vengeance for their undutifulness.

In 1639, however, when Richelieu sent French troops into Spanish Roussillon, the Catalans fought loyally and successfully for their province against the invaders. But the Castilians sent to reinforce them behaved so atrociously that in June 1640 the Catalans broke into revolt. Catalonia remained for 16 years a province of France rather than of Spain. It was to return to its allegiance to Philip IV out of dislike of the French rather than as a result of any prowess of Spanish arms. In December of the same year (1640) a well-planned revolution in Lisbon led in turn to the independence of Portugal, which Spain was unable to recover in spite of an exhausting struggle of nearly 28 years (1640-68). As a consequence of these revolts Olivares was overthrown by a court intrigue (Jan. 1643) and succeeded as chief minister by his sister's son Don Luis de Haro.

The earlier actions of the Thirty Years' War had shown that Spanish soldiers had not lost their old quality; but the French victory at Rocroi (May 1643) was not only a decisive defeat of Spanish arms but also the final invalidation of those Spanish tactics that had dominated the battlefields of Europe for nearly 150 years. Though the peace of Westphalia (1648) at last ended the Thirty Years' War, it brought no peace to Spain, with which France remained at war. It was only the Fronde in France that enabled Philip IV to struggle on till the peace of the Pyrenees in 1659, when Cerdaña and Roussillon were ceded to Louis XIV, who next year married his cousin Marie Thérèse (Maria Teresa), Philip's daughter by his first wife, Elizabeth of France. By this time the erysense of wars combined with the misgovernment of a corrupt and far too numerous civil service had brought Spain to that lowest point of economic decadence toward which it had been moving with increasing speed for nearly a century.

Charles II (1665-1700).—The fruit of Philip IV's consanguineous second marriage (1649)—with his sister Maria Anna's daughter Mariana (sc. Maria Anna also), whose father was yet another
Habsburg, the emperor Ferdinand III—the last king of the house
of Austria, was so infirm in body and in mind that he was unable
to take much significant part in the government of his dominions.
Since Charles II succeeded his father in his fourth year his mother
ruled in his name as regent, strongly opposed by Philip IV's popular and ambitious bastard son, Don John of Austria. Mariana
used as her chief ministers first the German Jesuit Johann Eberhard Nithard and then the Granadine adventurer Fernando de
Valenzuela. But these were one after the other driven from power
by Don John, with the help of his faction of the grandees.

Finally Don John became strong enough to force Mariana into a convent and to persuade the king to marry Marie Louise of Orléans (Aug. 1679) in the interests of France. But Don John

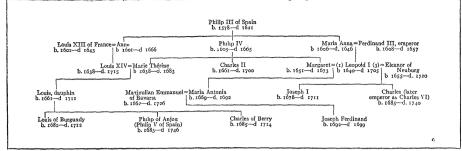
in power was a disappointment to his adherents. On his death (Sept. 1679) Mariana and the Austrian faction resumed their control of the king; and on the death of Marie Louise (1689) they induced Charles to marry Maria Anna of Neuburg, daughter of Philip William of Palatinate-Neuburg and sister-in-law of the emperor Leopold I, in the interests of the Austrian claimant to the Spanish succession. The passive Spanish domain was now the bone of contention of the powers of Europe.

While Spain was barely governed at all under the infant Charles and his capricious mother its financial and economic position became almost unbelievably bad. Crowds of reckless civil servants spread havoc everywhere. Corruption of public officers at home and abroad continued to keep the national treasury bankrupt, however crushing was the weight of taxation upon the people. Manufacturing, except for a few coarse articles for immediate home consumption, was virtually dead. Idlers and discharged soldiers, vagabonds and rogues of all sorts swarmed in the cities and about the court, but working hands were so few that even the poor harvests still raised in northern and central Spain were gathered in by French labourers who returned home again with their wages in their pockets. The trade and industry in Madrid, such as they were, were carried on almost exclusively by Frenchmen of whom there were 40,000 in the capital, mostly calling themselves Flemings and Burgundians in order to escape the differential taxation imposed upon Frenchmen. The total revenues of the crown of Castile on the accession of Charles II are given by a contemporary writer, Alonso Núñez de Castro, in Solo Madrid es Corte (Madrid, 1669), as amounting to 15,750,000 ducats derived from a great variety of sources. Of all this sum, 8,500,000 ducats are said to be pledged; in any case not more than a third would ever reach the treasury. The average amount received from Aragon, Valencia, etc., appears to have been 2,000,000 ducats, and the average annual revenue from the Indies, derived from a royalty of one-fifth of the precious metals mined and other tributes, is set down in the anonymous Relation de l'estat et gouvernement [d'Espagne] (Cologne, 1667) at 1,500,000 ducats. It is probably not far wrong to estimate the national income-apart from the royal patrimony, which was now mostly pledged or alienated-at about 9,000,000 ducats (of debased copper) actually encashed. The cost of the royal establishments reached the sum of 1,700,000 ducats a yearabout one-fifth of the whole amount received into the national exchequer. The ecclesiastical revenues of the kingdoms of Castile alone amounted to 12,000,000 ducats and the entire revenues of the same kingdoms, clerical and lay, are stated at 113,000,000 ducats. If this really was the case, taxation would not seem to have been so onerous as the complaints would lead us to believe; but since much of the land was now out of cultivation and the country depopulated, it is certain that the income was far inferior to that stated as the nominal value. It will be readily understood from these statements that Spain was in no position to undertake an adventurous foreign policy.

But the restless ambitions of the French king Louis XIV left Charles's dominions small chance of peace, whether in Flanders or in the Mediterranean. Louis fought a series of wars (1667-68, 1672-78, 1683-84; see France: History) with the object of annexing portions of them. Complications with the English and with the Dutch led, however, to the frustration of Louis's plans and to the attempts by William III of England to deprive France of the whole of the Spanish inheritance by means of partition treaties, in which the Spanish people were not consulted. Charles II, anxious above all to preserve the unity of the Spanish empire, made his will leaving the whole vast inheritance to Louis XIV's grandson, Philip of Anjou. Having signed it he died on Nov. 1, 1700, in the 40th year of his age and his 80th to judge from his appearance. The last of the house of Austria, he left Spain exhausted and bankrupt. (R. T. D.)

# THE SPANISH SUCCESSION

The military and naval history of the War of the Spanish Succession is outlined in the article Spanish Succession, War of the It may be useful here to examine how the conflict arose. The accompanying genealogy shows the descent of the principal claim-



ants of the succession.

Philip III's two daughters, Anne and Maria Anna, had married, in 1615 and in 1631, Louis XIII of France and the future emperor Ferdinand III respectively; and two sons of these marriages, Louis XIV and Leopold I, married their Spanish cousins, Philip IV's daughters Marie Thérèse and her half-sister Margaret, in 1660 and in 1666 respectively. Marie Thérèse explicitly renounced her claim to the Spanish succession on her marriage to the French king, as her aunt Anne had done; but Margaret made no such renunciation and was moreover named in Philip IV's will as the next heir after his son Charles. Consequently, when Maria Antonia, daughter of Margaret and wife, from 1685, of the Bavarian elector Maximilian Emmanuel, gave birth in 1692 to a son, the electoral prince Joseph Ferdinand, this prince could be regarded as heir presumptive to his great-uncle Charles II of Spain. Leopold I, however, had persuaded his daughter Maria Antonia to bestow her right to her mother's succession on him and on the sons of his third marriage; but the validity of this bestowal, on which the immediate Habsburg claims to the succession were based, was dubious. Also dubious, at the same time, was the Bourbon claim, based on dis-

regard of the French queens' acts of renunciation.

In the precarious lifetime of Charles II, French influences within Spain itself were heavily counterbalanced in the field of international politics by the attitude of the maritime powers. and the United Provinces, now in personal union under King William III, were strongly opposed to the Bourbon claim, fearing not only the aggrandisement of French power that would result from its success but also the loss of their well-established trade with Spain and the Indies. In Oct. 1698, therefore, Louis XIV and William III agreed, in the first partition treaty (signed at The Hague), to recognize Joseph Ferdinand's rights to Spain, the Netherlands and the Indies. Milan, however, was to go to the archduke Charles, the emperor Leopold's younger surviving son (who would presumably be excluded from the imperial throne by his elder brother); and the rest of Spanish Italy, as well as the Basque province of Guipúzcoa, was to go to the dauphin Louis. Spain was indignant at this partition, and in Nov. 1698 Charles II retorted to it in a will that named Joseph Ferdinand as heir to the whole succession, thereby giving the Bavarian claim a final authority independent of the partition treaty (which moreover the emperor had not approved). But in Feb. 1699 the child Joseph Ferdinand died, and new negotiations were urgently required. The second partition treaty, signed by France, England and the United Provinces in March 1700, offered Spain, the Netherlands and the Indies to the archduke Charles (the dauphin was to get Spanish Italy except Milan, instead of which he would have Lorraine); but the emperor declined to accede to it, hoping to win the whole succession for the archduke in reward of refusing to divide it. To counter this new partition, Charles II made his last will, leaving the Spanish dominions, which were to be kept separate from any other crown and undivided, to Philip, duke of Anjou, second son of the dauphin Louis; failing Anjou, to his younger brother Charles of Berry; failing Berry, to the archduke Charles.

Charles II died on Nov. 1, 1700, and Louis XIV was now con-

fronted with a dilemma. If he accepted the whole succession for his grandson, he would be violating the partition treaty; if he stood by the treaty, the will would prescribe exactly what the treaty had been intended by France to prevent—the passing of the whole succession to the Habsburgs. He chose the former alternative, acknowledging Philip of Anjou as Philip V of Spain. The War of the Spanish Succession ensued. (X.)

#### THE BOURBON DYNASTY

Under the treaty of Utrecht (q.v.), which ended the War of the Spanish Succession in 1713, Philip of Anjou was recognized as king of Spain but lost Gibraltar and Minorca to the English, the Spanish dominions in Italy and Flanders to the Austrians and Sicily to Savoy. To this extent the hopes that had led Charles II to appoint Philip his heir were falsified, though there were compensations. After two centuries Spain in Europe was at last driven back upon itself and given a stimulus, long sorely needed, to put its own house in order. The change in dynasty brought too a radical revision of the whole intellectual background, French taste and French ideas gradually percolating the upper classes of society and changing the course of political thinking and of literature. The Bourbon theory of state was no less absolutist than that of the Habsburgs had been, but it rested on a much more enlightened conception of responsibility and worked efficiently (in the early reigns) through ministers, not corruptly through favourites drawn from an effete pobility.

Philip V (1700-46).—In internal affairs the years of the war were of capital importance in Spanish history in spite of the confusion of a country bitterly divided in its loyalties and overrun by foreign armies, with its capital repeatedly changing hands and the constant levies on manpower and economic resources a running score. The general political and administrative nullity of the Spanish upper class of this generation and the political views of the French monarchy led to the assumption of all real power by the French and, later, the Italian servants and advisers of the king. French economists, Jean Orry and Michel Amelot, marquis de Gournay, became ministers of finance, and Marie Anne de la Trémoille, princesse des Ursins, sent by Louis XIV to counsel the child-queen Maria Louisa of Savoy, was before long the mov-

ing spirit behind the throne.

Under such direction important financial and administrative reforms were begun, notably in the collection of the national revenue, which Orry had found in 1701 to amount to little more than one-half of normal expenditure. The Cortes of Castile, in which those of Aragon and Valencia (1709) and of Catalonia (1724) were successively merged, was summoned four times only during Philip's long reign, to hear and approve royal decisions. The votting of subsidies, the original basis of their power, continued to be vested in small permanent commissions. In central government, under the chief organ, the consejo real, more direct responsibility attached to the secretaries of the subordinate councils (state, grace and justice, war, navy and the Indies, finance, was the normal distribution). From 1714 these were called ministers, foreshadowing the modern cabinet system born in 1787 with their de-

liberation in common as a council of state.

The absolutist and centralizing nature of some of these innovations exacerbated the separatist tendencies of the northeastern regions, which had embraced the Austrian cause against the Bourbon dynasty Philip was forced to reduce Aragon, Catalonia and Valencia by arms. The Catalans had relied on assurances from England and from the emperor that their fueros would be secured to them in the general peace. Deceived in this, they tought on desperately on their own, and Barcelona was only taken in 1714. the year after the signing of the treaty of Utrecht, when the city had been reduced to a shambles. Most of the privileges of these kingdoms now disappeared, those of Aragon and Valencia in 1707; those of Catalonia (exemption from conscription, the right to a separate coinage and some part of its penal law surviving) in 1716 The University of Barcelona was removed to Cerveia, and the use of Catalan was forbidden in courts of justice. The Basque province), which had sided with Philip, retained their fueros With this exception the writ of Castile now ran throughout Spain as never before, and Philip, dividing the country-formerly a composite of traditional "kingdoms"-into provinces each under a captain general, set about imposing a new unity of administration. Municipal councils, office in which had become purchasable and hereditary, were again made elective and required to submit their accounts annually to and to deposit all surplus moneys with the crown. The promulgation in 1713 of the Salic law, intended to ensure that Spain should never again fall to the Habsburgs through marriage, was to play an unexpected part in the outbreak of the First Cailist War more than a century later.

Maria Louisa of Savoy died in 1714, leaving three sons, Louis, Philip (who died young) and Ferdinand, and Philip V was straightway married to Elizabeth Farnese (q.v.), the duke of Parma's daughter, who ruled him thereafter and, exploiting his desire to follow a policy independent of France, dragged him into a series of adventures aimed at securing Italian dominions for her own offspring. The princesse des Ursins she repaid for her part in the match with instant dismissal Giulio Alberoni, an Italian priest, became head of the government, and for the remainder of the reign the queen's Italian ambitions menaced the peace of Europe and Spain's prospects of recovery. France and England threatened war in defense of the terms of Utrecht. Alberoni, spinning a web of intrigue in half the courts of Europe, was undaunted. He occupied Sardinia in Nov. 1717 and landed 30,000 troops in Sicily in the following July. England acted without declaration of war and destroyed the rising Spanish navy off Cape Passsero in August. General hostilities followed. Spain tried to send an expedition to aid the Jacobites in Scotland (1719), a French army overran the Basque provinces, English warships wrought havoc in Galicia, the emperor regained Sicily. Alberoni, made the scapegoat, was banished in Dec. 1719. By the peace of 1720 the emperor formally renounced his claim to Spain; Philip renounced his to the Austrian territories in Italy (including Sicily); and the succession of Elizabeth Farnese's issue to Tuscany and Parma was acknowledged.

Philip, increasingly a prey to religious melancholia, began in 1721 the construction of the vast La Granja palace, at San Ildefonso near Segovia, planned to remind him of Versailles; and there he withdrew almost entirely from the conduct of affairs. In Jan. 1724 he abdicated in favour of his eldest son Louis (Luis) I, whose death in August caused him reluctantly to resume the crown. An estrangement with France over the succession to the sickly Louis XV brought a momentary rapprochement with the emperor Charles VI, but this cooled even before the seizure by imperial troops of the duchy of Parma on the death of the duke, Antonio Farnese, in Jan. 1731. English diplomacy effected the cession of the duchy to Elizabeth Farnese's eldest son Charles. Spain had made great sacrifices to achieve so much of her ambition, but there was more to come. In 1733, the emperor being occupied by the War of the Polish Succession, Spain signed the first "family compact" with France, declared war on Austria and overran Naples and Sicily, of which territories Charles was crowned king in 1733, relinguishing Parma and Tuscany to the emperor.

Gibraltar was a continuing bone of contention with England.

Another, even more acute, was English contraband trade with the new world, greatly facilitated by the trading privileges won at Uttecht. Wat broke out in 1739, and Portobelo on the Caribbean was sacked by the English. The conflict merged soon after in the War oi the Austrian Succession, in which Phillip appeared in the strange tole of claimant to the empire. The second "family compact" (1743) was the prelude to much fighting in Italy, Elizabeth Farness being set now on winning territories for her second son, Philip. On July 9, 1746, Philip V died, almost insane. For more than 40 of the 46 years of his 1eign Spain had been at war. His government had been largely French, then largely Italian, with power very rarely in his hands and Spanish interests very rarely in the forefront. More positively, Spain had begin at last, with José de Patiño and José del Campillo, to produce statesmen of its own, who needed only peace to show the nation's powers of recuperation.

Ferdinand VI (1746-59) .- Ferdinand, Philip V's third and only surviving son by his first wife, was modest and retiring and much under the influence of his Portuguese queen, Barbara of Bragança, who like him was wedded to a policy of peace. This was the great novelty of the reign. At the end of the War of the Austrian Succession, the treaty of Aix-la-Chapelle (Oct. 18, 1748; Spanish accession Oct. 20) confirmed England in the commercial privileges that it enjoyed in the new world (the South Sea company was two years later, under the treaty of Madrid, Oct. 5, 1750, to receive £100,000 in compensation for the annulment of the asiento treaty) and assigned the duchies of Parma, Piacenza and Guastalla to the infante Philip (with reversion to their previous possessors should he succeed his brother Charles in the Two Sicilies or in Spain). Ferdinand henceforth steadfastly rejected the competitive blandishments of France and England alike, unmoved even by offers of Gibraltar or Minorca. Cenón de Somodevilla, marqués de la Ensenada (q.v.), and José de Carvajal, his two great ministers, though inclining respectively to France and to England, were Spaniards first and made of the national recovery their major concern. Ensenada, following in Patiño's footsteps, did much to revive agriculture, to stimulate commerce and mining and to strengthen the navy. Fiscal reform and improved communications were other factors in the restoration of a bankrupt country to comparative prosperity. Between the beginning and the middle of the century the population of Spain had risen from 5,700,000 to 7,500,000. In the general spread of enlightenment, exemplified since the change of dynasty in the proliferation of academies and other learned bodies, two details were significant of the new national temper. One was Ferdinand's attracting of foreign scholars and craftsmen to Spain; the other the profound modification in the character of the Inquisition. Under Philip this had continued active, holding 782 autos-da-fé and imposing 14,000 sentences during the reign. Under Ferdinand its vigour and rigours were much relaxed and it was no longer an instrument of state policy.

Foreign policy was marked by a series of treaties all aimed at the peaceful settlement of possible motives of discord: fronter issues with Portugal and with England in America (both 1750); the neutrality of Italy, under an agreement with Austria, Tuscany and Parma, which Naples, still reflecting the ambitions of Elizabeth Farnese, refused to sign (1752): rights of ecclesiastical patronage in Spain, settled in Spain's favour by a concordat (1753). Ferdinand's death, childless, in 1759 brought to an untimely end the country's first substantial respite from war for more than a century. The heir to the crown, Ferdinand's half-brother Charles, had already, from his kingdom of Naples, which he now resigned, proved a disturbing influence in Ferdinand's policy of peace and welcomed the wider sphere for action.

Charles III (1759–88).—Charles III was one of the most sincere and one of the most successful of the "enlightened despots" of the 18th century; for Spain he was the last. He came to Spain, aged 43, after a long apprenticeship to kingship and laboured unceasingly to advance the country's material prosperity. Widowed within a few months of his accession, he acted for himself; but his minister of finance was an Italian, Leopoldo de Gregorio, marqués de Squillace, his ideas were those of the French encyclo-

paedists and his attempt to reform the Spanish way of life from the bottom up, as in dress, led to an initial period of friction culminating in the Esquilache revolt of 1766, which caused Charles to fly in alarm from his capital and put an end to the long succession of foreigners at the helm of state.

The count of Aranda (q.v.), who now emerged, with the count of Florida Blanca (q.v.), as the statesman of the reign, had likewise imbibed advanced ideas, particularly as regards the church, in long residence abroad. In April 1767 Charles decreed the expulsion of the Jesuits, as a body not owning allegiance to the state, from Spain and the American colonies and exerted his whole influence to secure the suppression of their society One consequence was the nationalizing and secularizing of education. The Holy Office, firmly denied the right of trial in civil offenses, was finally shorn of its importance. In 1780 it burned its last victim, accused of witchcraft, in Seville. A decree of 1773 proclaiming the dignity of labour, even for the nobility, illumined another facet of the national resurgence. Land distribution to peasants, the colonization of deserted areas (6,000 Bayarians were settled in the Sierra Morena), the spread of new industries under foreign instruction, the creation of a network of canals and highways throughout the country, were among the many measures which, combined with continuous administrative reform, improved the lot of the working classes and stimulated all in the common effort. The new national lottery proved a valuable and popular source of revenue. By 1788 the population had reached 10,250,000.

Charles's foreign policy was rooted in a deep distrust of England, the "enemy" both in America and in respect of Gibraltar and Minorca. Hence the third "family compact" (1761-62) and, since England and France were then at grips in the Seven Years' War, the former's declaration of war on Spain in Jan. 1762. The peace of 1763 cost Spain Florida, all its territories east of the Mississippi and more valuable trading concessions. In 1770 the conflict threatened a renewal over Spain's occupation of the Falkland Islands, from which the defection of France caused it to withdraw. England's dispute with its North American colonies confronted Charles with his most acute dilemma. To aid the rebels was tempting; the implications for his own American colonies of such countenancing of revolt only too obvious. In 1779 he opted to aid, following France's example of two years earlier; and in the general settlement of 1783 he recovered Florida and Minorca. Gibraltar, twice besieged, proved impregnable. Substantial administrative advances in the new world too (among the most beneficial was the institution of imperial free trade) were hampered by the overriding demands of the treasury at home. The years 1780-81 in particular were marked by serious uprisings both of Indians and of Creoles. In the Mediterranean an unsuccessful attempt was made in 1775 to seize Algiers, a notorious centre of piracy. The suppression of corsair raids on the Spanish coast was at length achieved by treaty with the regency of Algiers in 1786.

Charles IV (1788-1808) .- The fourth Bourbon was at the opposite pole in character and gifts from his father. Sluggish and stupid to the verge of imbecility and much influenced by his wife. Maria Louisa of Parma, a coarse, passionate and narrow-minded woman, he soon became the plaything of events. The French Revolution not only meant the end of the "family compact" on which Spain had relied in its policy of opposition to Great Britain, it involved Spain in a crusade on behalf of Louis XVI and, after his execution in Jan. 1793, in enthusiastic support for the first coalition against France. By then Florida Blanca and Aranda had been replaced by a young guardsman, Manuel de Godoy, who was at once the queen's lover and the favourite of the king. paign, undertaken mainly in the Roussillon, was a failure, and French troops advanced into Spain almost to the Ebro. Constrained to make peace by the treaty of Basle (1795)—whence Godoy's title of "prince of the peace"—Spain found itself tied hand and foot to the French republic. The treaty of San Ildefonso (1796) was a virtual renewal of the "family compact," but with terms far more disadvantageous to Spain. A scheme for a joint attack on the English coast was foiled by the battle of St. Vincent, in which John Jervis and Horatio Nelson forced the Spanish fleet to retire to Cadiz. Great Britain further seized Trinidad and set itself to encourage discontent in the Spanish colonies

The French occupation of Rome and the overthrow of the papal government in favour of a republic were offensive to Spanish opinion, as the dispossession of Ferdinand, duke of Parma, of his territories was to the crown, and Godoy fell from office in March 1798. But Spain was not free to pursue an independent policy, and the return of Bonaparte from Egypt and his emergence as first consul began a period of ever-deepening humiliation. Turning his attention to the peninsula, Napoleon fastened on Godoy as his totol, and a new treaty of San Ildefonso (Oct. 1, 1800-), in which Spain ceded Louisiana and six warships against promises concerning the duke of Parma, was followed by Godoy's return to power. In 1801 he led in person an attack on Portugal, at France's behest The invasion was barely resisted, and Portugal undertook to close its ports to England in return for respect for its territorial integrity.

Napoleon, soon involved in a new war with England, extorted from Spain a new treaty (Oct. 9, 1803) more burdensome still than that of 1796, Spain undertaking to pay a monthly subsidy of 6,000,000 fr. and to enforce Portuguese neutrality. Inevitably Spain too was drawn into the conflict with England: the last remnants of its maritime power were shattered at Cape Finisterre and Trafalgar, and an English force seized Buenos Aires.

Spanish subservience to France was increased and the fate of the Spanish crown deeply compromised by a rivalry for power a court between Godoy and the heir to the throne, Prince Ferdinand, whom Godoy discovered to be intriguing secretly with Napoleon for support. By the convention of Fontainebleau (Oct. 27, 1807) Spain had agreed with Napoleon on plans for the conquest and dismemberment of Portugal, thus giving Napoleon an excuse to send a French army under Andache Junot through Spain to Lisbon, whereupon the Portuguese royal family fled to Brazil. When, shortly after, Godoy induced Charles to order the prince's arrest on charges of plotting to dethrone his father and to murder his mother and Godoy, the resultant scandal and confusion enabled Napoleon to pour more and more troops into Spain, under pretext of reinforcing Junot. Soon even this excuse was dropped, and by Feb. 1808 the French invasion stood clearly revealed as one of concuses.

Godov now would have fought but, the king refusing, could only counsel instead that the Spanish royal family too should embark for America. It removed to Aranjuez, where a mob instigated by the prince's party provoked a riot and clamoured for Godoy's head. The rioters were only appeased by Charles's announcement (March 17) of his abdication in favour of Ferdinand. Six days later Joachim Murat occupied Madrid. Napoleon meanwhile had advanced to Bayonne, near the frontier, whither at his orders Murat now dispatched Charles, his wife and Godoy. Napoleon had already decided to place one of his brothers on the Spanish throne and by specious promises easily lured Ferdinand likewise to Bayonne. There, confronted by his parents and Godoy in a scene of pitiful degradation, he was forced to restore the throne to his father, who laid it at the feet of Napoleon. The next six years Ferdinand spent under military guard at Valençay; his parents retired to Rome. On May 13 Murat announced to an improvised "junta of regency" at Madrid that Napoleon desired them to accept Joseph Bonaparte as their king

The War of Independence (1808-14).—Spanish sentiments of loyalty and independence were, however, too profound to be daunted. For the first time Napoleon found himself faced, not by selfish and terrified rulers, but by an infuriated people who rose against the French on May 2, 1808. The rising in Madrid began the movement which ultimately proved fatal to Napoleon's power. At first he treated the novel phenomenon with contempt; but, although Madrid was held by the French, the Spaniards showed great capacity for guerrilla warfare in the provinces. The French were repulsed from Valencia and Pierre Antoine Dupont, who had advanced into the heart of Andalusia, was compelled to retreat and ultimately to capitulate with all his army at Bailén (July 10). The Spaniards now advanced upon the capital, which Joseph Bonaparte had just entered, and expelled him.

To some extent this too was a civil war, for a small but not

unimportant section of Spaniards, who had been much influenced by the doctrines of the French Revolution, continued to see in France the bulwark of liberal principles and looked to Joseph and his constitution of Bayonne as marking the dawn of responsible government in Spain. The struggle for independence, though in a progressive minority, was to seem in retrospect to have been a struggle no less against the spirit of the age. But the combined defection of the crown, of its senior statesmen, of a large part of the higher nobility and of the intellectual Afrancesados made the reaction of the Spanish people, thus left leaderless, the more remarkable. Its first concern was to improvise a provisional organization based on earlier provincial and regional juntas; and bourgeoisie and provincial yeomanry together succeeded in creating a system capable of resisting French domination.

The military superiority of the French ruled out hopes of an immediate victory, but Napoleon himself was compelled to come to Spain to direct operations. With this the tide swept once more against the patriots. Napoleon restored his brother in Madrid. Sir John Moore, advancing from Portugal with an English army to the relief of the capital, was forced to retreat; and only after a desperate battle, in which he fell, could his troops re-embark at Corunna. Napoleon, thinking his task completed, had now withdrawn, leaving Marshals Nicolas de Dieu Soult and Claude Victor-Perrin to complete the reduction of the provinces. The two defenses of Saragossa under siege (1808 and 1809) and that of Gerona (1809) are among the most heroic pages in the annals of Spain, but proved alike unavailing. With the fall of Seville in Jan. 1810 the central junta fled to Cádiz. Only the obstinate resistance of the duke of Wellington in Portugal, the continuous activity of the guerrilleros and dissensions among the French saved the peninsula from final submission.

The Spanish Cortes, if never so entirely suspended as the statesgeneral of France, had become in the course of the 18th century little more than a rubber stamp. Already under Philip V those of the other regions had been merged in the Cortes of Castile. Now, under the influence of the ideas of revolutionary France, the reformist patriots of Cádiz planned their re-establishment on a more democratic though still national basis, and in 1810 a new Cortes was convened in that city. It included for the first time delegates of the colonies, chosen perforce, like those of enemyoccupied Spain, from among those of their citizens who happened to be then present in Cádiz. The third estate, with 184 deputies, was sufficient to swamp the nobles and the clergy, and the debate on the new constitution soon produced a deep cleavage between Liberales-it was then that the term took on its party political connotation-and Serviles. The former won the day, and the constitution of 1812 was duly promulgated. Its 384 articles attributed to the Spanish nation the exclusive right to determine its fundamental laws. The king would legislate with the Cortes, a single chamber; but royal decrees, to be valid, required the countersignature of a minister, and ministers were responsible to the Cortes. Freedom of the press, though not of religious belief, was assured, and legal codes were made uniform for the whole country. The constitution was doubtless unworkable in many respects and never achieved more than a symbolic importance; but by vesting in the people for the first time the responsibility for determining under what laws they should live it closed an epoch in their history and made of constitutionalism the first characteristic of the new age. Its influence was profound also in two other directions. Its radical idealism, offending the mass of the people, threw them into the arms of the liberated Ferdinand and prepared the way for one of the most reactionary regimes in Spain's record, the tendency persisting thereafter for Spanish politics to swing from extreme to extreme. Also it gave warrant for the later identification of liberalism with anticlericalism on the one hand and with centralization on the other, to the great complication and confounding of the political scene in subsequent periods of stress and crisis.

Expulsion of the French.—In the eventual recovery of its territorial integrity and independence, Spain owed a great deal to British assistance. Wellington's campaign of 1812, though it gave

him the temporary occupation of Madrid, was again indecisive; but, after Napoleon's disastrous retreat from Moscow and the withdrawal of French troops from Spain to central Europe, he found himself in 1813 fighting at last on equal terms. The defeat of Jean Baptiste Jourdan at Vitoria on June 21 finally decided the issue in the peninsula. Joseph retired altogether, and Wellington fought his way across the Pyrenees into France. Napoleon, after his crushing defeat at Leipzig, recognized the impossibility of retaining his hold on Spain by releasing Ferdinand, who returned to Madrid in March 1814.

Ferdinand VII (1814-33).—Before entering Spain Ferdinand had undertaken to maintain the constitution of 1812; and on reaching Figueras he was met by a formal demand in this sense from the Cortes. But he was quick to appraise the true temper of the nation and in rejecting the demand now he was supported alike by the army, the church and the masses. Had he been capable of governing well, he might have ruled despotically for long enough. He was instead base by nature, without real capacity and at once cruel and cowardly. Himself governed by a camarilla of low favourites, he changed his ministers incessantly on caprice and was consistent only in his ferocious persecution of the Liberales.

Partial revolts were easily crushed. That of Jan. 1820, beginning as a mutiny at Cádiz in protest against the sending of an expeditionary force to crush rebellion in the American colonies, became a revolution Its leader and hero, Col. Rafael Riego, was one of a number of officers, many of them erstwhile prisoners in France, who now subscribed to liberal doctrines. Six years of tyrannical excesses had turned the army largely against Ferdinand, and for three years, till 1823, he was a prisoner in the hands of a section of his subjects, who proclaimed once more the constitution of 1812. Ferdinand appealed for help to the monarchies of the Holy alliance, who were much concerned to see kingship thus contemned. As early as 1820 the emperor Alexander I of Russia had proposed joint intervention. The project came to nothing because of British opposition and the refusal of Metternich to contemplate the march of a powerful Russian force through the Austrian dominions. In 1822 the question arose again at the congress of Verona, France proposing that it march into Spain, as Austria had into Naples.

Great Britain saw in the demand only a pretext for reviving traditional Bourbon ambitions in the peninsula and protested vigorously; but the mandate was granted by a majority of the powers and on April 7, 1823, Louis Antoine de Bourbon, duke of Angoulême, crossed the Bidassoa at the head of a powerful army. The result was a startling proof of the flimsy hold of liberalism on the Spanish people. What Napoleon had failed to accomplish in years, Angoulême seemed to have achieved in a few weeks. Napoleon, however, had sought to impose upon Spain an alien dynasty; Angoulême came to restore the Spanish king "to his own" and found some Spaniards forthcoming with active support and the majority at least tacitly co-operative. The Cortes, carrying the king a prisoner, fled again to Cádiz, where after a brief siege it surrendered. Ferdinand, alleging compulsion, refused to honour the amnesty he had sworn, and the French troops witnessed with helpless indignation an orgy of cruel reaction begun under the protection of their bayonets.

The Spanish Colonies .- The emancipation of Spain's American colonies was an indirect result of Napoleon's detention of Ferdinand and invasion of Spain. Juntas in the various administrative capitals overseas assumed power first in the name of Ferdinand against Joseph Bonaparte, then in the name of the colonies themselves against Spain. Some of these had already become independent de facto by 1810, and many more became so in the ten years following; and the recognition of their independence de jure was, for Great Britain at least, merely a question of time. When the French invasion of Spain was seen to be inevitable, George Canning informed the French government that Great Britain would not tolerate any subjugation of the Spanish colonies by foreign force. The United States, though declining to act in concert, followed with the famous message of Pres. James Monroe (Dec. 2, 1823) intimating his country's opposition to any interference by Europe in the Americas. The republic of Colombia had

already been recognized by the United States in 1822. Great Brit-old, was declared of age. ain recognized Mexico and Colombia in 1824 and only delayed recognition of the other new states until they should have given proof of stability. There now remained to Spain, of its far-flung empire, only the islands of Cuba, Puerto Rico and the Philippines.

The Succession Question .- Ferdinand, still childless on the death of his third wife in 1829, married Maria Cristina of Naples in that year and in so doing threatened the mounting hopes of his brother Don Carlos regarding the succession. Don Carlos was likewise an extreme reactionary, and the clash of ambitions threw Maria Cristina on the support of the Liberals. The birth of a daughter, Isabella, in 1830 greatly complicated the issue. By the ancient law of Castile and León women could rule in their own right. This right had, however, been abrogated by an act of 1713 designed to prevent any union of the crowns of Spain and France; and, although Charles IV had restored the former position in 1789, his enactment had never been published and its validity was now hotly disputed. Hence the birth of Carlism, which was for more than half a century to be a disturbing factor in the Spanish scene. When, on Sept. 29, 1833, Ferdinand died, his daughter was proclaimed queen as Isabella II, with Maria Cristina as regent. The First Carlist War broke out almost immediately.

The Regency for Isabella II (1833-43) .- Maria Cristina too would have ruled despotically if she could, but the support of the army and control of the machinery of government were not in themselves sufficient to resist the Carlists, in whose ranks were to be found not merely the clergy and other ultraconservative elements but also large numbers of Basques, Catalans and other peoples of the periphery who had been persuaded that their regional fueros were in danger and supplied the real fighting strength of the movement in defense of them. The necessities of her position thus drove the regent to accept parliamentary institutions under the constitution of 1837 and the return from England and France of the many exiles of the preceding decade gave much support to the liberal cause. But neither Maria Cristina nor her daughter ever genuinely accepted the principle of representative government and there ensued, within the civil war, a bitter struggle between parliament and the parliamentary cause on the one hand and the crown on the other, to the discredit of both.

The First Carlist War, which was for the crown a dynastic issue and for the nation a conflict between irreconcilable political principles, involved Great Britain in military commitments on the government's side and threatened more than once to disturb the peace of Europe. It ended with the convention of Vergara of Aug. 31, 1830, a recognition of Carlist defeat. Baldomero Espartero, the Liberal general, undertook to recommend to the Cortes the substantial confirmation of the Basque fueros, and Don Carlos left the country. But the Carlist cause remained alive; and the Cortes, which insisted, in the name of national unity and uniformity, on whittling down the fueros until little more than administrative autonomy remained, ensured continuing Basque support for Carlism. An earlier measure of kindred intent had been the supersession for administrative purposes, in 1833, of the earlier kingdoms of Spain by 49 provinces on the French model. From that year dates too the Catalan renaixença, a resurgence of regional feeling at once cultural and political that was to have far-reaching consequences. Another enactment destined to provoke repercussions for many years was the acceptance in the constitution of 1837 of state responsibility for the upkeep of the church and the consequent disposal by the state of ecclesiastical property. The Jesuits, readmitted by Ferdinand VII, had been re-expelled in 1835.

With the removal of the Carlist threat to the throne the regent was emboldened in her absolutist leanings. The new constitution of 1837, though much strengthening the royal prerogative, was still liberal and bore traces of the English Reform bill of 1832. Maria Cristina now sought to have it overthrown. Failing in this, she directed an attack on the independence of the municipalities in 1840, which provoked a major crisis that culminated in her abdication. Espartero was proclaimed in her place, and Spain had its first experience of the army in political control. After three disturbed years a military rising, with liberal and moderate backing, drove Espartero likewise into exile, and Isabella, then only 13 years

Isabella II (1843-68) .- The new reign proved but a continuation of the regency, a confused conflict between the attempts of the crown to rule despotically with a mere pretence of a Cortes and the nation's growing demand for honest and efficient parliamentary government. New constitutions (1845, 1852, 1855) alternated between the progressive and the reactionary and caused a spurious importance to attach to the letter as distinct from the spirit of constitutionalism. Party leaders were almost always generals, Espartero, Ramón María Narváez (leader of the "Moderates" or extreme conservatives), Leopoldo O'Donnell, Juan Prim. As such they were unable, even where willing, to further the cause of civic responsibility in the nation at large.

The queen's marriage in 1846 provoked international repercussions. Louis Philippe of France, seeking to revive the family alliance, with the aid of the queen mother constrained Isabella to wed her cousin Don Francisco de Asís de Borbón, who was believed to be impotent; on the same day her younger sister Maria Luisa Fernanda was married to Louis Philippe's son Antoine, duc de Montpensier. The affair broke the entente between England and France-Palmerston having only agreed on condition that the second marriage waited on the birth of an heir to the first-and was a contributory cause of the downfall of Louis Philippe (see FRANCE: History). The church's right to hold and acquire property, restored by a concordat of 1851, was again called in question by the pope's acquiescence, under a new agreement of 1858, in the policy of dispossession. The major external event of the reign was the Moroccan War of 1859-60, in which victory over the Moors in the field was foiled of its full harvest by the opposition of England and France.

Cumulative discontents against the crown, reflected in the emergence of a republican party in 1854, culminated in a mutiny at Cádiz, in Sept. 1868, of a squadron under Adm. Juan Bautista Topete, which became the signal for a general secession. The stand for the queen made at Alcolea by Gen. Manuel Pavía, marqués de Novaliches, was an exception. Even her prime minister, Luis González Bravo, deserted her. Isabella crossed into France an exile, and her reign ended. The revolution of 1868 was the first to be openly directed against the dynasty. The "spurious race of Bourbon," it was boasted, had disappeared; and, as in 1810, sovereignty was again for the moment vested in the people.

## AMEDEO AND THE FIRST REPUBLIC, 1870-75

The mass of the nation was, however, not yet ready for a republic, and a constituent Cortes, assembled in 1869, voted for a continuance of the monarchy under a different monarch; Gen, Francisco Serrano, a leader of the revolution, was declared regent until one could be found. In the constitution of 1869 may be found, for the first time since that of 1812, the entire program of the liberalism of the period. Monarchist opinion was divided, some favouring Isabella's son Alphonso under a regency, some the widower Ferdinand of Saxe-Coburg (formerly king-consort and then regent of Portugal), others the duc de Montpensier, or a Carlist or even the aged Espartero. The search for a democratic king, said Prim, the prime minister, was like looking for an atheist The offer of the crown to Prince Leopold of in heaven. Hohenzollern-Sigmaringen proved the spark that fired the Franco-

At length, in Aug. 1870, Prince Amedeo (in Spanish, Amadeo) of Savoy, second son of Victor Emmanuel II, accepted the offer of nomination. He was elected on Nov. 3 and landed in Cartagena on Dec. 27. On that day Prim was assassinated. Amedeo's reign lasted nominally till Feb. 1873. It was a period of turmoil and confusion. The monarch, become the tool of intriguing politicians, was looked on as an intruder by men of principle, royalist and republican alike. The Carlists threatened a new rising in the north, there was republican agitation in the towns and when the first honourable excuse presented itself Amedeo resigned.

Republican Interlude.—Disillusionment with monarchy was for the moment complete, and the Cortes proclaimed Spain a republic. New elections were held to a constituent Cortes, but the republic ran its brief and tempestuous course without a constitu-

tion. Beyond initial acceptance of the federal idea there was little agreement on first principles. Four presidents held office within the year, Estanislao Figueras, Francisco Pi Margall, Nicolás Salmerón and Emilio Castelar y Ripoll; ministries never knew stability, and many regions disavowed the authority of Madrid and proceeded to act independently. Cantonalists, going beyond federalism to a proposal to split Spain into cantons, seized Cartagena and the Spanish navy in its harbour, which was recovered for the government only by the help of British and German squadrons. The republic had further to contend with a new Carlist revolt, with monarchist opposition and with an insurrection in Cuba.

As it grew ever clearer that only the army could restore authority and order, one major plank in the republican program, the taking of the army out of politics, had perforce to be abandoned, and General Pavía was charged with the pacification of Andalusia. Castelar, reintroducing conscription, provided the means of reducing Cartagena and pursuing the war against the Carlists with vigour. When the Cortes reassembled in Jan. 1874 the extreme parties voted against Castelar, whereupon Pavía, then captain general of Madrid, turned the Cortes into the streets. The federal republic was dead. A unitary regime followed, under General Serrano, until, in Dec. 1874, another army pronunciamiento restored the Bourbons. Alphonso XII, 17 years old and till then at school in England, landed at Barcelona on Jan. 10, 1875.

## THE LATER BOURBONS, 1875-1931

Alphonso XII (1875–85).—National exhaustion and disillusion caused a substantial rallying of the nation around the young king. Pacification, military and political, was his first concern. The Carlists were not finally quelled until the beginning of 1876, when a general amnesty was balanced by the forfeiture by the Basque provinces of their differential system of 'taxation and military service. Part of the large army thus released was then sent to Cuba, where after a further 18 months of fighting the insurgents accepted the conventign of El Zanjón (Feb. 12, 1878). Arsenio Martínez de Campos, Spanish commander in chief, was made governor general and held out to the island the prospect of reforms, including a more liberal tariff and eventual self-government.

Alphonso's first premier, the conservative Antonio Cánovas del Castillo, ruled at first dictatorially without the assistance of parliament. Royal decrees set aside most of the legislation and reforms of the previous regime, respecting only—for a term—universal suffrage, on which basis a new Cortes was convoked in 1876. The constitution of that year was a compromise between that of 1845 and the more democratic principles of the charter of 1869; it was to remain in force for 47 years. By it the franchise was limited to taxpayers; the senate became in part elective; religious dissidence was tolerated though not recognized; and a considerable freedom of association was granted. Constitutional guarantees might, however, be suspended when the security of the state so demanded, a provision that left a tempting reserve of power in the hands of the crown, while the parallelism of civil and military districts facilitated its invocation.

The Liberals under Práxedes Mateo Sagasta formed the Fusionista party, whose name was indicative of its heterogeneity. But the real opposition came from the Socialist-Republican left. From the founding in 1869 of a Spanish section of the international, labour organization developed rapidly. The split between Marx and Mikhail Bakunin was reflected in Spain on a regional basis, labour being predominantly Marxist in Castile and Anarchist in Catalonia. Regionalism, likewise at its most active in Catalonia, provided another outlet for political dissatisfaction with Madrid.

Cánovas' first administration lasted till Feb. 1881, when, under suspicion of heading the country once again toward absolutism, he gave way to Sagasta and the Liberals. Thereafter, to the end of the century, the two parties alternated in power on an agreed rotatory system based on "made" elections that soon became one factor in the gradual discrediting of the restored monarchy. In Aug. 1883 an attempted republican rising, though soon quelled, led to the discovery of widespread revolutionary activities throughout the country. Fifty Republicans were returned to the Cortes at the general election of March 1893. In the country at large the

last two decades of the 19th century were scarred by an increasing resort to direct action and crimes of violence, with corresponding waves of harsh official repression.

Alphonso's first wife, his cousin Mercedes, daughter of the duc de Montpensier, had died in May 1878, five months after the wedding. His second marriage (1879) was with Christina (Maria Cristina), a second cousin of the Austrian emperor Francis Joseph. On Nov. 25, 1885, he died, leaving two daughters. Six months later a posthumous son, Alphonso XIII, was born. The queen was proclaimed regent.

Regency for Alphonso XIII.—The regency began with five years of Liberal rule, marked by the civil code of 1889, another major step in the consolidation of the country's still heterogeneous legislation, by the restoration of universal suffrage and of trial by jury and by a liberalizing of the laws affecting the right of association and the liberty of the press. Attempts to curb the political proclivities of the army were less successful and added military to Conservative opposition. The elections of 1890, which returned the Conservatives to office, showed that very few of those lately enfranchised had voted; they showed also that the home office's

control of the voting continued as before.

Cánovas now based his economic policy on protection, completely reversing the moderate free-trade policy which had been so beneficial to Spanish foreign trade since 1868. Heavy increases in duties on agricultural imports, particularly on breadstuffs, and the denunciation of all treaties of commerce that contained most-favoured-nation clauses soon made their adverse effects felt and evoked loud protest. Industrial interests alone benefited, and imports of raw materials, notably chemicals, coal and coke, increased. In 1892 Cánovas admitted that never since the restoration had the budget been balanced and that the exchequer was bankrupt. Political bankruptcy could be seen further in the failure of both parties to tackle the problem of the latifundios and a land-sterved peasantry. Signs of labour unrest multiplied, again chiefly in Catalonia.

Morocco and Cuba.—The Rif tribes bordering the Spanish zone in Morocco had never been good neighbours. In 1894 an incursion into Spanish territory resulted in defeat for the Spanish forces and a severe shock to public opinion at home. An army of 25,000 men, with 30 generals, was sent to Mellila, but hostilities were averted for the time being by a treaty signed in Fez and by the sultan's agreement to pay an indemnity of 20,000,000 pesetas. Earlier, between 1884 and 1886, Spain had established dominion over the vast territory of Rio de Oro, south of Morocco, in furtherance of a new African policy of pacific penetration advocated by Joaquin Costa.

The position in Cuba had again grown threatening, and press censorship left Spanish opinion unprepared for its outcome. Cuban autonomist deputies in the Cortes had formally tabled the demand for home rule in 1878, but this was rejected, as was a Conservative measure of 1893 for political and administrative reforms tending in that direction. In 1895 a much weaker Cuban Reform bill was passed by all parties, but before it could be promulgated a separatist rising had broken out in the old haunts of Creole dissatisfaction, near Santiago de Cuba, backed by a strong body of sympathy in the United States. Sagasta dispatched a force of 12,000 men to reinforce the 15,000 Spanish troops already in the island, and Cánovas, succeeding once more to the premiership, insisted that submission must precede any concessions. Gen. V. Weyler y Nicolau applied himself to the stamping out of disaffection with a ruthlessness which brought repeated diplomatic representations from the United States, which at the same time was supplying the rebels with arms,

Realizing the danger of more direct U.S. intervention, Cánovas presented to the Cortes a bill granting Cuba a substantially enlarged autonomy. His assassination by an anarchist on Aug. 9, 1897, brought Sagasta back into office. Recalling Weyler, Sagasta hastily enacted conciliatory legislation and sought to propitiate the United States, even offering a treaty of commerce which would have allowed the U.S. every advantage in trade with the West Indies possessed by Spain itself. But things had already gone too far, both in Cuba and in the United States, where public opinion

I32 SPAIN

pressed irresistibly on congress and president alike.

Spanish-American War, 1898.—On Feb. 15, 1898, in circumstances never clearly established, the U.S. cruiser "Maine" blew up in the port of Havana, and events moved quickly to a crisis. Spain appealed to courts and governments and to the pope for mediation, but none was disposed to go beyond mild representations to Washington. In April Pres. William McKinley approved a resolution demanding the cessation of hostilities in Cuba with a view to evacuation by the Spanish forces. Sagasta gave the U.S. minister in Madrid his passports and severed relations with the United States; the known inadequacy of Spain's resources for a struggle could not prevent it from yielding to the urge to defend the last remnants of its colonial empire.

The sequel is soon told. The Spanish fleet in the far east was defeated in Manila bay, the Caribbean fleet was destroyed off Santiago de Cuba and all communication between Spain and the colonies was severed. Within a fortnight of the landing of a U.S. force near Santiago the Spanish garrison surrendered (see SPANISH-AMERICAN WAR). At the end of July Spain sued for peace. The agreement of Aug. 9 stipulated clearly that Spanish rule in the new world must be considered at an end; and by the peace treaty of Paris (Dec. 12, 1898) Spain renounced unconditionally all sovereign rights over Cuba and Puerto Rico and ceded to the United States, in consideration of a payment of \$20,000,000, the Philippine Islands, the Sulus and the largest of the Marianas. The Carolines and a few other Pacific islands Spain sold to Germany in 1899, and a couple of islands omitted in the treaty of Paris were purchased by the United States in 1900. Apart from holdings in North and West Africa, the Spanish empire was at an end.

The Reaction in Spain.—The Liberal goverment was held responsible for the debacle; but the seeds had been sown long before, and the change to a Conservative cabinet was the least significant among its consequences. From the mood of sober analysis and heart-searching that ensued there emerged the "generation of '98", a group of thinkers who through their chosen medium—the essay—effected a renovation not merely of literature but of the country's intellectual life. The debate on the country's role in history led to a cleavage between europeizantes and africanizantes; it led also to a new interest in Africa as the one remaining field of overseas activity. With the radical reduction of its commitments the army became top-heavy, at once an intolerable drain on the nation's economy and more prone than ever to meddling in politics. The wave of solidarity with Spain that swept through Latin America went far to neutralize remaining antagonisms in this sphere.

Long-due reforms in taxation and the servicing of the nation's debts were carried through by a vigorous Conservative minister of finance, Raimundo Fernández de Villaverde. Bondholders were called on for even heavier sacrifices than taxpayers, and the interest on colonial debts, like that on internal debts and on Spanish holdings of external debts, was made payable in pesetas. But in the main the political scene remained untouched by the new spirit. Sagasta, premier once more in March 1901, was confronted by two major problems. One was the growth of the religious orders and congregations, in defiance of the Law of Associations of 1887 by which all congregations were required to register their members and, when not specifically recognized under the concordat of 1851, to apply for authorization. A proposal now to enforce the law greatly incensed the church. The papal nuncio announced that Rome would only consent to discuss the question on condition that all requests for authorization would be granted. To avoid a crisis just when the young king was about to become of age, Sagasta accepted a modus vivendi. A final settlement was not reached with the Vatican until 1912,

Industrial unrest constituted a more pressing peril. Fomented by socialist agitation and by anarchist direct action, it led in Jan, 1902 to serious riots in Barcelona and Saragossa and on Feb. 16 to a general strike in the former city. General Weyler's methods in restoring order all but brought the government down. They provided no solution to anarchism, which under the influence of Georges Sorel was now moving toward syndicalism as a basis for organized opposition to all government as such.

Accession of Alphonso XIII, 1902.—Alphonso XIII was enthroned on his 16th bitthday, May 17, 1902. He was still then under clerical and reactionary influences, and his contemptuous treatment of ministers showed from the beginning an intention of intervening actively in politics. His first official act was to countermand a decree closing the military colleges, aimed at reducing the disproportionate officer strength of the army. Sagasta died in 1903. Conservatives and Liberals alike were now suffering from weakened leadership, and there ensued a period of instability and frequent changes of government.

A tendency to disintegration in the political parties was symptomatic of the growing subordination of national to sectional interests. It became an important factor in the eventual collapse of representative government. This political instability contributed to the general unrest; and the old antagonisms, born of the conflict between the industrial north and the agricultural south and of the now traditional cleavages over regional, social and religious issues, were increasingly complicated by labour agitation. The notorious Law of Jurisdictions of 1905, under which attacks on officers and military institutions were to be tried before military tribunals, was a serious capitulation of the civil authority, that had farreaching consequences.

Alphonso's marriage on May 31, 1906, to Victoria Eugenia (Ena) of Battenberg, princess of Great Britain, marked a stage in his emancipation from clerical-conservative tutelage. Ecclesiastical controversy again loomed large at this period, formal recognition of the validity of civil marriage arousing such agitation among the clergy that the government threatened the bishop of Tuy and the Cordova chapter with prosecution. A new Law of Associations in 1906 brought the Liberal party itself to the verge of disruption, and after three changes of premiers the Conservatives returned to power under Antonio Maura.

Maura (1907-09).—Maura, who had already been premier under the regency, had many qualities of leadership. A sincere Catholic, though no clerical, he pursued first the maintenance of order and the reform of local government. A bill to the latter end was submitted to the Cortes in Oct. 1907. Aimed at destroying the power of the caciques or local bosses and at educating the electorate in their privileges and responsibilities, it made voting compulsory, abolished official interference with the polls and increased considerably the responsibility of local elected bodies. The bill met with strong Liberal opposition because of its alleged regionalistic tendencies and, though finally approved by the lower house in Feb. 1909, did not reach the statute book.

The elections of 1907 were notable for the return of a strong republican minority and the striking victory of the Solidaridad Catalana, a fusion, resulting directly from the Law of Jurisdictions, of seven Catalan parties in defense of regionalist interests. Of the 44 seats allotted to Catalonia, 41 were gained by its candidates. Maura, ruling rather as an enlightened despot than as the head of a constitutional government, was concerned also to strengthen the navy, to reform and to reconstruct the police force, to institute industrial tribunals and to regulate the conditions of work of women and children.

Trouble long brewing in Morocco broke out in July 1909 with an attack by Rif tribesmen on Spanish railway workers. The need to reinforce the Spanish troops in Africa had for some time been apparent, but Maura had hesitated to lay the necessary estimates before the Cortes. The proposal now of the war minister, Gen. Arsenio Linares, to organize a new field force by calling out the reserves, with its vivid memories of the useless miseries of earlier overseas expeditions, provoked another general strike in Barcelona; and a movement at first directed against "conscription" rapidly developed into a revolutionary attack on the established order in church and state that spread to the whole province. Churches and convents were favourite targets for violence. In Barcelona the rising was suppressed after three days of street fighting (July 27–29).

On July 28 martial law was proclaimed throughout Spain, and a military reign of terror continued until the end of September. In the fortress of Montjuich in Barcelona were collected not only rioters caught red-handed but many others, notably journalists,

whose opinions were unpalatable to the government. A sensation was caused by the arrest of Francisco Ferrer, a theoretical anarchist well known in many countries for his anticlerical educational work and especially as the founder of lay schools in Spain. Ferrer was tried by court-martial and shot. The execution aroused widespread indignation throughout Europe and produced a ministerial crisis in Madrid. The government, already weakened by a reverse in Morocco (Sept. 30), was furiously attacked by the Liberals under Segismundo Moret y Prendergast at the opening of the Cortes in October, and Maura resigned.

Moret and Canalejas (1909-12).-Moret's Liberal ministry sent General Weyler back to Barcelona to keep order, released most of the Montjuich prisoners, reduced the forces in Morocco and reopened negotiations with Rome for a modification of the concordat. In Feb. 1910 Moret was forced to resign through the king's refusal to grant him a dissolution, and José Canalejas y Méndez, the outstanding Liberal of his day, took office. His government, "inspired by the universal spirit of liberty of conscience," tackled the continuing refusal of the religious houses to comply with the law (in respect of registration and the payment of taxes when engaged in industry and commerce) and announced measures both to restrict the number of religious houses and to implement the religious toleration enshrined in the constitution. A violent Catholic agitation resulted, 72 Spanish bishops and archbishops presenting a formal protest to the government. To attacks from the Vatican Canalejas retorted with the famous "Padlock law" at the end of 1910 forbidding the settling of further congregations in Spain until a revision of the concordat should have been agreed on with Rome.

On the Vatican's demanding that all the obnoxious measures be rescinded as a preliminary to negotiations, the Spanish ambassador to the Vatican was recalled. Hints were dropped in papal circles of a possible rapprochement with the Carlist claimant to the throne, and diplomatic relations were not restored until 1912. The overthrow of the monarchy in Portugal on Oct. 5, 1910, and the expulsion thence by the new republican regime of all religious congregations did not ease the government's difficulties.

French activities in Morocco at this time compelled Spain to adopt a more active policy in its zone. To counterbalance the French entry into Fez a Spanish force was landed at Larache in June 1911 and took Alcazarquivir and Arcila. The recruiting of native regiments under Spanish officers did something to lessen popular indignation at home. France was prevented by the Agadir incident from reacting strongly, but a certain tension continued and pervaded the negotiations for a Franco-Spanish agreement following on the Franco-German treaty on Morocco. Concluded on Nov. 27, 1912, that agreement reduced the Spanish zone for the third time in 12 years.

A general railway strike in the middle of 1912 threatened the country with chaos. Canalejas met it by drafting railway workers into military service and compelling them to continue at their posts as soldiers. Such firmness was balanced by a genuine readiness to understand legitimate grievances, which led the Catalanists to make a serious attempt to come to terms. The premier responded by introducing a bill of mancomunidades (common-bine in one joint body (mancomunitat) to which the state would grant a substantial measure of devolution. The bill, which was inevitably unacceptable to many Liberals and Conservatives alike, and was regarded in Catalonia as merely a first instalment of Catalan demands, had not passed the Cortes when, on Nov. 12, 1912, Canalejas too was assassinated by an anarchist.

The Parties in Decline.—The new premier, Alvaro de Figueroa y Torres, conde de Romanones, was natural heir to the Liberal leadership, but he was unable to maintain the firm party discipline of his predecessor. He pursued meantime Canalejas' policy of seeking to attract and absorb the more moderate wing of the republican left, a policy the desirability of which had been greatly enhanced by the revolution in Portugal. Alphonso himself recognized the need for such an accommodation, and the response of republican leaders like Melquiades Alvarez led to hopes that the disintegration of the regime might yet be checked.

These hopes were dashed, firstly by an internal crisis in the Liberal party over the bill of mancomunidades, then by the "implacable hostlity" proclaimed by Maura against any policy of collaboration with the antidynastic parties. With the resignation of Romanones in Oct 1913 the king realized that the Liberal policy which he had consistently followed since 1909 was at an end. Maura's views aroused, however, such intense popular resentment that Alphonso entrusted responsibility instead to his fellow-Conservative Eduardo Dato, a choice that initiated the disintegration of the Conservative party in its turn.

The tangled fate of the bill of mancomunidades was resolved, against Dato's judgment, by a royal decree of Dec. 18, 1913, that granted to the four Catalan provinces the right to group together for "exclusively administrative purposes within their competence." This and several similar royal decisions in military matters, which savoured of unconstitutional action, created considerable opposition to the government. But internal difficulties were soon to be merged in the all-absorbing preoccupations and repercussions of World War I.

World War I.—The international situation of Spain at the outbreak of war in 1914 was determined officially by the agreement between Spain, France and England signed at Cartagena in 1907 and confirmed in conversations held there in 1913 between Raymond Poincaré and Romanones, which stipulated that. "should new circumstances arise tending to alter the territorial status quo" in the Mediterranean or on the Atlantic coasts of Europe and Africa, the three powers would "enter into communication" in order to take any necessary measures.

The war was obviously such a circumstance. France and England made no sign, but Dato promptly declared for absolute neutality, Spain having no stake in the conflict. As for the nation, its sympathies were divided. The working classes, most of the intellectuals and the trading communities—the Liberal left—were pro-Ally. The clergy, most of the army and of the bureaucracy and the "idle rich"—the Conservative right—were pro-German. But there was agreement on the one essential of keeping out, and the Cortes, resuming its sittings on Oct. 30, 1914, unanimously endorsed the government's decision.

A debate on military reforms brought Dato's government down in Dec. 1915, and Romanones again formed a Liberal ministry. By then the country was profiting from industrial activity on the Allied account, the peseta appreciated and the foundations were laid for the repatriation of the foreign debt. The picture had its reverse. In Morocco military operations were again necessary, this time to defend the mines from hostile tribes; while Spanish shipping was victimized by a ruthless German submarine campaign. By Sept. 1916 Spain had lost more than 30,000 tons by torpedo attack and another 50,000 in obscure circumstances. When, on Jan. 31, 1917, Germany intimated an "absolute blockade" of the Allied coasts, Romanones delivered a spirited answer intended partly to test public opinion.

His resignation on April 19, which cost him the leadership of his party, was not solely the result of the nation's failure to rise to his Toward the middle of 1916 the army had begun to organize secretly its so-called juntas de defensa in furtherance first of its professional efficiency, second-and soon chiefly-of its traditional prerogatives, the threat to which came principally from the king's fondness for personal intervention. Before long they were presuming to dictate to the government in a manner which led Romanones to attempt their dissolution. But this new menace to authority from the one bulwark of order loomed larger with each endeavour to exorcize it, and Romanones chose the easier path. Under his successor, Manuel García Prieto, an order to arrest the leaders of the juntas provoked an ultimatum (June 1, 1917) that brought the new government down; and Dato, recalled to office, capitulated before them, conceding to their regulations the force of law. This victory of a movement revolutionary in essence encouraged at first, in a public not alive to its implications, hopes of a renovation of political life. Coupled with early reports of the Russian Revolution, it stimulated the ferment at work in the country, and political manifestoes asking for a "renovation" in government and constitution followed one another (Socialists June 12,

Catalanists June 16, left coalition June 16).

In the teeth of government opposition, an assembly of senators and deputies convoked in Baraclona formally demanded constitutional reform and set up three commissions to report to a second meeting in Madrid. This movement, which might conceivably have provided the renovation so urgently needed, was defeated by the resort to direct action of extreme labour elements. On Aug. 13, three days before the planned second meeting, a revolutionary general strike broke out, led this time by the Socialist U.G.T. (General Workers' union) of Madrid and aimed openly at establishing a socialist democratic republic, which soon threatened to paralyze the whole country. A state of war was again declared. The army now showed its true colours and put down the strike by machine guns, and the juntas remained the only real force left in the country.

Among the victims was the constitution. The new minister for war imposed on the king by the juntas, Juan de la Cierva, dominated a heterogeneous ministry of Maurists, Liberals and Catalanists. Its short life (Nov. 1917–Feb. 1918), in spite of army support, showed that a severe blow had been struck not merely at party government but at cabinet government. Brought down by a telegraph stilke, it was followed by a hiatus that only ended when Alphonso, at a midnight meeting of former premiers at the palace on March 21, constituined them under threat of abdication to form a ministry of all the talents, under Maura. This lasted till Nov. 6. The abdication of the kaiser and the toppling of thrones throughment in the return of the Liberals to power, first under García Prieto, then (Dec. 3) under Romanones, whose first act as premier was to visit Pres. Woodrow Wilson in Paris.

The Postwar Situation.-Spared the war, Spain had passed nonetheless through a very disturbed and anxious four years. The submarine war cost it 65 vessels, in all 140,000 tons, which Germany had agreed to indemnify on a ton-for-ton basis. Against this, the influx of capital went far to revolutionize its economy. Gold reserves in the Bank of Spain, £22,680,000 in 1914, had risen to £88,920,000 in 1918. Not merely was Spain able to resorb in large part its foreign industrial debt and, almost entirely, its national debt and to acquire the ownership of the railways, new industries were founded, not all of which disappeared with the return of peace, and in older industries such as the Basque iron and steel works, plant and conditions were modernized. A mingling of two political currents, one a democratic and constitutional agitation born of the Allied victory, the other a revolutionary agitation akin in the civil sphere to that of the juntas de defensa in the military, created an involved situation in Barcelona which issued in the spring of 1919 into open conflict between the military and the civil authorities. When the former expelled the latter from the town, the failure to take up so flagrant a challenge brought the government down, and again there ensued a period of cabinet instability. Its most notable feature was that "made" elections, the mainspring of the old system, were failing now to produce the desired majorities. On March 8, 1921, Dato, who had been engaged in trying to rebuild Conservative unity, was assassinated.

The murder accelerated the final disintegration of the rotatory system which, ever since the death of Alphonso XII, had served the monarchy as substitute for a real constitutional regime on the English model. To its own internal weaknesses was added the triple assault from outside. There were the antidynastic elements, once lumped together under the common label of Republicans, now moving toward socialism on the one hand and toward different varieties of syndicalist or anarchist revolution on the other hand; there were the Catalan home rulers, gradually evolving from autonomy toward separatism under the stimulus of the respect shown by Versailles for the principle of self-determination; and third there was what might be called the military syndicalism embodied in the defense juntas.

With the last-named, governments lacked the moral courage to deal; toward the violence so frequently associated with the first they opposed more violence, failing to recognize legitimate grievances where they existed and tending always to identify the employers' interests with those of authority. To Catalanism opnosi-

tion in Madrid was instinctive, and the failure of a new approach from Barcelona in 1918-19 did much both to strengthen and to unify support for the movement throughout Catalonia. By 1923, when two strong groups, Estat Català and Acció Catalana, of the right and left respectively, were in agreement on the main objective and had concluded a triple alliance with Basque and Galician autonomists, it was clear that this issue was destined to loom larger and larger in the country's politics.

War in Morocco.—Effective occupation and pacification of the Spanish zone in Morocco were still far from complete, and in guerilla warfare the tribesmen were often more than a match for Spanish troops, with whom service in Morocco had become notoriously unpopular. In 1921 Manuel Fernández Silvestre, in command at Melilla, embarked impulsively, with Alphonso's personal backing, on an operation which ended in crushing disaster at Anual (July 21). To heavy losses in men and matériel was added a forced withdrawal from the whole eastern zone, the fruit of 12 years of slow penetration. General Silvestre committed suicide.

The repercussions in Spain were profound. The government fell, and Maura was called on to face the emergency. An army of 140,000 men was sent to the rescue of the troops in Morocco the growing public demand for an inquiry the new government had at length to give way, and General Picasso was charged with investigating responsibilities, his report being submitted in due course to a committee of the Cortes. Meanwhile the juntas de defensa had reacted strongly with a campaign of threats and accusations against the Cortes, which they sought to hold responsible for the general disorganization underlying the Moroccan crisis The government retorted with a formal disbandment of the juntas, replacing them by juntas informativas subject, in theory at least, to the minister for war. But the juntas were the stronger, and early in 1922 Maura was forced from office. His successor, another Conservative, José Sánchez Guerra, was brought down in December by the debate in the Cortes on the Picasso report. The insistence in Socialist sectors of opinion that definite responsibilities attached to specified individuals and should be brought home to them charged the issue with high explosive.

A Liberal coalition followed and was confirmed in office at the general election of April 1923. The sensational feature of this was the return of Socialists for five out of the seven seats in Madrid, a success attributed by their party to the strong line that it had taken on the war in Morocco. The burden which the Moroccan problem imposed on the exchequer (an average of 358,000,000 pesetas annually in 1919–23 as compared with 75,000,000 pesetas for 1909–13 and 146,000,000 pesetas for 1913–19) was aggravated by the gradual wilting of the artificial prosperity of the war years and recurrent industrial troubles at home. For the most part, however, these problems were but facets of the basic inability of government after government to uphold the prestige of authority. In the 21 years since Alphonso's accession to the throne there had been 33 ministries.

Dictatorship of Primo de Rivera (1923-30).—In Sept. 1923 the report of the Cortes commission on the Anual disaster was ready. Several politicians were believed to be deeply involved. some as having abetted the king in his fondness for unconstitutional initiative. The reaction of the army, notoriously restive under parliamentary or civilian criticism, was awaited with some concern. Suddenly, on Sept. 13, a dramatic stroke from this quarter brought to an end the system under which the country had lived since 1875. The captain general of Catalonia, Miguel Primo de Rivera, marqués de Estella, rebelled against the government from his headquarters in Barcelona, rejecting its authority and threatening its members with jail. His manifesto declared it imperative to liberate the country from "the professional politicians, the men who for one reason or another are responsible for the period of misfortune and corruption which began in 1898 and threatens to bring Spain to a tragic and dishonourable end." "The wide net of greedy politics," he added, "has caught and imprisoned in its meshes the royal will itself." He announced the setting-up of a military directorate which would find for the Moroccan problem a "quick, dignified and sensible" solution and which would bring home responsibility promptly and justly by the formation

of tribunals "of recognized moral authority"

The premier proposed to the king strong action against the rebels, who included now the military authorities of Bilbao and Saragossa and a council of high officers in Madrid. The king asked for time for reflection, and the government resigned. Two hours later a deputation of generals was received at the palace and the king requested Primo de Rivera, who was still in Barcelona, to take office. Administratively the new directorate struck an original note in that the only minister was Primo de Rivera himself, ministerial departments being left in charge of permanent officials while the "directors" concerned themselves with specific problems as they arose. The one significant exception was the home office, which was entrusted to Gen. Severiano Martínez Anido with the rank of undersecretary of state. Public opinion received the pronunciamiento without demonstration, save for a protest from the Socialist party. The directorate declared the country to be in a state of war. A strict press censorship and a ban on political manifestations were imposed. The Cortes was dismissed, and the seizure of the files of the Commission on Responsibilities, shelving the further inquiry into the Moroccan disaster which was due to begin on Sept. 15, made clear the reason for the timing of the coup. When, two months later, the king refused to acknowledge his obligation under the constitution to convoke a new Cortes within three months of a dissolution, he made equally clear his personal responsibility in the collapse of the parliamentary regime and rendered it inevitable that the eventual fall of the dictatorship should involve that of the throne. In November king and dictator paid an official visit to Italy and expressed open admiration of Fascism,

The compelling problem was still Morocco, and it was there that the dictator won his greatest success and the nation's gratitude. The first phase, initiated in the summer of 1924, was one of cutting losses and retreating to a base line near the coast sufficient to cover Ceuta and Melilla. Primo de Rivera claimed later that in this he was interpresing the popular will, "which was weary and sceptical of any other possible solution." He himself led the operation in the field. It evoked opposition from the army and was not effected without heavy loss, but by the end of the year it was completed

Abdel Krim's sudden attack on the French protectorate in 1925, which led to combined action by France and Spain against the rebellious tribes, made possible a complete reversal of policy. The brilliant landing (Sept. 8) in Alhucemas bay, again led by Primo de Rivera in person—the other generals having refused—was a thrust at the heart of the enemy's power, and within a month Abdel Krim was in flight. The pacification of the entire Spanish zone was not completed until 1927, but already Spain's position and prestige in Africa had been retrieved.

Primo de Rivera was now tempted to consider his mission at an end and withdraw, but there was substantial popular support for the view that the dictatorship could contribute no less to the sofving of the nation's internal difficulties. He decided, however, that the military directorate had by now served its purpose and, replacing this in Dec. 1925 by a predominantly civilian cabinet, sought to base his regime on more normal political foundations. The Unión Patriótica (1926) was an attempt to form a nonparty organization of all such good citizens as would accept his own motto of "Country, Religion, Monarchy"; the "supreme national assembly" (Sept. 1927) represented a pseudo Cortes largely nominated by the dictator and given a merely advisory function.

Primo de Rivera remained the fount of power and, in his zeal for reform, was driven inevitably to abuse that power, both by attempting to force the pace and by riding roughshod over dissident susceptibilities. His successes lay accordingly in such spheres as public works, finance and public order. In the conciliation of opposition elements he failed to make headway. The Confederación del Ebro, associating the many interests concerned in the utilization of that river, was a notable innovation and the forenuner of others of the same nature. Ambitious schemes for the electrification of the railways and for road development were set on foot. Income tax was introduced in Dec. 1926 and gradually worked its way into the national finances. Morocco had ceased

to be an intolerable drain on the exchequer, and in x927. for the first time in 20 years, no loan was raised. Economic policy was directed to the correction of the heavy adverse balance of trade by stimulating home industries, canalizing investment and creating state monopolies. In the labour field an elaborate system of corporations was initiated; deriving from the Italian model, it won the approval of many Socialist leaders. An agrarian credit bank gave promise of new life to the small farmer; the other great problem in agriculture, the breaking-up of the latifundios, the regime left untouched

In 1925 the government undertook the reorganization of provinical and municipal administration. The right to levy certain rates was delegated to municipalities, with a corresponding widening of their range of action; and female and proportional suffrage were instituted in local elections. One important provision in the decree of provincial reform was the abolition of the mancomunital, the central body in Barcelona responsible for co-ordinating the work of Catalan local councils. In its Catalan policy the directorate had soon reversed the sympathetic attitude to autonomy voiced in Primo de Rivera's first utterances, which were evidently directed to winning support in Catalanist circles for his coup d'état Army opposition to any measures of Catalan devolution combined with the inherent logic of dictatorship to create an attitude agad a policy described in Catalonia as one of systematic persecution.

In external relations interest centred chiefly on the League of Nations. In 1926 Spain claimed a permanent seat on the council of the League in fulfilment of repeated promises by the French and British governments. Similar claims by Brazil, Poland, China and Persia and opposition from Germany, Sweden and others to any increase in the number of permanent seats led to a confused situation and to much resentment in Spain. At the June meeting of the council Spain's representative was ominously absent, and on Aug. 9 Spain signed a treaty with Italy stipulating mutual neutrality in the event of unprovoked aggression. Further to stress this independent mood, Primo de Rivera announced in the latter month his desire for such a drastic change in the Tangier convention as would have amounted to the setting up in Tangier of a Spanish protectorate. The assembly and the council of the League decided in December to institute a special semipermanent seat on the council for Spain. Spain refused this and gave notice of withdrawal from the League.

Negotiations with France over Tangier led finally to a number of French concessions which improved the security position in the Spanish zone of Morocco. This was a factor when, on the invitation of the president of the League council in March 1928 to reconsider its attitude, Spain announced its readiness to remain a member of the League and to accept such status on the council as the League might determine.

The year 1926 witnessed three attempts to overthrow the dictatorship by force. A military rebellion at Valencia in June, led by old General Weyler and Gen. Joaquín Aguilera, was nipped in the bud. Trouble with the artillery corps arose from a measure in July abolishing its cherished tradition of accepting promotion by seniority only as a guarantee against favouritism. A compromise settlement was, the corps claimed, broken by Primo de Rivera, and in September the artillery officers too prepared a revolt. Its failure was followed by the abolition of the corps. An ammesty later restored all but a few to their posts, but much ill-feeling remained. In November Col. Francesc Macid, exide leader of the separatist Estat Català party, launched a futile attempt to invade Catalonia from France and set up a provisional government there for the restoration of "the national sovereignty."

By the end of 1928 civil discontent with the dictatorship had combined with army unrest to render the dictator's position more difficult. Continual dissensions between dictator and king, riots in the universities and protests from intellectuals were symptoms of the general unease. The world economic crisis of 1929 was soon reflected in a serious fall in the peseta. In Jan. 1930 the finance minister, José Calvo Sotelo, resigned; and when, shortly after, the captains general of the army intimated that they no longer stood behind the dictator his fall became inevitable. On Jan. 28, 1930, Primo de Rivera admitted defeat and, laying down the reins,

crossed the Pyrenees. He was already broken in health and died in Paris on March 16.

Fall of the Monarchy.-A temporary government under Gen. Dámaso Berenguer now sought to prepare the way for a return to constitutional rule. Unrest, however, continued. Revolutionary strikes multiplied all over the country. The ranks of republicanism were swollen by all those who refused to absolve the king from his responsibility in the abrogating of the constitution, and a revolutionary committee, pledged to bring about a republic, concluded with Catalan autonomists the pact of San Sebastián (Aug 17) whereby it undertook, in return for their support, to introduce a bill for regional autonomy as soon as it was in power. The peseta, which had dropped from 29 to the pound sterling to 36 50 during 1929, fell to 51 by the autumn of 1930. An abortive military rising took place at Taca (Dec. 15). On Feb 14, 1931, the government resigned, and a new administration under Adm. Juan Bautista Aznar was charged with convoking, first, municipal elections, and then parliamentary elections for a constituent Cortes. It was generally understood, nonetheless, that the former would be taken as a test of the national temper on the one great issue and that, if the outcome were held to warrant it, the revolutionary committee would attempt to seize power.

Full results of the municipal elections of April 12, 1931, which went off quetly enough, were never published. The only figures issued showed that 22,150 seats had gone to Monarchists and 5,875 to Republicans. But in Barcelona the Republicans had a three-to-ne majority of votes; in Madrid, Niceto Alcalá Zamora y Torres, leader of the revolutionary committee, headed the poll; and most of the large cities showed republican majorities. Alcalá Zamora took the bold course of demanding Alphonso's abdication and the immediate transfer of powers to his committee. The king, after some parleying, agreed to leave Spain, but without formal abdication, and on the night of April 14 he embarked at Cartagena for France. The revolutionary committee became the provisional government of the second republic.

#### THE SECOND REPUBLIC, 1931-36

King Alphonso's action, and the fact that the army was no longer behind the monarch, allowed the establishment of the new regime without bloodshed But the initial optimism did not allow for long the illusion that the nation as a whole had turned to fervent belief in responsible democracy or achieved the competence to exercise it. Right-wing elements-army, church, landed aristocracy -were prepared to tolerate the republic so long as it respected what they believed to be their prescriptive rights. Left-wing elements-Anarcho-Syndicalists and the more extreme Socialists (Communism was as yet an insignificant force in Spain)-regarded its advent as but a stage to the overthrow of the established order of society. The regional autonomists, fortified by the pact of San Sebastián, appeared to Madrid to be intent on disrupting the national unity. Moreover, the new government, attempting to steer a middle course through all these dangers, was forced by the quantity of social problems facing it to action that of necessity invaded sphere after sphere of vested interests. The dictatorship had been merely the culmination of a long denial to the mass of the people of education in political responsibility. The republic found itself heir to the consequences, and the challenge to the political stature of the nation was as searching as that to the statesmanship and administrative ability of those now come to authority.

The whole course of the republic was marked by revolutionary strikes, anticlerical outrages and incipient revolts against the regime, now of the right, now of the left, now of the regions of the periphery. In May 1931 churches were burned by the mobs in Madrid, Valencia and throughout southern Spain. The monarchist messpaper ABC was suspended and the primate, Pedro Cardinal Segura y Sáenz, expelled from Spain for alleged monarchical indiscretions. A Communist rebellion was crushed in Jan. 1932, a rightwing rising under Gen. José Sanjurjo in the following August. The economic life of the country was seriously jeopardized by its constant subordination to political agitation.

Parliamentary elections held in June 1931 gave the left-wing parties 315 out of the 466 seats in the new constituent Cortes.

The Monarchists had I deputy. The Cortes met in July, and on Dec. 9 the new constitution was promulgated. This defined Spain as "a democratic republic of workers of all classes," with authority "emanating from the people" and no official religion. It bound Spain to respect for the rules of international law and to the renunciation of war as an instrument of national policy. Provision was made for the granting of autonomy to regions which could justify the demand for it, but any federation of autonomous re gions was forbidden. Titles of nobility were abolished. Free expression of opinion was guaranteed, and both sexes were given the vote from the age of 23. All property and wealth were declared subordinated to the interests of the national economy; forcible expropriation of property, against adequate indemnity, might be authorized by the Cortes. Marriage was to be founded on sex equality, and unions were made dissoluble "as a result of mutual disagreement or on the petition of either party." Primary education would be, not merely compulsory and tree, as nominelly under the monarchy, but exclusively lay,

Legislative authority was assigned to a unicameral Cortes, with four years as the maximum length of each parliament. The president, to be chosen by an electoral college comprising all deputies and an equal number of ad hoc members, was to hold office for six years. His powers included the nomination of the prime minister and considerable authority over the Cortes. Amendment of the constitution required an absolute majority in the Cortes and the lapse of at least four years from the date of promulgation.

The most hotly debated clauses related to religion. New measures in this field included the disestablishment of the church, the cessation from Dec. 1933 of state payment of the clergy (a form of compensation for past expropriations agreed upon in the concordat of 1851) and the submission to a special law of all religious confessions and congregations. Freedom of conscience and of worship was recognized, subject to government sanction for all public manifestations of religion. Religious orders requiring a vow of obedience to an authority foreign to the state wege to be dissolved and their property nationalized for educative and charitable purposes. Other orders would likewise be dissolved if considered a peril to the safety of the state. None might hold more property than was necessary to its sustenance, and none could engage in industry, commerce or education. Finally, it would be "permissible" for the property of all the orders to be nationalized.

These provisions occasioned a first serious political crisis. Manuel Azaña y Díaz, who as war minister had been active in reorganizing the army and reducing its officer strength, violently attacked the religious orders in the Cortes, announcing as the government's intention the dissolution in Spain, under the "vow of obedience" clause, of the Society of Jesus (this took effect on Jan. 23, 1932) and the application of the other clauses with the utmost rigour. When, after an all-night sitting, the clauses were approved by a half-empty house (178 votes to 59), the prime minister, Niceto Alcalá Zamora, and the home secretary, Miguel Maura, resigned (Oct. 14, 1931). Azaña thereupon became premier, and in December Alcalá Zamora was elected first president of the republic.

A week after Azaña's accession came the notorious Law for the Defense of the Republic, under which certain constitutional guarantees might be suspended at the discretion of a single minister. By it the home secretary was empowered to cancel meetings, dissolve associations, close clubs and suppress newspapers. Eleven "acts of aggression" against the republic were named, some in the vaguest terms, and made punishable with fines or exile. The frequent and severe invocation of this law gave Spain in many ways less freedom than it had enjoyed under Primo de Rivera.

Left-Wing Government (1931–33).—Once the constitution was promulgated, Azaña recast his government, which became predominantly Socialist. The chief measures of 1932 were the Agrarian law and the Statute of Catalan Autonomy. The agrarian problem, one of the most pressing inherited by the republic, hinged on the prevalence throughout central and southern Spain of huge estates held by absentee landlords and worked by peasants at starvation wages. The new law (Sept. 15) provided for expropriation at discretion, against payment in government bonds to the value

of the estate as assessed for taxation. Its administration was entrusted to a state-subsidized Institute of Agrarian Reform, representative of both owners and landworkers.

The movement for regional autonomy was strong in the Basque provinces (although not successful there until Oct. 1, 1936, after the outbreak of the Civil War); it was weaker among Galicians and Valencians, who were far less united in their claims. In Catalonia its urgency was extreme. The fall of the monarchy had been followed there by the immediate proclamation of a "Catalan state, in a manifesto envisaging a "confederation of Iberian peoples." Appeals from Madrid secured the substitution of the historic and less provocative term generalitat of Catalonia and resignation to the status of an autonomous region within a unitary Spain. The necessary plebiscite of the Catalan people (Aug. 2, 1931) gave a vote of 592,961 for the draft Autonomy statute and of 3,276 against. Despite considerable opposition within the Cortes and from various interests without, the statute, much revised, was approved on Sept. 9 by 314 votes to 24. By it the generalitat was empowered, among much else, to organize its own police services and be responsible for public order, to execute much state legislation and to found and maintain its own educational institutions. Catalan and Castilian were to be "co-official" languages. Though bitterly disillusioned by the mutilations suffered by the statute. Catalonia, under its presidents Francesc Macià and-on his death in 1933-Lluis Companys, became on the whole the most contented part of Spain and the least affected by strikes and revolts. The Law of Religious Confessions and Congregations, implementing the clauses of the constitution dealing with religious activities, also had a stormy passage, lasting seven months (Oct. 1932-May 1933). The proposal that teaching by the orders was to cease after 1933 made necessary alternative provision for the education of at least 350,000 children-an impossible undertaking. Already in June 1931, in Madrid alone, 50,000 children were without schools. The Cortes had authorized the creation of 27,000 new schools, 7,000 to be finished within a year; but efficient teachers could not be thus improvised. Misgivings were widespread and were shared by the president himself, who deferred signing the law until the expiry of the period allowed by the constitution.

During these two years, despite the government's efforts to cope with its many major problems, opinion had been running strongly against the left. Opposition was much exacerbated in Jan. 1933 by the ruthless handling of disturbances in the village of Casas Viejas. In April partial municipal elections, held in 2,500 rural districts, gave impressive Conservative majorities. In the autumn Azaña resigned; and, after the Radical leader Alejandro Lerroux had failed to form a government, the Cortes was dissolved and elections fixed for Nov. 19. In them the new female vote, totalling 6,500,000, could be foreseen as likely to strengthen any swing to the right.

Centre-Right Government (1933-35) .- The election results showed how deep was the disillusion with the republican experiment to date. In the new Cortes the right held 207 seats, the centre 167 and the left 99. The centre thus held the balance of power, and-with occasional infiltrations from the right-governed for the next two years, generally under Lerroux. Changes of government were numerous (seven in 1935 alone). The most important, in Oct. 1934, admitted three members of the right and precipitated revolutions in Catalonia and Asturias. In Barcelona, on Oct. 6, the generalitat again proclaimed the Catalan state of the federal Spanish republic. The central government reacted strongly. After some street fighting, Companys and his fellowministers were arrested, the Autonomy statute was annulled in fact if not formally and Catalonia was again ruled from Madrid. The extremist revolt in Asturias (Oct. 6-13), which resulted in 1,335 killed and 2,951 wounded, was liquidated with extreme severity, reprisals being taken all over Spain. It was during this period that the Falangist (Spanish Fascist) party was founded by José Antonio Primo de Rivera, son of the former dictator. The right-wing leader in the Cortes was Gil Robles.

Government policy during this biennium was directed broadly to obstructing previous legislation of the left until, in Dec. 1935, revision of the constitution should become legally possible. Thus the substitution of lay for religious schools was indefinitely postponed, the clergy had part of their state stipends restored to them,
the transfer of powers to Catalonia was delayed and a new Agrarian law treated the large landowners with respectful benevolence.
But as the date in question drew near it became evident that this
negative policy and the severity of the government's repressive
measures were in their turn producing a widespread reaction.
Azaña, arrested on suspicion after the Catalan revolt, tried, set
free and later rearrested, became a popular hero and the centre of
progressive hopes, the "strong man" who would soon return to
power and carry to completion the reforms already begun. Some
looked on him as a possible dictator of the left. By the end of 1935
the centre-right could hold on to power no longer. The president
acceded to a dissolution, and new elections were announced for
Feb. 16, 1936.

The Popular Front (Feb.-July 1936) .- From the political manoeuvring preparatory to the elections Azaña emerged as the leader not only of his own party but also of the group of parties and trade unions (Republicans, Left Republican union, Socialists, Communists, Trotskyists, Syndicalists and Anarchists) that now banded together, in spite of the previous abstention of some from political action, to ensure electoral victory for the left. This popular front, so-called after a similar French combination, won by a substantial majority (left 256, centre 52, right 165), and no sooner were the results announced than tumult broke loose. Officials dispossessed during the preceding two years clamoured for reinstatement; prisons were burst open; bands of peasants seized land and defied the law to eject them; churches, seminaries, monasteries and the offices and houses of capitalists were set on fire; there was a wave of murders by gunmen. During the first four months of popular front rule 113 general and 218 partial strikes took place, while 170 churches, 69 clubs and the offices of 10 newspapers were fired by incendiaries, who attempted to burn a further 284 buildings, 251 of them churches.

Politically, the event of this period was the deposition, on the charge of unconstitutional dissolution of the Cortes, of President Alcalá Zamora. Having tried for so long to steer a middle course, the president found himself under attack by both right and left. Azaña had gone so far as to break off relations with him. Only 5 deputies voted for the president, 238 against. On May 10 Azaña was elected, almost unanimously, as his successor.

The new prime minister, Santiago Casares Quiroga, proved wholly unable to cope with the indiscipline of the country. While his government worked out fresh measures of reform, Spanish fascism grew, much as republicanism had grown in 1930–31, as a protest against the virtual usurpation of power by extremist violence. The premier flung down a challenge: "In its relations with fascism, the government is a belligerent." The challenge was taken up, and soon violence and counterviolence had relegated the activities of the Cortes to insignificance.

On July 13, in revenge for the murder of a Communist Heutenant in the shock troops, the former dictator's one-time finance minister, José Calvo Sotelo, was arrested and murdered by men in officers' uniform. Four days later an army mutiny broke out in Spanish Morocco, led by Gen. Francisco Franco Bahamonde, which spread next day to the mainland and within 48 hours had involved the whole country in civil war. The second republic had lasted just three times as long as the first, but it ended in much the same way and for much the same reasons.

## THE CIVIL WAR, 1936-39

Everywhere garrisons revolted. In the south Seville (under Gen, Gonzalo Queipo de Llano), Córdova, Granada and Cádiz supported the rebels; in the north, all Galicia, most of León and part of Asturias, with Burgos (for three years the nationalist head-quarters), Salamanca, Valladolid, Segovia, Pamplona and Saragossa. Both in Madrid and in Barcelona the mutinies failed (otherwise there might have been no war), and the government began the struggle with the whole of eastern and most of southern Spain under its control. The Basque provinces illustrated the tug of conflicting loyalties. Vizcaya and Guipíacoa, setting autonomy above all else, threw in their lot with the regime pledged to secure

this for them; Alava sided, as also did Navarre, with the insurgents, who claimed to have risen in defense of religion and traditional values.

The nationalists, as these called themselves, representing that theirs was no mere pronunciamiento but a movimiento nacional, lost several outstanding men early, notably General Sanjurjo and Gen. Emilio Mola, killed in aeroplane crashes, and Gen. Manuel Goded Llopis, shot after the unsuccessful rising in Barcelona. They had, however, the bulk of the army, of the armed police and of the arsenals. The popular front had to rely chiefly on untrained volunteers and on such arms, outside the arsenals of Madrid and Barcelona, as the unions had been storing for their own purposes. Much time was necessary to turn improvised militias into an efficient army, and by then the nationalists had greatly improved their positions.

Casares Quiroga had resigned the premiership on the outbreak of war. President Azaña, choosing a moderate, Diego Martinez Barrio, to succeed him, found his choice vetoed by the leaders of the extremist groups. The "strong man" was compelled to give way and, from then until his own resignation in Feb. 1939, was but a figurehead. The new government, thus chosen in contravention of the constitution, lost its claim to legality, and the constitution was no longer taken seriously.

By the end of July 1936 foreign intervention had begun. From the U.S.S.R., the All-Union Central Council of Trade Unions made the republicans a first payment of 12,145,000 roubles; both the U.S.S.R. and Mexico began to send war matériel; extremist volunteers (mainly Communist) from many countries entered Spain large numbers and formed the international brigade. The nationalists received combatants, technicians and large supplies of war matériel from Italy and Germany, the fruit seemingly of prior consultation with Rome and Berlin. Realizing the danger of international complications, France approached the leading powers, and as a result formal embargoes were placed on the export of war matériel and a nonintervention committee, representing 27 nations, was set up in London. Intervention continued nonetheless throughout the war.

With the capture of Badajoz in the middle of August the nationalists were enabled to unite their northern with their southern forces; and while the former took Irún and San Sebastián early in September, the latter advanced rapidly upon Madrid. The capital was saved by the detour made to relieve the nationalist garrison imprisoned in the Alcázar of Toledo (Sept. 27). Thanks to this delay the international brigade was moved up in strength before the arrival of the nationalists on Nov. 6; and instead of submitting to a triumphal entry the Madrileños held out through a 28 months' siege.

As the threat to the capital developed, the government, now under Francisco Largo Caballero and enlarged by the inclusion of both Communists and Anarcho-Syndicalists, moved to Valencia (Nov. 7), leaving Madrid in charge of a defense council under Gen. José Miaja. President Azaña had already gone to Barcelona. There the generalitat was allowed to retain nominal power and even to take over services reserved by the Autonomy statute to the state; bur real power had passed to the unions, which collectivized industry and commerce (Oct. 28) and were responsible for the ban on public worship that only ended with final defeat,

Apart from the taking of Målaga, little was achieved by the insurgents in the winter of 1936–37, two attempts to cut the roads to Madrid conspicuously failing. In April 1937 a new and successful offensive was begun in the north, with Bilbao as its first objective. The city's "iron ring" of defenses held out for nearly two months, but on June 19 the Basque capital fell and one of Spain's two autonomous regions was again centralized. Santander was taken on Aug. 25, and Gijón, the last town to hold out in the north, on Oct. 21.

On both sides the war was marked, especially in its early stages, by a ruthlessness which astounded the civilized world. Not only were churches burned or descenated and public religious observances forbidden throughout republican Spain; ten bishops and many thousands of priests, religious and devout members of the laity were murdered in cold blood, for no political activity or

crime. The nationalists for their part organized mass executions (e.g., in Badajoz), and the Basque town of Guernica was subjected to terroristic air bombardment.

On Oct. I, 1936, General Franco assumed the leadership of nationalist Spain and outlined the features of his proposed "broadly totalitarian" rule. These included abolition of popular suffrage and of regional autonomy; equitable and graduated taxation; complete religious tolerance and a new concordat with Rome; in foreign affairs, suppression of all "Sovietic contacts" and preferential treatment for "nations of related race, language or ideology" A technical council of state was set up, to be succeeded in Jan 1938 by a cabinet on the orthodox pattern. On April 19, 1937, the two main nationalist groups—Falangists and Traditionalists—were fused into a single party, the Falange Española Tradicionalista, and all other parties were dissolved. The organization of the F.E.T. was developed four months later by the creation of a national council of about 50 members and a junta politica or party cabinet invested with considerable powers.

Much constructive legislation was promulgated even during the war, such as the Labour charter of March 9, 1938, which, under captions like "Work for All," "Remuneration and Security," "Protection and Production," gave the worker an undertaking, somewhat vaguely worded, that the "new state" had not come simply to restore the ancien régime. In agrarian policy the objective was to give every labourer a living wage and every peasant family a small holding and to improve sanitary and housing conditions in the villages. Little idea was given as yet of how such aims were to be accomplished. Another feature of the Labour charter was the creation of vertical syndicates combining into one organism, under state direction, all the elements functioning within a single service or branch of production. This departure earned for the new regime the adjective "national-syndicalist."

The republican cause suffered from internal differences much more fundamental than were to be found on the other side, and serious clashes occurred. A miniature civil war within the Civil War was caused by an Anarcho-Syndicalist rising that raged for a week in Barcelona (May 3-10, 1937). On this followed a major crisis in the Valencian government, leading to the formation of a new cabinet, under Juan Negrín, from which the Anarcho-Syndicalists were eliminated; they were not again represented in the government until April 1938. The generalitat underwent numerous crises on a smaller scale (six between Sept. 1936 and June 1937 alone), which were due also, principally, to the clash between centralizing and decentralizing groups, though, as the combat became fiercer, these drew more closely together. Largescale plot and spy trials were frequent, some of them implicating the anomalously placed Trotskyists, whose group, known as the P.O.U.M. (Partido Obrero de Unificación Marxista) was the Cinderella of the republican family.

By the end of the first year of war, General Franco held 35 of Spain's 50 provincial capitals and 119,600 sq.mi, of territory. But the republicans had as yet scarcely organized their "new army," and the struggle was far from over. The loss of the north and the consequent unification of front simplified their practical problems; and when, on Dec. 4, 1937, they launched an unexpected offensive in Aragon, it won them the city of Teruel (Jan. 9, 1938). This was to be their last, as it was almost their first, important gain and was lost once more on Feb. 22. With the spring the nationalists regained the initiative, relieved Huesca, penetrated into Catalonia, captured Lérida (April 3) and pursued the enemy up the Segre valley to Tremp. An almost simultaneous push farther south carried them to the Mediterranean (April 15), and soon they had carved themselves a corridor 40 mi. wide, threatening Castellon to the south and Tortosa to the north. Republican Spain was thus cut in two, and its government, which had removed from Valencia to Barcelona on Oct. 31, 1937, deputed General Miaja, the defender of Madrid, to act as civil and military governor of its central and southern territory.

International Activity.—The efforts made by the London committee to prevent, or at least to lessen, foreign intervention were many and complicated. Though the entry of foreign combatants was made illegal (Feb. 21, 1937), they continued to enter,

despite a coastal control system inaugurated on March 7. All the powers save Great Britain and Fiance soon withdrew from this, and Great Britain proposed its supersession by port control and by the granting to both parties of belligerent rights as soon as the withdrawal of foreign combatants already in Spain should have made substantial progress. In fact General Franco never withdrew more than 10,000 of these during the war, and the republicans, though more amenable, had not completed withdrawal at its close. Belligerent rights were, therefore, never granted.

In the summer of 1937 intensified pronationalist submarine warfare in the Mediterranean led to a nine-power conference's beingled at Nyon, Switz. This organized (Sept 14) a new system of maritime zone patrols and agreed that any submarine attacking a non-Spanish merchant ship should itself be attacked. As the fighting moved more and more toward eastern Spain, attention became increasingly centred on the bombing of Mediterranean ports, which often resulted in great damage to neutral shipping and much loss of life among civilians. Protests were made by several powers and by the Vatican against the repeated bombing of open towns (Granollers suffered 700 casualties in one air raid, and Falset, near Gandesa, was almost completely destroyed).

The idea of peace negotiations, which the powers would have supported, was rejected throughout by General Franco, who insisted on the unconditional surrender which he eventually obtained. Signs that the republicans were envisaging defeat first came in April 1938, when Negrin formulated 13 points as his irreducible minimum. At the time of the Munich conversations (Sept. 1938) these were given great publicity, and there was talk of a more moderate republican government which might canvass for an armistice. That this was not formed may have been because of a checking of the nationalists on the Ebro (July 26-Nov. 18, 1938), which gave the republicans new hopes of an indefinite prolongation of the struggle. These proved vain. Their army was exhausted, their people half-starved, their territory cumbered by about 3,000,000 refugees from the west. When at length the nationalists were able to recross the Ebro, even the severe winter could not hold back their final sweep to victory.

The End of the War.-The war had been one of lightning offensives and wearisome delays, and it conformed to type to the end. The last great offensive began on Dec. 23. A general advance in Catalonia soon developed into an attack on Barcelona which, menaced from both northwest and southwest, fell on Jan. 26, 1939, after a campaign of only 34 days. The government fled north to Figueras, where, on Feb. 1, 62 members of the republican Cortes held a meeting in the castle vault and Negrín hurled defiance at the enemy, while announcing that his 13 points were now reduced to 3. Pursued northward along the three main roads to France, the republican forces soon lost the rest of Catalonia. Hundreds of thousands of refugees poured into France, able-bodied men of military age being at first sent back, though eventually admitted and interned. When Gerona fell on Feb. 4, the government moved to a village near the French frontier. Across this, a day later, passed a succession of presidents: Azaña, Companys and the Basque president José Antonio de Aguirre.

On Feb. 28 Azaña resigned, Negrín and his cabinet returning to continue the struggle from Madrid while the nationalists prepared to move south to attack the capital. With no heating in the city, only two ounces of food daily and hundreds dying of starvation, attack proved unnecessary. On March 5 all parties except the Communists formed a new council of defense, again under General Miaja, ousting the Negrín government. A revolt against the council by Communist and other Negrín supporters broke out two days later but was suppressed after a week of heavy fighting, and the council addressed itself to preparing for surrender. On March 28, without resistance, 200,000 nationalist troops marched into the capital. By the following day the rest of republican Spain had surrendered, and Burgos radio announced that the civil war was over. It had lasted two years and 254 days and was estimated to have cost 1,000,000 lives.

# GENERAL FRANCO'S GOVERNMENT

Great Britain and France had recognized General Franco's gov-

ennment on Feb. 27; the United States followed suit on April r. A victory parade in Madrid on May 19 was followed within a few days by the departure from Spain of the German and Italian combatants; and during the summer the various ministries returned to the capital. These few months saw the first stages of reconstruction, to speed which General Franco "adopted" the most severely damaged towns and granted extraordinary credits for house building, the repair of public buildings and the rehabilitation of the transport system. The Falange, reorganized, outnumbered the Traditionalists in the government, and Ramón Serrano Súñer, appointed minister of the interior and later foreign minister, emerged as the second strongest figure in the administration. He was brother-in-law to the caudillo (leader), as General Franco was now called in his capacity as head of the Falangist party.

World War II .- With the outbreak of hostilities between Germany and the Allies in Sept. 1939, General Franco was quick to reaffirm Spain's neutrality. Six months earlier, in March, Spain had joined the anti-Comintern bloc; but a much more significant action, as it proved, was the conclusion only four days after this of a treaty of friendship and nonaggression with Portugal. This agreement, reinforced by a protocol of July 1940, seemed calculated to rule out any step capable of involving Spain in war with Great Britain's oldest ally. The Soviet-German pact came as a great shock to Spanish idealism, and the overrunning of Catholic Poland brought consternation to "the most Catholic country in Europe." Germany's attack on the U.S.S.R. in June 1941 helped to restore the perspective, and Spain dispatched its blue division of volunteers to fight by Germany's side in the Ukraine. In a speech of July 18, 1942, General Franco reiterated his stand: "Yesterday, today and tomorrow, for the countries of Europe there exists only one danger-Communism." Earlier he had promised 1,000,000 volunteers for the defense of Berlin should this ever be threatened by the Russians.

Meanwhile, Spain had used the occasion of Italy's entry into the war to alter the status of Tangier, and on Nov. 24, 1940, the administration of the international zone was formally combined with that of Spanish Morocco. England refused to recognize this unilateral action and protested against attacks on British property in Tangier; but a modus vivendi was reached on Feb. 26, 1941, when Great Britain, while reserving all rights, accepted the new situation meantime. The redefinition, likewise in June 1940, of Spain's own status as one of nonbelligerency and the emphasis laid on its new-found "will to empire" reflected confidence in an impending Axis victory and the desire to share in any redistribution of colonial territories. The presence of German troops at the Pyrenees after the French collapse weighed heavily thereafter on Spanish policy; but although General Franco journeyed to Hendaye, Fr., on Oct. 23, 1940, to meet Hitler and to Bordighera, It., to meet Mussolini four months later (Feb. 12, 1941), he succeeded in avoiding irrevocable commitments. The creation in Nov. 1940 of the Council of Hispanity, its concern being "all activities tending to the unification of culture, economic interests and power throughout the Hispanic world," was aimed at the recovery of prestige and influence in Spanish America. The atmosphere across the Atlantic, as country after country identified itself with the Allied cause, was, however, unsympathetic in the main toward Spain and its totalitarian leanings, Argentina being the notable exception.

By late 1942 the course of the war was giving General Franco cause for second thoughts. The dismissal of the violently germanophile Serrano Súñer from the foreign ministry in September was one sign that Spain was cautiously reverting from nopbeligerency to neutrality. The Allied landings in North Africa in November, followed by the German occupation of the whole of France, threatened Spain for a moment with involuntary involvement in hostilities, and partial mobilization was decreed. But the danger passed, and in December an Iberian bloc was formally cemented with Portugal. This, described by Gen. Francisco Gómez Jordana y Souza, now foreign minister (it was he who had signed the original nonaggression pact with Portugal in 1939), as "an instrument of peace capable of playing its part in international policy," confirmed the new direction; and with the collapse of

Italy in July 1943 Spain began to urge the desirability of a compromise peace, in which it aspired to play the role of mediator. The Allies however were still not convinced that Spanish neutrality was genuine and in Feb 1944 the United States, to encourage its structer observance, imposed an embargo on oil shipments to Spain. This bore fruit in an agreement of May 2, Spain giving satisfaction on various outstanding Allied grievances concerning exports of wolfram to Germany, German agents in Tangier, Italian ships in Spanish ports and the blue division.

Ostracism by the United Nations.-The ending of the war in Europe in May 1945 and the political landslide to the left that swept the continent, from Great Britain to Greece, as its first consequence confronted the Spanish regime with a position of acute difficulty. Overtures concerning Spain's claim to a voice in the peace settlement and urging the need for a western entente against Soviet expansion were rudely brushed aside. The Potsdam declaration of July branded Franco's regime as unfit to associate with the United Nations, one-third of whom were Spain's daughter nations in Latin America. In August, at an international conference in Paris on Tangier, the U.S.S.R. but not Spain being represented, Spain was given a month in which to remove its troops from the city. In that same month Mexico, which had never recognized the new Spanish regime, granted hospitality and recognition to a Spanish republican government in exile. The culmination of this general ostracism was the decision of the United Nations in Dec. 1946, by 34 votes to 6, to demand the replacement of the regime by one "deriving its authority from the governed," coupled with the recommendation that all member nations should recall their ambassadors or ministers from Madrid. Apart from Portugal and Argentina, Spain had very few friends left.

Internal Politics.-This danger had been foreseen. Once the tide of war had clearly turned, the "totalitarian state" gave way to a new term, "organic democracy". A pseudo Cortes was inaugurated (March 1943), and Franco began to drop hints of a restoration of the monarchy. In Oct. 1944 a first approach to elections took place, for the renewal of the syndical organization. This last was the residual sphere of influence of the Falangist party, whose program of national syndicalism had earlier supplied the doctrinal basis for the regime. But the party's entanglement in government was coming to be felt as an embarrassment. The secretary-general of the party, now the sole survivor of three original Falangist ministers without portfolio, was dropped in a far-reaching cabinet reorganization in July 1945, and General Franco announced to the world that the Falange no longer wielded any political power in Spain. Party control of press, radio and propaganda was transferred in August to the ministry of education. The Falangist salute was abolished by decree in the following September, and the title of caudillo was supposed to recede with the party into the background.

Relations With the Church.-The appointment as foreign minister, in the aforementioned cabinet reconstruction, of Alberto Martín Artajo, former president of Catholic Action and not a party member, was likewise aimed at foreign opinion and particularly at closer relations with the Vatican. These had lacked something of the cordiality to which the regime had from the beginning felt itself entitled. Repeal of the divorce law, restoration of religious education and of budget provision for the church, and the return to the Jesuits of their property and prerogatives had followed close on victory in the Civil War, but there had been no progress toward the new concordat promised in the program of the "new state." A modus vivendi reached in June 1941, to allow the filling of vacant sees, then numbering about 20 out of 55, merely revalidated the first four articles of the concordat of 1851. The church distrusted certain of the totalitarian implications of the regime and by 1945 was demanding—as in a pastoral letter issued (Aug. 28) by the archbishop of Toledo and primate of Spain, Enrique Pla y Deniel, to mark the end of the world waran end to the "constituent period" and a return to a constitution "in conformity with Spain's historic tradition and the degree of political education of the Spanish people."

As during the war, however, a restoration of the kingship was

still to General Franco only the last resort. In March 1945 the pretender Don Juan, third son of Alphonso XIII (who had designated him as his successor before his death in Rome on Feb. 28, 1941), had called on General Franco in a manifesto to resign, offering Spain a new constitution to be determined by popular vote, a legislative assembly, guarantees of political liberty and individual rights, recognition of regional characteristics and an amnesty. Only the mention of an amnesty provoked any response, On April 29 it was announced that all political charges against republicans were being dropped and exiles were invited to return In October came a proclamation of full pardon for all prisoners convicted of political offenses committed during the Civil War, Coming six and a half years after the end of hostilities, the detail was elequent of the animosity with which the regime had persecuted its political opponents. The execution on Oct 17, 1940, of Lluis Companys, former president of Catalonia, who had been taken in France and handed over by the Vichy government, was perhaps the blackest and most impolitic stain on the record

Political evolution did not signify any abandonment of "the fundamental principles of the state," which were declared to be sacrosanct in a charter of rights, the Fuero de los Españoles, submitted to the Cortes on July 19, 1945; and it gradually became clear that by a restoration General Franco understood, not a return to the traditional monarchy, but only such a solution for the problem of the succession as would guarantee the continuity of those principles under a guise more acceptable to public opinion. This was made explicit in a Law of Succession published on April 1, 1947, by which Spain constituted itself a kingdom and the successor to General Franco was declared to be that person of royal blood with the best right who fulfilled certain conditions, swore to observe the fundamental laws of the regime and was approved by a two-thirds vote of the Cortes. Failing such a king, a council of the kingdom, acting jointly with the government, would nominate a regent. The fundamental laws of the kingdom were defined as the Fuero, the Labour charter, the law creating the Cortes, a law of Oct. 1945 instituting a national referendum for issues transcending normal methods for the consultation of public opinion and the Law of Succession itself. Don Juan rejected the law in toto as being completely at variance with Spanish tradition, but it was approved by the Cortes on June 7 and submitted to referendum on July 6. Of more than 17,000,000 voters on the register, 82%-being 93% of those who voted-were reported to have voted in favour. In Oct. 1947 General Franco assumed the prerogative of conferring titles of nobility.

International Relations.—The exclusion of Spain from Marshall aid and the failure of repeated approaches to the United States for loans were aggravations of the acute economic difficulties that had weighed on the regime ever since the end of the Civil War. A succession of droughts and bad harvests, together with the refusal of foreign credits, caused shortages of food, of water, gas and electricity and of raw materials and plant for industry, all gravely impeding the nation's recovery and contributing to black-market abuses on a scale that threatened alike public morale and administrative efficiency. They did not suffice seriously to threaten the regime. Apathy, born of the devastation of the Civil War and the desire at all costs to avoid another, had become a major political factor. The army was still behind the regime, and the psychological effect of the ostracizing of Spain by the United Nations had been to bind Spaniards together in defiance of outside interference. By late 1950 the withdrawal of ambassadors was seen to have had the opposite effect to that intended, and on Nov. 4, by 38 votes to 10, with 12 abstentions, the United Nations rescinded its resolution of Dec. 1946, thus paying the way for Spain's return to the family of nations.

paving the way for Spain's return to the family of nations. Binitographys.—B. Sanchez Alonso, Fuentes de la historia española e hispanoamericana, 3 vol. (Madrid, 1924—96), and Historia de la historia española, 3 vol. (Madrid, 1924—90); A. Ballesteros y Beretta, Historia de España y su influencia en la historia universal, y vol. (Barcelona, 1918—41); R. Altamira y Crevea, Historia de España y de la civilización española, 4 vol. to 1808, 4th ed. (Madrid, 1928—99), with continuation to 1923 by P. Zabala y Lera, 2 vol. (Barcelona, 1930), A. History of Spanish Civilization, Eng. trans. by P. Volkov (1930), and A History of Spanish Civilization, Eng. trans. by M. Lee (1944); R. Menéndez Pidal (ed.), Historia de España (Madrid, 1935 fl.), and The Spaniards

in Their History (1950); J. P. de Oliveira Martins, A History of Iberian Civilication, Eng. trans. by A. F. G. Bell (1930); M. A. S. Hume, The Spanish People (London, 1901), W. C. Atkinson, Spain, a Brief History (London, 1934); A. Mousset, Histoire d'Espagne (Paris,

iberian Civilication, Eng. trans. by A. F. G. Bell (1930); M. A S. Hume, The Spanish People (London, 1931), W. C. Atkinson, Spain, a Brief History (London, 1934); A. Mousset, Histoire d'Expagne (Paris, 1947).

For pre-Roman and Roman Spain: P. Bosch Gimpera, El Pobla intento antiguo y la formación de los publos de Expaña (Marcion, 1943), and Etnología de la península libérica (Barcelona, 1931); A. Schulten and P. Bosch Gimpera, Fontes Hispaniae antiqua (Rarcelona, 1932), A. Schulten Hispania: geografia, tenología, historia, (Barcelona, 1920), Tarlessos (Hamburg, 1922), and tenología, historia, (Barcelona, 1920), Tarlessos (Hamburg, 1922), and tenología, historia, (Barcelona, 1920), Tarlessos (Hamburg, 1922), and tenología, historia, (Barcelona, 1922), H. Obermaier, Fossia Man in Spain, Eng. trans. by C. D. Matthews (1924), and, with H. Breuil, The Zow of Altaméra at Santillan del Mar, Eng. ed. (Machid, 1935); Z. C. H. V. Sutherland, The Carpenter, The Freeks in Spain (1925); C. H. V. Sutherland in Romans in Spain (Londona, 1939); P. Dixon, The Iberians of Spain (1946); Rhys Carpenter, The Freeks in Spain (1926); and articles by R. Knox McElderry, I. A. Richmond and C. H. V. Sutherland in the Journal of Roman Studies, vol. viii, ix, xrd and xxiv (1918-34).

For mediaeval Spain: A. Castro, España en su historia: Cristianos, Moros y Judios (Buenos Astro, España en su historia: Cristianos, Moros y Judios (Buenos Astro, España en su historia: Cristianos, Moros y Judios (Buenos Astro, España en su historia: Cristianos, Moros y Judios (Buenos Astro, España en su historia, Cristianos, Moros y Judios (Buenos Astro, España en su historia, Cristianos, Moros y Judios (Buenos Astro, España en su historia; Cristianos, Moros y Judios (Buenos Astro, España en su historia, Cristianos, Moros y Judios (Buenos Astro, España en su historia (1934), The Cid and His Spain, Eng. tr. by H. Sunderland (London, 1933); E. Lévi-Provençal, Historio de Arespagna and Catolonia (London, 1934); E. Lévi-Provençal, Historio de Arespagna (1934), An

### POPULATION

The Iberian peninsula has such important remains of most of the phases of civilization, from the later Palaeolithic Age onward, that the racial make-up of its population is, doubtless, highly complex. It is said that, as in the Dordogne in France and on the Welsh moorlands and elsewhere, very long-headed dark types which were characteristic of western Europe in the Aurignacian period of the Palaeolithic still occur among the people of the Basque provinces and Trás-os-Montes. The peninsula, generally, is inhabited by long-headed peoples without any of the large blocks of broadheads which characterize, for example, France and Italy.

The Basque language (q.v.) is a mysterious survival in the western Pyrenees (Navarre) and in the Basque provinces to the west Catalan, widely spoken in northeastern Spain, in Valencia and in the French Roussillon, is allied to Balearic speech and

Table I .- Population of the Provinces of Spain

TABLE 1.—	-Population	0) 1111 - 1111		·
				Density
l	Area in	Pop. in	Pop. in	per
Provinces	sq.mi.	1930	1950	sq mi.
1	DQ.III.	1931	1	in 1950
			ļ	
New Castile:	)			6
Madrid	3,000	1,383,951	1,926,311	623.4
Guadalajara .	4,709	203,998	203,278	43.2 80.0
Toledo Cuenca	5,925	489,396	527,474	51.0
Ciudad Real	6,588 7,622	309,526 491,657	335,719 567,027	74-4
Old Castile:	7,022	492,037	307,027	/4.4
Burgos	5,481	355,299	397,048	72.4
Logroño	1,946	203,789	229,791	118.1
Santander	2,108	364,147	404,921	192.1
Ávila	3,144	221,386	251,030	79.8
Segovia	2,682	174,158	201,433	75.1
Soria	3,977	156,207	161,182	40.5
Palencia	3 096	207,546	233,290	75-4
Valladolid	3,155	301,571	347,768	110.2
Asturias:			000	
Oviedo	4,207	791,855	888,149	211.1
León: Salamanca	0			86.6
Zamora	4,758	339,101	411,963 315,885	
León	4,082 5,937	280,148 441,908	544,779	77-4 91 <sub>-</sub> 8
Estremadura:	3,937	441,900	344,779	3.40
Badajoz	8,358	702,418	815,780	97.6
Cáceres	7,705	449,756	549,077	71.3
Galicia ·	1,11-3	449/10-	3497-11	,
Corunna	3,051	767,608	955,772	313-3
Lugo	3,815	468,619	508,916	133.4
Orense	2,695	426,043	466,302	173.0
Pontevedra .	1,695	568,011	671,609	396.2
Andalusia:				l
Almería	3,388	341,550	357,401	105.5
Granada	4,838	643,705	782,953	161.8 266.7
Málaga	2,813	613,160 668,862	750,115 781,908	
Jaén	5,300 5,209	674,415	765,697	147-5 147-0
Cádiz	2,827	507,972	700,396	247.8
Seville	5,429	805,252	1,099,374	202.5
Huelva	3,907	354,963	368,013	94.2
Valencia:	0,5-1	00475	0.,0	
Castellón de la				1
Plana	2,579	308,746	325,091	126.1
Valencia	4,239	1,042,154	1,347,912	318.0
Alicante	2,264	545,838	634,065	280.1
Murcia:				
Albacete	5,739	332,619	397,100	69.2
Murcia	4,369	645,449	756,721	173.2
Lérida	4,691	274 425	324,062	69.r
Gerona	2,264	314,435 325,551	324,002	144 6
Barcelona	3,033	1,800,638	2,232,119	735.9
Tarragona	2,426	350,668	356,811	147.1
Aragon:	.,,,	33-7-30	1	
Huesca	5,849	242,958	236,232	404
Saragossa				1
(Zaragoza)	6,608	535,816	621,768	94.1
Teruel	5,721	252,785	236,002	41.2
Navarre:		00		
Navarre	4,056	345,883	382,932	94.4
Basque Provinces:	9.6	40= 0==	760 700	68o.8
Vizcaya (Biscay).	836 728	485,205	569,188	513.8
Guipúzcoa Álava	1,176	302,329 104,176	374,040	100.4
Canary Islands:	1,1,0	104,170	1.0,012	100.4
Las Palmas .	1,565	250,991	375,227	239.8
Santa Cruz de	-,5-5	-3-799*	3/3/-2/	-03
Tenerife .	1,329	304,137	418,101	314.6
Balearic Islands .	1,936	365,512	422,080	2180
Total			ļ	7106
lotal	194,945	23,563,867	27,976,755	143.5

Provençal and differs from Castilian Spanish, though both are derived from Latin. Galician is akin to Portuguese.

It was usually the eastern, southern and western coasts of the peninsula that maintained contacts with ancient Mediterranean civilizations. This is one factor in the contrast in social and cultural traditions observable between Galicia and Asturias, on the one hand, and the rest of Spain. But in the main physical considerations, such as the natural differences between pluviose and arid Spain, have contributed no less than historical phenomena to

characterize and mark off one from another the great regions of

It has often been said that Roman Spain had a large population; estimates up to 50,000,000 have been ventured, but without the slightest foundation in fact. After a century of commercial expansion Catalonia had a population of only 300,000 in 1378. This region by 1940 contained about one-tenth of the total population, as a result of a relatively more rapid growth during modern times About 6,000,000 certainly seems to be the maximum figure for the population of all Spain at the close of the 14th century. On the basis of separate regional enumerations of households, the population at the end of the 16th century has been placed at 8,000,-000 Economic decay, war and pestilence probably brought about a decline in numbers during the next century. The effects of emigration to the new world were probably not so severe as contemporary writers supposed.

Modern demographic data begin with the census of 1787, which showed a population of 10,268,150 By 1857 this figure had grown to 15 495,212, and the census of 1897 enumerated 18,065,635 Relatively, Spain fell behind other European countries in the 19th century, while these countries were experiencing rapid industrialization

Population increased 26.7% from 1900 to 1930 and the ravages of the Civil War of 1936-39 did not prevent an increase (98%) in the decade 1930-40. In 1950 the population was 27,976,755, an increase of 8.1% over 1940.

Of the total population in 1950, the following 20 cities, all with more than 75,000 inhabitants, accounted for 19.8%; Madrid, 1.571.939, Barcelona, 1,278,605; Valencia, 467.989, Seville, 324,-553; Málaga, 240,899; Saragossa, 235,444; Bilbao, 225,812; Granada, 142,642; Córdova, 141,579; Valladolid, 115,157; Las Palmas de Gran Canaria, 142,116; Corunna, 122,620; San Sebastián, 90.846; Cádiz, 100,249; Santander, 85,640; Gijón, 86,523; Murcia, 84,757; Jerez de la Frontera, 80,161; Salamanca, 80,084; Santa Cruz de Tenerife, 75,412. Madrid, which was larger than Barcelona in 1920 but smaller in 1930, had recovered its position partly by means of the incorporation of adjacent townships The rate of growth in urban centres in the decade 1940-50 was uneven; Barcelona increased 18.4%; Madrid, 44.4%; Valencia, 14.2%; and Las Palmas, 45 2%. On the average the provincial capitals were 24.2% larger in 1940 than in 1930.

Religion.-Roman Catholicism is the established religion of Spain. There are o metropolitan and 61 suffragan sees. The primate of all Spain is the archbishop of Toledo. Meditation was the chief function of the orders for women, but more than half the religious houses for men concerned themselves with education.

With important exceptions, Spanish liberalism has been anticlerical. The influence of the church was curbed during the revolutionary period of 1868-74, but the restoration greatly favoured the growth of monastic and ecclesiastical institutions. Disestablishment was one of the first major objectives of the second republic in 1931. The clergy were removed from the state pay roll. religious bodies were prohibited from teaching and trading and the Jesuit order was expelled. After the civil war of 1936-39, the new regime restored the church, substantially, to its prerepublican position; confiscated property was returned to the orders, which were authorized to acquire by expropriation additional real property; religious education was reintroduced, divorce was suppressed and the cemeteries were returned to ecclesiastical jurisdiction. On June 7, 1941, the government signed an interim agreement with the Holy See regulating appointments to the Spanish hierarchy. In consultation with the papal nuncio the executive was to nominate six persons for each episcopal vacancy. The pope was then to designate three of these as a panel from which the chief of state was to fill the post. The dignitaries of the church subscribed to an oath of fealty to the state, (R. S. S.; X.)

Education.—"Every Spaniard has the right to education. whether at home or in private or public centres of instruction, at choice" (Fuero de los Españoles). A Primary Education bill of July 1945 envisaged the building of 100,000 primary schools additional to the 54,000 then in existence, of which 3,000 had been established since the Civil War. Church and other private interests may found schools; the church has the right to inspect the religious instruction which is compulsory in all All instruction is free and compulsory in theory from 6 to 12 years of age (the full primary course runs to 15) and must be given in Castilian, with separation of the sexes save in sparsely populated areas. The same official textbooks are used throughout the country. Figures for 1947-48 showed 55,111 public primary schools with 2,121,958 boys, 2,099,480 girls and 55,833 teachers. There were 53 training colleges. The officially admitted figure for illiteracy was 208%.

Secondary education follows lines laid down by a law of Sept. 1938. Of 212,210 pupils (girls 74,319) in 119 schools in 1947-48, more than one-half were at schools run by the religious orders, one-quarter at private lay schools (both fee-paying) and the remainder at free state schools. The course (bachillerato) runs from 10 to 17 years of age, terminating with a state examination conducted by the universities, to which this serves as entrance qualification. Choice of textbooks is free, subject to official approval; French is the first foreign language Teachers in state schools must be graduates, and there is again segregation of the sexes Technical secondary schools for working-class pupils were promised in a proyecto de ley of July 1949

University education is regulated by a law of July 1943. There are 12 state universities, Barcelona, Granada, La Laguna (Canaries), Madrid, Murcia, Oviedo, Salamanca, Santiago, Seville, Valencia, Valladolid and Saragossa (these serving as centres of the country's 12 educational districts), with a total of about 47,000 students, who pay fees. Madrid has seven faculties (philosophy and letters, law, political economy, science, medicine, pharmacy, veterinary science); Murcia and La Laguna, the most recent foundations, a faculty of law only, with one or two other isolated departments. Entrants must pass, in addition to the state examination mentioned above, a qualifying faculty examination. Hostels (colegios mayores) house a proportion of the students The university city of Madrid, largely destroyed in the Civil War, was rebuilt and enlarged. Religious instruction is compulsory for all students, but theological training is reserved to church seminaries. There is no university autonomy, rectors and teaching staff being state-appointed.

# GOVERNMENT, ADMINISTRATION AND DEFENSE

The "new state" promulgated no formal constitution but five fundamental laws of the nation: the Labour charter (March 1938), the Law of the Cortes (July 1942), the Fuero de los Españoles (a charter of rights, July 1945), the National Referendum law (Oct. 1945) and the Law of Succession (June 1947). With the lastnamed the formative period of the regime was held to have ended. Its article r defined Spain politically as "a Catholic, social and representative state hereby constituted, in accordance with tradition, a kingdom." General Franco, head of the state, would be succeeded eventually by a king, being a person of the blood royal acceptable to the council of the realm, the government and the Cortes or, failing such, by a regent equally acceptable.

A regency council of three, appointed ex officio, would act in an interregnum. A name for the succession might be proposed to the Cortes at any time by General Franco: in his default, by government and council of the realm acting jointly. Such king or regent must swear the fundamental laws and fidelity to the principles of the national movement. A term and conditions might be set to a regency. Kingship would be hereditary, subject to the foregoing, and restricted to males. In pursuance of this law, General Franco resuscitated in Oct. 1947 the power of the head of the state to create titles of nobility.

The council of the realm, instituted by the Law of Succession, is the supreme consultative body, advising the head of the state on all matters of his exclusive competence, such as declaring war or making peace, the choice of a successor and the exclusion of royal personages from the succession. Seven of its 14 members are ex officio, 4 elected by the Cortes and 3 nominated by the head of the state. The Cortes, established by a law of July 1942 as the "superior organism for the participation of the Spanish people in the work of the state," discusses and may propose laws, the

head of the state, who with his ministers normally initiates legislation, having the power of veto. Ministers, members of the Falangist national council (reduced from 100 to 50 in 1946), civil governors, mayors of provincial capitals and heads of universities and of other learned bodies are members (procuradores) ex officio. The head of the state nominates as many as 50 more: a further so are elected to represent provincial municipalities; and syndicalist associations elect representatives of employers, technicians and workers, in equal numbers, up to a total of one-third of the whole. Elected members serve for three years. The Cortes functions both as a whole, to consider all major legislation, and by commissions. It has no control over the government, though members may ask questions of ministers Laws of outstanding importance are submitted further to national referendum, a procedure of 1907 reinstituted in 1945, in which all citizens over 21 years of age are required to vote. The head of the state presides over the cabinet, on which the secretary-general of the Falangist party sits without portfolio. General Franco stated in 1945 that the Falange no longer wielded any political power.

Local Government.-The statutes of regional autonomy passed by the republic were abrogated after the Civil War (Navarre and Alava, however, having sided with the nationalists, were in 1941-42 confirmed in possession of their traditional concierto económico, whereby in return for a block contribution to the exchequer they enjoy rights of financial autonomy); and legislation dealing with provincial and municipal government was modified The 50 provinces-named, except for Navarre, the 3 Basque provinces and the Balearics, after their capitals-are officially regarded as intermediary administrative units between state and municipality. The provincial council (diputación) is elected partly from representatives of municipalities, partly from economic, cultural and professional bodies; councillors serve for six years, half their number changing every three years. The displacement of politically disaffected diputaciones by administrative commissions (comisiones gestoras) nominated by the civil governor, a measure introduced under the dictatorship of Pumo de Rivera, was invoked on occasion under Franco. Even without this, the civil governor, appointed by the government and responsible to the minister of the interior, effectively controls the life of the province. He is answerable for public order, through the civil guard and in the last resort the army, exercises delegated state authority and may suspend decisions of the council. The mancomunidad or interprovincial association for the integration of common interests-best exemplified in that of the four constituent provinces of Catalonia instituted in 1914 and suppressed in 1939-continues in the Canary Islands (two provinces since 1028).

A municipal law of July 1945 laid the bases of municipal administration. In towns of 10,000 inhabitants and more the mayor (alcalde) is appointed by the government, in smaller communities by the civil governor of the province. (Municipalities may be either urban or rural and number in all 9,342.) The first elections since 1936 took place in Nov.-Dec. 1949, one-third of each council (ayuntamiento) being elected from among representatives of heads of families, the other two-thirds, in equal numbers, from those of syndical organizations and of economic, cultural and professional bodies, all Spaniards over 21 years of age having the vote. The mayor is regarded as a delegate of the central government and under its orders, whether intimated directly or through the civil governor, the council tending in consequence to fill a merely advisory function. The Institute of Local Administration founded in Madrid in 1940 had among its objects the training of local government officials and employees.

Judicial System and Law.—The principle of the independence of the judiciary, proclaimed by the republican constitution of 1931, remained for some time in abeyance after the Civil War, the new regime availing itself freely of legal process for political ends, notably through the tribunal of political responsibilities (1939) and the tribunal for the repression of Freemasonry and Communism (1940). Penal legislation at this stage was often retrospective, and the oath required of all judges, magistrates and fiscals bound them first to unconditional adhesion to the caudillo,

only secondly to "the upright and impartial administration of justice" By the Fuero de los Españoles (1945) no Spaniard may be held for more than 72 hours without being handed over to a judicial authority or be sentenced unheard or for a crime antedating the law in question. Judges and magistrates are now irremovable save as is provided for by law.

"Pending the definitive organization of the administration of justice m the New State," the supreme court was reconstituted in Aug. 1938. The president and 15 of its 20 members became direct, the remaining 5 indirect. government appointees Appeals are not admitted to its administrative division (contencioso administrativo) against government decisions There are 15 regional provincial serves as court of first instance for criminal offenses Below these are the 554 district judges, who hear civil cases in first instance, and the 9,342 municipal judges (not commonly lawyers) who deal with petty offenses and minor civil issues in each municipality. The jury system exists except for military trials.

Spanish law is founded on Roman law, Gothic common law and surviving elements of mediaeval customary and local law. Modern substantive law includes the civil code of 1889, much indebted to that of France; the penal code (1870; revised 1877 and 1932); the commercial code (1885), the labour code (1926) and the codes of civil and criminal procedure (1881–82). Numerous decrees and laws of the "new state" have modified or abrogated important sections of the statute law in force in 1936.

Defense.—On the conclusion of the Civil War the army was reorganized (July 1939), the standing army consisting of eight corps in Spain, corresponding to the eight military regions (capitanias generales) of Madrid, Seville, Valencia, Barcelona, Saragossa, Burgos, Valladolid and Coruna (numbered in that order and known by number), two in Morocco, two general commands in the Balearics and the Canaries, an independent cavalry division and the general artillerly reserve, making in all 25 divisions. A ninth military region (Granada) was constituted in Jan. 1944, of one division only. General Franco, as head of the armed forces, is chief of the supreme general staff and of the national defense council. Compulsory military service (two years) was instituted in Aug. 1940. The Falangist militia was dissolved in Dec. 1943.

The navy possesses 6 cruisers built between 1923 and 1936 (from 4,686 to 10,670 tons), 22 destroyers, 9 sloops, 9 mine layers, 6 submarines, 7 mine sweepers, 16 motor torpedo boats and various smaller craft, with, in 1951, 14 destroyers, 4 submarines and 7 mine sweepers under construction. The naval dockyards are at Ferrol, Cartagena and, on a smaller scale, Cádiz. Officers and ratings, including marines, total 22,300.

An "army of the air" was created by decree of Oct. 1939, which divided Spain into five air regions, with the Balearics, the Canaries and West Africa, and Morocco as three more. There are an air branch (with special sections including parachutists) and air infantry (for nonflying duties, including aerodrome defense). Personnel are trained at an air staff college, an air force academy and various technical schools.

Of the total ordinary budget for 1951, 5,704,000,000 pesetas or 31.6% was allotted to the armed services. (W. C. An.)

## ECONOMICS

Agriculture—Spain is essentially an agricultural country. More than 55% of the population work on the land (47% as casual labourers, 29% as landowners and 16% as tenant farmers in 1948); and in 1950 approximately 50% of the national income was derived from agricultural products, which supplied the bulk of the nation's food and were the principal source of foreign currency. In general the land is arid and poor. About two-thirds of it suffers from aridity; in certain small irrigated regions round the edges of the peninsula there exists a very productive soil, but the large central tableland (Meseta) consists chiefly of moorland, steppe pasture or desert. The agricultural yield per acre was thus less than that of other western European countries. Of a total area of 50,000,000 ha, about 17,000,000 ha (of which a quarter lay fallow), were under crops, while natural pasture and

shrubs (pastos y montes) covered about 23,500,000 ha. and cultivated trees and shrubs 3 500,000 ha

The progress of agriculture was not only handicapped by climatic conditions, it was also long retarded by the resistance of the landed classes to legislation for its development. The best land was for centuries in possession of the church or nobles. Cultivation, particularly in the central provinces, was sacrificed to large-scale sheep farming. During the first half of the 19th century extensive areas of common land were purchased by the middle classes. Estimates made c. 1930 showed that in Estremadura, Andalusia and La Mancha about 7,000 landed proprietors (most of them absentees) owned 15,000,000 ac. Living conditions for the tenant farmers and the landless labourer (often unemployed) were precarious. In attempting to redress this, the republican government met such opposition that little improvement was made before the outbreak of the Civil War.

Agricultural technique remained on the whole out-of-date, and mechanization (even in the 1950s) was rare. Irrigation, which is really vital to Spanish agriculture, had long been planned. Lack of capital and later the Civil War held up its development. Until the Civil War Spain did, however, manage to be selfsupporting in many agricultural products and even to produce a surplus for export in some In the immediate years following the conflict, agricultural production fell by 20% and cereal by 30%. The decrease in cereal acreage was the result of the imposition of control prices, the lack of fertilizers and machinery. Producers found more profit in industrial crops such as cotton, tobacco, esparto, vegetables and fruits (whose prices were not controlled). Some slight recovery in cereal production took place however after 1945 under the encouragement of the government. Nevertheless, whereas before 1935 Spain was almost self-sufficient in essential foodstuffs, in later years considerable quantities (particularly of

wheat) had to be imported.

Under General Franco attempts to improve agriculture were begun by the establishment in Oct. 1939 of the National Institute of Land Settlement, a successor to the republic's Institute of Agrarian Reform. Subsequent legislation included steps to buy develop and break up among small holders various large and unproductive estates; to select certain areas for irrigation and general development; to reorganize and combine existing agricultural organizations; to introduce a more helpful system of loans; and to promote some technical agricultural training.

In 1950, however, land was still divided very unequally (45% of farming land being occupied by farms of more than 100 ha. [I ha. = 2.471 ac.] and 30% by those of less than 5 ha.), and much depended on casual labour. Most small farms were uneconomical, and the rate of agricultural unemployment was high (permanent workers in 1948 were about 8%). Spain remained the least fertilized country in Europe because of a lack of nitrogenous fertilizers (new plant, however, was increasing the supply) and one in which scientific and mechanical cultivation was still out-of-date. Hence agriculture was failing to support the workers dependent on it or to provide for the basic needs of the country as a whole.

Crop Distribution .- Wheat was by far the most important cereal of the country, being chiefly grown in parts of León, of Old and New Castile and of Aragon and, to the southwest, in Estremadura and Andalusia. Except in good years, yield before 1939 was less than 10 q. (110 metric quintals=1 short ton) per hectare (total annual production was 4,400,000 q. before the Civil War, to be compared with 2,200,000 q. in 1947 and 4,800,000 in 1951). Barley and to a lesser extent oats and rye were the next important cereals. Barley (the chief grain fodder) was the principal product of the southeast but was subordinated to other cereals elsewhere: oats and rye were grown on the poorer soils, with rye (and maize) predominating in the northwest. Rice, a staple food in Spain (the second producer in Europe) was chiefly grown in Valencia and

Murcia. Other widely grown products were pulses (again a staple diet-chiefly chick-peas, dry peas, broad beans, dry beans and lentils) and potatoes (whose output had after 1945 become inadequate for home consumption). Onions occupied an area of more than 15,000 ha, which produced nearly 3,000,000 q in 1950.

Olives were one of the greatest sources of agricultural wealth; the chief producing district was Andalusia with less important areas in Catalonia, Castile and Estremadura. Around 98% of the crop was used to extract olive oil (600 tons in 1951). The cultivation of vines (1,432,000 ha. or 3% of the total area in 1950) was widespread; table wines were produced in La Rioja district and Catalonia, dessert wines in Valencia and Málaga, sherries in the southwest and brandy in Jerez. Must wine was exported in large quantities to France for blending. Total wine production in 1950 was 1,568,000 tons.

Fruit growing and market gardening (13% of the national production) were second only to cereals in Spain, and an increasing acreage was devoted to this type of agriculture. Citrus fruits (particularly oranges), stone and soft fruits and vegetables formed the basis for a large dried or tinned export trade.

Esparto, hemp and flax (more than 1,000,000 quintals in 1950) and cotton were produced in appreciable quantities as increasing attention was paid to industrial crops. Tobacco was principally grown in Granada (30,000 tons in 1950) The silk industry from silkworms bred in Murcia and Alicante (which produce 98% of Spain's natural silk) had declined considerably by 1950 to a total

The most important industrial food crops were sugar cane and sugar beets (the latter industry being nationalized); produce was 23,300 tons of sugar cane and 153,200 tons of sugar beets in 1950 Secondary industrial food crops were peanuts, the red pepper plant and aniseed. (See Table II.)

TABLE II .- Principal Crops: Areas Sown and Yield\* (in ooo ha and tons)

Crop		rage	19	49	19	50	1951		
		Ha.	Tons	Ha	Tons	Ha.	Tons	Ha	Tons
Wheat . Barley . Oats . Rye . Maize . Pulses . Potatoes . Sugar Beets	:	4,557 1,895 776 593 435 733 440 89	4,364 2,394 670 551 709 531 4,954 2,150	4,100 1,490 750 570 360 816 360 93	3,035 1,460 500 489 540 316 2,560 1,330	4,100 1,550 650 640 375 789 360	3,380 1,500 500 560 610 317 3,000 1,379	4,200 1,544 628 622	4,400 1,800 580 510 650 4,000
Rice		47	293	57	280	58	240	60	285

\*Figures for these and other commodities, even when official, should be regarded simply as indicating general trends.

Livestock.-Draught and working animals in 1950 still played an important part in Spanish agricultural life, as methods of tillage were primitive, roads bad and tractors insufficient. Plowing was done by cows or oxen; mules and asses were used for transport. Horses, mules and asses were bred chiefly throughout Catalonia and the basin of mules and asses were bred chiefly throughout Catalonia and the basin of the Ebro, in the Cantabrians and in Andalusia. Sheep were bred in all parts of the country and especially in the provinces of Estremadura and Old Castile. After World War II there was a marked increase in their number. The three basic breeds were Churro (long-woolled), Merino (short-woolled) and Manchegan. The wool of the Churro (found mostly in Old Castile) is a coarse variety; the fleece of the Marino (of which Scoit were had a secreptable its owner and secreptable is only and silly and Merino (of which Spain long had a monopoly) is curly and silky and yields a fine wool. All breeds give a good supply of milk, and the Manchegan a savoury mutton.

Pigs were raised chiefly in the western provinces and in Galicia. Cat-Pigs were raised cheirly in the western provinces and in Galicia. Cat-tle were bred mostly in the northwest and north—for all purposes. Dairy farming was practically confined to this area and even there was on a small scale. In other parts of the country cows were raised for working and meat production. Table III gives figures for livestock. Fishing.—Spain has a coast line of nearly 2,000 mi.; but good natural harbours are found only in Galicia, which proviace, with its sheltered inlets, was the main source of the fishing industry. Principal fish were scripings anchouse hake tunny and bream and shellfish and

fish were sardines, anchovies, hake, tunny and bream and shellfish and crustaceans in large quantities. After the second decade of the 20th century the catch showed a steady increase: 135,600 tons in 1917; 387,000 in 1934; 481,600 in 1944; and 501,000 in 1950. By 1950 the fishing fleet consisted of nearly 40,500 vessels, totalling 238,000 tons.

TABLE III .- Livestock

		Year				Horses	Mules	Asses	Cattle	Sheep	Goats	Pigs	
1919 1935 1948	:	:	:	:	:	594,300 800,000 608,000	1,069,400 1,479,000 1,078,000	1,104,500 999,000 747,000	3,396,500 4,215,000 3,300,000	19,337,400 17,325,000 15,921,000	3,070,600 4,690,000 4,222,000	4,228,900 5,141,000 2,688,000	

Forestry.-The area occupied by woodlands in 1940 totalled 7,292,000 ha, of which 2,610,000 were under pines, 873,000 under oak, 418,000 under beech. 125,000 under poplar and 3,266,000 under miscellaneous trees Cork (of which the Iberian peninsula has almost a monopoly) was produced from the cork oak principally in Andalusia and Catalonia, and the centre of the industry was Catalonia (production 75,000 tons in 1950) Products derived from the many varieties of Spain's aromatic plants included oil of rosemary, lavender and essences of sage, thyme, sweet majoram, etc

Minerals.-Spain has, since the time of the Phoenicians, been known as a rich storehouse of mineral wealth and was, before the disknown as a non-source or infinite weath and was, before the unservery of deposits outside Europe, a leading world producer of copper, mercury, lead and iron ore. The exploitation of other regions, together with Spain's political instability, lack of capital, etc., contributed during the 20th century toward a serious decline in the relative importance of the country's output.

The more important pining areas are situated as follows: in the

The more important mining areas are situated as follows: in the extreme north, that is, in the Basque provinces and the Asturias, particularly Vizcaya, Santander, Oviedo and Lugo, where both iron ore and coal are found, in the Sierra Morena area of the southwest, that is, in the invitwestern provinces of Andalusia (Seville, Huelva, Córdoya and Jaén), where are deposits of coal, lead and copper; and finally in the Sierra Nevada region of Murcia and Almería in the southwest, which has iron ore, lead and zinc

The number of workers in the mines was (1950), 154,000.

Coal—Spain being geologically composed largely of igneous rocks, carboniferous strata are relatively rare. The largest occur in the Cantabrian mountains of the north, where the Asturian coal field (about 1,000 sq.mi.) is the most important. It produces about 75% of Spain's Smaller basins exist in the other northern provinces the south there are two main areas and several minor ones in the lower hills of the Sierra Morena Finally, small fields exist in the extreme northeast (the provinces of Barcelona and Lérida).

normeas the provinces of barceiona and bernay.

Coal production was greatly stimulated by World War I, reaching an annual production of more than 7,250,000 tons in 1918. After a temporary decline in the immediate postwar years, it again reached this mark, but the Civil War brought a setback in production. After the outbreak of World War II, production again increased considerably, reaching a total of 11,400,000 tons by 1950. This fell considerably short of national requirements and (with coking coal) was supplemented by imports from the United States, Great Britain, Belgium, France and the Ruhr. The greater proportion of Spanish coal was of an inferior quality, and the amount of anthractic small. The country had to im-

port higher-glade coal.

Iron and Copper Ore and Pyrites.—Iron ore and pyrites were chiefly found in the Cantabrian provinces, particularly Vizcaya, where ores with an average iron content of 50% occur. Large-scale exploitation began c. 1875, and in the first decade of the 20th century the area was reading a composition annually. By 1038 this figure had fallen to producing 5,000,000 tons annually. By 1938 this figure had fallen to less than 2,000,000; i.e., to somewhat less than half the national output. Iron ore was also found in central and southern Spain, but its quality was not so uniformly good nor was it as easily worked as in the north. Deposits of iron pyrites with a large sulphur content were found in Deposits of iron pyrites with a large sulphur content were found in fuelva and Seville. The total production of iron ore steadily decreased to approximately 500,000 tons in 1945 but showed some recovery in subsequent years, when more mines, which had suspended operations, were encouraged by higher prevailing prices to resume production. Spain tor many years was a leading producer of copper ore and pyrites (in which a small proportion of copper was usually found with iron). The principal 20ne was in the Sierra Morena, particularly western Seville (El Castillo), and Huelva (the region between the Odiel and the Guadiana and along the Rio Tinto). Output of copper and pyrites has varied considerably: 3,750,000 tons in 1913; 1,500,000 in 1918; 10,000,000 in 1938; 10,000 ton 1939. Output of copper or alone was 68,100 in 1940 and 252,000 in 1950 (metal content 1.2 and 5.1).

Lead Ore.-In the earlier years of the 20th century Spain was second Lead Ore.—In the earlief years of the 20th century Spain was second to the United States in the production of lead. The chief area was to the east of the Sierra Morena, particularly the districts of Linares, La Carolina (in the province of Jaén), with a less prolific one to the west in Córdova. A second area lay in the southwestern provinces of Murcia and Almeria. Deposits also existed in the north, especially in Santander.

Mercury.—Spain remained one of the chief producers of mercury, Most important were the mines of Almadén in the central province of Cludad Real (exploited since Roman times), which still possessed in 1950 immense reserves. Other lesser supplies were found in Oviedo and on the southern slopes of the Sierra Nevada in Granada. Output

and on the southern stopes of the Sterra Nevada in Granada. Output has decreased, except for brief periods, since the end of the 19th century, when the mines of Almadén alone produced around 2,000 tons annually. Other Minerals—Other mineral ores found in Spain were manganese (in the provinces of the Asturias, Huesca, Ciudad Real and Huelva), in ore together with wolfram (in the northwest) and zinc (in Santander and southeastern Murcia). Between 1918 and 1939 the production of these minerals tended to decline, but in later years their importance to armaments stimulated output. Small deposits of many other metals, such as cobalt, nickel, antimony and hismuth also occur. Spain has for many centuries been well known for its precious metals. Silver was found ailled to the lead ore, especially in Murcia, Almeria, Jaén and Córdova, and in 1950 gold was still being worked in Almeria.

Other mineral products particularly include potassic salt in the Catalan basin, sulphur at Hellen (Albacete) and Libros (Teruel), rock sulphur and asphalt. Table IV illustrates the production of the principal

TABLE IV .- Mineral Production (in metric tons)

Mineral	1935	1939	1945	1950
Coal Lignite Pyntes* Iron Ore* Lead ore* Zinc* Mercury (distilled)	6,946,000 321,000 2,185,000 1,320,000 61,700 45,000 1,229	6,606,000 194,000 1,548,000 1,150,000 28,700 49,000 1,238	10,732,000 1,351,000 693,000 550,000 27,600 32,000 1,403	11,400,000 1,345,000 1,490,000 1,044,000 39,500 62,400 691
Manganese (NO <sub>2</sub> content) Tungsten ore*	1,500	1,800	9,500	7,400 510
Tin concentrates Phosphates	166 20,000	10,000	20,000	58a 10,000
Salt Potash* Sulphur	920,000 126,000 9,000	819,000 26,000 6,000	700,000 121,000 7,000	1,169,000

\*Metal or salt content

Industries.- The industrial areas of Spain comprised a few small regions within the predominantly agricultural country. Industrial development was seriously retarded by long periods of internal strife and

veropinelis was seriously retardited by long periods of interial surface and of specific properties of the properties of the and of capital and a certain social and religious traditionalism. Progress was, however, stimulated by World War I, which helped the expansion of existing industries and introduced new ones. After 1978 these industries, protected by tariffs, extended still further. In the early 1930s, however, an increasing social unrest reversed that properess, and finally the Civil War left all industries in chaos and semiruin. Spain's neutrality during World War II gave the government an opportunity to restore the position somewhat

Textiles - From the late middle ages textiles were being made in the towns near the wool-producing areas, for example Segovia, Cuenca, Guadalajara, Burgos, Béjar; silk making was established in the provinces of Murcia, Seville and Valencia. But, with the advent of electricity and the importation of wool and cotton, the woollen and silk industries declined in many of these centres.

Textiles, of which cotton was by far the most important, were in the middle of the 20th century Spain's most important industry. Their principal area was Catalonia, where modern technique was first applied to the industry. There 90% of the cotton industry, 75% of the wool and most of the rayon became concentrated. Less important areas were Valencia, the Basque provinces and Andalusia The cotton industry had about 68,000 looms with more than 2,250,000 spindles in 1910, 72,000 looms (chiefly automatic and mechanical) with more than 2,000,000 spindles by 1933, and 96,400 looms with 2,342,000 spindles in 1950. The number of workers in the industry in 1950 was 162,000. Barcelona and its district was by far the most important centre of textiles. Subsidiary textile industries, again mostly concentrated in Catalonia and particularly around Barcelona, comprised flax, hemp and jute, silk and hosiery

Metallurgy.—Spain's output of minerals was only devoted in a minor degree to the domestic metallurgical industry. The principal area of this was centred on Bilbao (which produced the greater part of Spain's pig iron and steel); a second area was round La Felguera, Albana, Moreda-Gijón in the Asturias and Santander (iron and steel); a third area was in Valencia (steel); and a fourth area was in the producing regions of the Sierra Morena Production of iron and steel in 1950, though higher than in 1935, was still well below what it had been in the peak year of 1929, and the shortage was handicapping secondary industries.

industries.

Copper refineries were chiefly situated in the province of Huelva and at Córdova, lead smelters at La Carolina and Linares (province of Jaén). Lead smelting was also to be found at Cartagena and La Unión (Murcia), zinc smelting at Reocin (Santander) and Castrillon

(Oviedo).

(Oviedo). The main centres of shipbuilding were at Bilbao, Barcelona, Gijón, Valencia, Cartagena and Cádiz; locomotives, rolling stock and machinery were manufactured at Bilbao, Barcelona, Valencia and Saragossa; armament centres were found at Trubia, Oviedo, Seville and Eibar. The electrical industry, which developed steadily after 1939, was found in most of the larger towns and especially in Barcelona, Córdova, and Eibar. The number of workers in the various metallurgical industries in 1950

was about 100,000. For production see Table V.

Chemical Industry.—Domestic mineral resources formed the basis

of a diversified and growing chemical industry, though sometimes their exploitation was found uneconomical because of transport costs. Phosexploitation was found uneconomical because of transport costs. Phosphates (largely imported from North Africa) were converted into superphosphates with sulphuric acid produced from pyrites. Such production was found chiefly in the seaboard provinces of Santander, Valencia, Murcia and Barcelona. Spain was also a large producer and exporter of potassic salts and by the 1950s was trying to develop the domestic exploitation of nitrate resources, so as to lessen dependence on imports from Chile. Other Spanish chemical products included sulphuric and nitric acids, paints, dyes, pharmaceuticals and explosives.

Table V -Metallurgical Production (in metric tons)

	1935	1939	1945	1951
Pig tron Crude steel Lead Zinc Blister copper	3 10,000 595,000 71,100 12,100 10,200	482,000 584,000 26,000 13,400 6,100	489,000 576,000 27,100 17,300 6,620 807	608,400 811,200 41,040 21,240 6,360
Tin Rolling-stock material	451,000	140	375,000	461,0001

11050

Miscellaneous Industries - The food industries were mainly based on the milling of cereals, the production of wines and oils and the curing of fish The refining of olive oil and processing of wine were widespread; fish products were manufactured chiefly in the northern and northwestern coastal towns; sugar refining was found especially in Saragossa and Granada. Good timber resources were raie; but two valuable forestry products were cork and resin The old established papermaking industry, chiefly dependent on raw imports, was centred in the Basque provinces and Catalonia Other industries included the production of cement (more than 2,500,000 tons in 1950), china, pottery and glass, leather and tobacco

Power—Spansh; coal is chiefly of an inferior quality and the country of the country of the control of the control of the country of the count

try's resources are insufficient to meet domestic demands Deposits of oil are likewise relatively negligible, the only important source being in the province of Ciudad Real. Water power was directly used to drive

many mills throughout the country.

The use of electrical power has been progressively developed, but the potentialities of the country were incompletely realized in this respect. Total electrical capacity (principally hydraulic as a lack of coal restricts thermic production) was 1,643,000 kv.amp. in 1933 (roughly 66% hydraulic) and grew from 2,000,000 to 2,200,000 between 1939 and 1947 Output was 2,896,000,000 kw.hr. in 1933; 5,600,000,000 in 1947, 7,265,000,000 (5,430,000,000 hydraulic and 1,835,000,000 thermic) in 1950 and 9,840,000,000 in 1952.

The north of the country was the chief source of hydroelectricity,

of which one-half was derived from the Pyrenean rivers and from the Ebro and its tributaries and one-quarter from the Cantabrian rivers. Plants of a much lesser capacity supplied power drawn from the rivers of the Sieria Morena and the Sierra Nevada The national system links the former grid systems of Catalonia, Valencia and Murcia, etc. (i.e., the southeast), Madrid, Andalusia, the Asturias and the Basque provinces; and plans were launched in 1944 to increase the total capacity of the reservoirs from 5,000,000 to 18,000,000 cu.m.

Communications.—The total length of roads in Spain was around

68,700 mi. in 1950 (cf., 46,650 in 1919 and 57,200 in 1932). The well-developed Roman system had been allowed to fall into decay, and in mediaeval times the only good paved roads were the pilgrimage ways. In the latter part of the 18th century the main (royal) routes were improved, but after the Peninsular War little repair or development took place until the 1920s. The Civil War resulted in another rapid de-terioration. Traffic on the roads was relatively small, and mostly con-centrated around Madrid and Barcelona (195,000 vehicles were registered in 1950).

tered in 1950). The first Spanish railway was opened in 1848, but later construction proceeded very slowly. By 1917 the total length of lines was 9,260 mi. (of which 2,189 were narrow gauge). By 1950 this length had reached 11,200 mi (75% broad gauge); 938 mi were electrified. Railways of standard gauge (1.676 m.) were nationalized in 1949. Only a few of the main lines were double tracked, and the mountainous nature of the

country restricted load and speed capacities considerably.

The rivers of the country are unsuitable for inland navigation because of variations in flow and in gradient and on account of their use for irrigation. Very few navigation canals were constructed. The Guadalquivir is the most important waterway, being navigable by ocean-going vessels for 54 mi., to Seville. The Ebro is the chief navigable river on the east and carried a certain amount of shallow-draught

Spain's mercantile navy increased from 884,000 tons in 1914 to 1,286,000 (its highest tonnage on record) in 1924. But in relation to world tonnage, Spain's proportion fell between 1896 and 1933 from 2,7% to 1.8%. The merchant fleet suffered severely during the Civil War but received extensive government aid after 1941 and had reached

a tonnage of 1,250,000 in 1952. Commerce.—Spain's commerce in relation to its size and geographical position was relatively small. Trade was mostly with northwestern trai position was relatively small. Trade was mostly with northwestern Europe and with the United States. Mineral ores and foodstuffs were exchanged for manufactured goods. A secondary trade was maintained with Latin America and with the Spanish colonies, in which small quantities of manufactured articles were re-exchanged for raw ma-

qualitates of maintactured altitudes well: e-channinged to law ma-terials. Trade policy was closely controlled. After 2018 a high customs barrier was erected, particularly for cotton. Before 1920 Spain's imports (worth 2,000,000,000 pesetas annually) were roughly matched by its exports. From that year until after 1946 Spanish trade suffered from abnormal conditions. The international crisis of the early 1930s was followed within three years by the Civil War, and trade sank to a quarter of what it had been before 1930. During World War II there was a pronounced recovery, but for several

years after 1945 the balance of trade was again unfavourable. The government tried to improve the situation by concluding numerous bilateral trading agreements and by negotiating various foreign loans (See Table VI.) In 1952 there was again a large adverse trade balance

(See I able VI.) In 1932 there was again a large adverse have bearing.

Before 1936 Great Britain provided one-tenth of the total imports and took one-quarter of the total exports of Spain. Imports from Great Britain were chiefly wool, metal and textile goods; exports were foodstuffs and wines and mineral ores. After 1946 Spanish exports to Great Britain had an increasingly favourable balance over its imports. Exports amounted to £18,697,500 and imports to £9,695,000 in 1949; and the figures for 1951 were £40,176,000 and £1,804,000 respectively.

TABLE VI -Foreign Trade (in ooo,ooo gold pesetas)

Item	1935	1940	1942	1945	1948	1950	1951
Imports	875	621	604	863	1,433	1,195 2	1,176 0
Exports	586	394	629	881	1,107	1,190 4	1,413 6
Balance	— 289	227	+25	+18	-326	-4 8	+237 6

With the United States the balance was very unfavourable to Spain. Cotton and petroleum were the chief imports, and exports mainly food products and wine. France, Spain's second largest customer before 1940, used to supply light machinery, chemical products, fine woollen and silk textiles and luxury articles in return for fruits, wines, vegetables and mineral ores. The closing of the Franco-Spanish frontier (1946-Feb. 1948) tended to retard the resumption of this trade after World War II. Germany was before the war Spain's second largest supplier and third largest purchaser. Of other European countries, Belgium and the Netherlands were Spain's chief trading partners Trade with the Latin-American countries chiefly concerned Argentina (which supplied creals, meat and hides) and Chile (nitrates). After World War II Spain attempted to supply Argentina with minerals, textiles and shipping equipment but was unable to carry out the undertakings.

Finance.—Spain has for centuries been unable to free itself of na-

tional insolvency. From 1808 expenditure always exceeded revenue, though some appearance of solvency might have been manipulated. Rarely were estimates of revenue fulfilled, and the balance of unpaid debts carried on from year to year was considerable. National accounts worsened considerably during the Civil War and the cost of reconstruction afterward absorbed any increase in revenue. Table VII shows specimen deficits that were actually budgeted for in certain years from 1932 but fails to reveal the actual state of insolvency. Actual revenue and expenditure, for instance, were 12,278,000,000 pesetas and 14,197,000,000 pesetas (cf,12,984,000,000 pesetas and 14,223,000,000 pesetas budgeted estimate) in 1947 and 13,137,000,000 pesetas and 15,421,000 pesetas (cf,15,115,000,000 pesetas and 15,196,000,000 pesetas) in 1948.

TABLE VII .- Budgets (in ooo.ooo pesetas)

	1934	1936	1937-39	1943	1950
Revenue	4,573	4,421	4,700	9,440	17,848
Expenditure .	4,600	4,569	12,000	9,456	18,052
Balance .	-27	-148	7,300	-16	204

The gap between revenue and expenditure was narrowed after 1939 by increased taxation on income, profits and real property and in the excise duties.

excise duties.

The funded national debt on Jan. 1, 1936, was 21,850,000,000 pesetas. Funding operations after 1939 included issues of 2,000,000,000 pesetas in 4% and 2,750,000,000 pesetas at 3% on treasury loans and the conversion of former 4½% and 5% long-term state loans to 4% and of short-term loans to 3%. The public debt then amounted, in 1940, to 28,900,000,000 pesetas, of which 1,200,000,000 pesetas in 1,200,000,000 pesetas, of which 1,200,000,000 pesetas in termal debt 2,108,000,000 pesetas; treasury bonds 8,700,000,000 pesetas; and guaranteed loans 1,145,000,000 pesetas. 1,145,000,000 pesetas. In 1950 the budget authorized new issues of government bonds amounting to 2,680,000,000 pesetas for para-statal bodies and 204,000,000 pesetas to cover the budget deficit.

Prices.—Deficit financing, the enormous cost of reconstruction and

Prices—Deficit financing, the enormous cost of reconstruction and the effect of World War II contributed to strong inflationary tendencies in 1939-43, which persisted unabated in the following years. The note issue of the Bank of Spain, which reached 4,800,000,000 pesetas in 1935, rose to 9,300,000,000 pesetas in July 1940 and soared to 15,700,000,000,000,000,000 pesetas, the figure showing an increase of 4,600,000,000 pesetas in three years. Wholesale prices advanced only 39% during the Civil War, but from 1940 to 1946 the price index increased 108%. The cost of living rose over the same period 102%, although the food component of the index increased 128%. To

arrive at a true index figure, however, the official figure should probably be increased by at least 50% to 60%. (See Table VIII.) Social Welfare and Labour.—In 1908 a National institute was established for granting old-age pensions and administering a scheme of social insurance; its funds came from endowments, state subsidies and donations.

TABLE VIII .- Price and Cost-of-Living Index (Tuly 1036=100)

	I	tem					1940	1945	1948	1950(Nov )
Wholesale pr Cost of living				•	•		176	305		382
Food All items		:	:	:	:	:	215 178	347 275	599 483	390 315

Extensive schemes for social and labour reform were envisaged by General Franco's administration in 1938. Compulsory social insurance was introduced in 1939. Based on contributions from employers and workers, it provided for family subsidies and national health benefits This was extended in 1948 to old-age pensions and sickness benefits Cost-of-living bonuses were from time to time granted to various categories of workers, and subsidies were allotted to provide employment in various agricultural areas.

ment in various agricultural areas.

Spain has a long history of tade corporations and guilds, which in the middle ages were often of a religious origin Guilds were abolished by a 10yal decree of 1836, and Spain's later domestic politics were scarcely favourable to the growth of more modern unions. Under the second republic (1931–36) the unions were unfettered by supervision

second republic (1931-39) the unions were interested by agic viscoin and became active political as well as social and economic organizations. Under General Franco a system of national or vertical syndicates (from the raw material to the marketing stage in every industry) was formed for each industry and for agriculture. These syndicates came to normen for each moustry and for agriculture. These syndicates came to control the whole economic activity of the country. In each district national syndicalist centres or horizontal syndicates backed by labour courts settle such problems as working hours, conditions of labour, wages and industrial disputes. (J\_D L)

wages and industrial disputes.

Bibliography—Anuario Estadistico de España; Overseas Economic
Survey: Spain (HM.S.O., London, 1949); G. Brenan, The Face of
Spain (London, 1950); M. Fuentes Irurozqui, Viaje a través de la
España economica (Madrid, 1948).

SPAIN, CODES OF. (For mediaeval codes, see Fuero; Germanic Laws, Early.) The codes in force at the present time cover a considerable part of the legislation of Spain.

They are: (1) The Código fundamental; 1e, the constitution of the state of 1876, which was preceded by the constitution of Cádiz of 1812, and that of 1869. (2) The Código civil, comprising the law on status, rights and duties of persons (primarily Spaniards) considered as active members of society from birth to death. It came into force on May 1, 1889, and in the same year was applied to Cuba, Puerto Rico and Philippine Islands. As in the Code Napoléon, the Roman concepts were followed. code in fact carried out the directions of the Ley de Bases of May 11, 1888. (3) The Código de comercio of 1885 which came into force on Jan. 1, 1886, following the code of 1829, was framed on the model of the French code of commerce with improvements taken from French jurisprudence and the previous local laws of Spain, such as the Novisima Recopilacion and the Ordinances of Bilbao. (4) The Código de enjuiciamiento civil (civil procedure) of Feb. 3, 1881. (5) The Código de enjuciamiento criminal of Dec. 22, 1872. (6) The Código penal of 1870. (7) The Ley Hipatecaria (mortgage law) of 1870. These have all been modified by subsequent legislation.

SPALATIN, GEORGE, the name taken by George Burkhardt (1484-1545), an important figure in the history of the Reformation, who was born on Jan. 17, 1484, at Spalt (whence he assumed the name Spalatinus), near Nuremberg, where his father was a tanner. He went to school at Nuremberg, and afterward to the University of Erfurt, where he took his bachelor's degree in 1499. There Nikolaus Marschalk, the most influential professor, made Spalatin his amanuensis and took him to the new University of Wittenberg in 1502. In 1505 Spalatin returned to Erfurt to study jurisprudence, and was welcomed by the little band of German humanists of whom Mutianus was chief. He became a teacher in the monastery at Georgenthal, and in 1508 he was ordained priest by Bishop Johann von Laasphe, who had ordained Luther. In 1509 Mutianus recommended him to Frederick III the Wise, the elector of Saxony, who made him tutor to his nephew, the future elector, John Frederick. The elector sent him to Wittenberg in 1511 and procured for him a canon's stall in Altenburg. He managed all the elector's correspondence.

Spalatin's letters to Luther have been lost, but Luther's answers remain and are extremely interesting. Spalatin read Luther's writings to the elector, and translated for his benefit those in Latin into German. He would have dissuaded Luther again and again from publishing books or engaging in overt acts against the papacy, but when the thing was

done none was so ready to translate the book or to justify the act.

On the death of Frederick the Wise in 1525 Spalatin no longer lived the Saxon court But he attended the imperial diets, and was the at the Saxon court at the Saxon court But he attended the imperial delts all the constant and valued adviser of the electors, John and John Frederick. During the later portion of his life, from 1526 onward, he was chiefly engaged in the visitation of churches and schools in electoral Saxony, reporting on the confiscation and application of ecclesiastical revenues and he was asked to undertake the same work for Albertine Saxony. He was also permanent visitor of Wittenberg university. He died on Jan 26, 1545, at Altenburg

Jan 26, 1545, at Altenburg
His writings include Annales reformationis, ed. by E. S. Cyprian
(Leipzig, 1718), and "Das Leben und die Zeitgeschichte Friedrichs
des Weisen," published in Georg Spalatins Hittorischer Nachlass und
Briefe, ed. by C. G. Neudecker and L. Preller (Jena, 1851). A list
of them may be found in A. Seelhem's George Spalatin as sichs.
Historiographer (1876). There is no good life of Spalatin, nor can
there be until his letters have been collected and edited, a work still
to be done. There is an excellent article on Spalatin, by T. Kolde, in
Herzog-Hauck, Realency-klobadus. BA viii (1766). Herzog-Hauck, Realencyklopadie, Bd. xviii (1906).

SPALATO or Spalatro: see Split or Spljet.

SPALDING, ALBERT (1888-1953), U.S. violinist, was born at Chicago, Ill., on Aug. 15, 1888. At seven he commenced his musical studies under Ulpiano Chiti in Florence, continuing them with Juan Buitrago in New York city and Narcisse Lefort in Paris. Spalding's debut was made in 1905 in Paris, where in 1906 he appeared with Adelina Patti. His first American appearance was with the New York Symphony orchestra in 1908. During World War I he served with the U.S. aviation corps in Italy. He played at La Scala, Milan, in 1919 His compositions include many works for the violin. He wrote an autobiography, Rise to Follow (1943). Spalding resumed his concert career in 1945 and died May 26, 1953, in New York city.

SPALDING, a market town and urban district in the parts of Holland, Lincolnshire, Eng. Pop. (1951) 11,031. Area, 12.2 so.mi. It is the centre of an extremely fertile fenland area, visited in spring for its flowering bulb fields; it cans locally grown fruit and vegetables and has a large beet-sugar factory and a livestock market (1938). The Welland river passes through the town by a deep channel. The parish church (once the priory church) of SS. Mary and Nicholas dates from 1284. Ayscoughfee hall (15th century, now belonging to the town) was the house of Maurice Johnson, a founder of the Spalding Gentlemen's society (1710), probably the earliest antiquarian society in England; its museum includes birds and antiquities.

SPALLANZANI, LAZARO (1729-1799), Italian priest and biologist, was born at Scandiano in Modena on Jan. 10, 1729 At the age of 15 he was sent to the Jesuit college at Reggio di Modena, and soon went to study law at the university of Bologna, where his kinswoman, Laura Bassi, was professor of physics; she, it is said, first interested him in science. After taking orders, he was professor at Reggio, Modena and, under Maria Theresa, at Pavia, where he enriched the museum by the collections from journeys along the shores of the Mediterranean. In 1785 he was invited to Padua, but his sovereign doubled his salary and gave him leave to visit Turkey, where he made many observations. He visited Vesuvius and Sicily in 1788 and embodied his researches in Viaggi alle due Sicilie (1792-97).

Spallanzani was a skilled experimenter in physiology. He studied

the circulation of the blood, respiration, digestion, the senses of bats, the electricity of the torpedo, the breeding of cels and the regeneration of different appendages of Amphibia, following the muscles, nerves and bones with a microscope. By filtering the semen he proved that spermatozoa were necessary for fertilization in different animals. He spermatozoa were necessary for tertuization in dinerent animais. He artificially inseminated a bitch. He supported the preformation theory of embryology. In a controversy with J. T. Needham he disproved (1765) the spontaneous generation of Infusoria, which did not develop in vegetable infusions that had been boiled long enough and kept in properly closed vessels. His great works are the Prodomo di un'opera da imprimersi sopra le reproduzioni animali (Modena, 1768); and Dissertazioni de fisica animale e vegetabile, 2 vol. (Modena, 1780). He died at Pavia on Feb. 12, 1799. (A. C. Ce.)

SPANDAU, a suburb of Berlin, Germany. Pop. (1933) 146,-408. Spandau is one of the oldest places in the Altmark, and received civic rights in 1232. It afterward became a favourite residence of the Hohenzollern electors of Brandenburg, and was fortified in 1577-83. In 1635 it surrendered to the Swedes, in 1806 to the French and in 1813 to Prussia. Spandau was the chief garrison town of Prussia and contained the imperial war treasure. It was

united with Greater Berlin in 1920.

SPANDRIL, SPANDREL in architecture a space between any arch or arch-like form and the horizontal moulding or beam above it; also, in an arcade, the wall surface between two adjacent arches and any horizontal member above them. In buildings of skeleton construction such as steel-framed skyscrapers, the term refers to the space between the top of a window and the sill of that in the story above.

SPANGENBERG, AUGUST GOTTLIEB (1704-1792), German Monavian bishop, Count Zinzendorl's successor, was born on July 15, 1704, at Klettenberg, on the south of the Harz mountains, where his father. Georg Spangenberg, was court preacher and ecclesiastical inspector of the countship of Hohenstein. Left an orphan at the age of 13, he was sent to the Gymnasium at Ilefeld, and from there in 1722 he passed to the university of Jena to study law. Professor Johann Franz Buddeus (g v) received him into his family, and a stipend was procured for him.

He soon abandoned law for theology; he took his degree in 1726 and began to give free lectures on theology. He also took an active part in a religious union of students, in the support of the free schools for poor children established in the suburbs of Jena and in the training of teachers In 1728 Count Zinzendorf visited Jena, and Spangenberg made his acquaintance; in 1730 he visited the Moravian colony at Herrnhut A collegium pastorale practicum for the care of the sick and poor was in consequence founded by him at Jena, which the authorities at once broke up as a Zinzendorfan institution. But Spangenberg's relations with the Moravians were confirmed by several visits to the colony, and only the accident of an unfavourable appeal prevented his appointment as chief elder of the community.

His free lectures in Jena led to an invitation from Gotthilf Francke to the post of assistant professor of theology and superintendent of schools connected with his orphanage at Halle. He started work there in Sept. 1732, but differences between the Pietists of Halle and himself soon became apparent. He found their religious life too formal, external and worldly; and they could not sanction his comparative indifference to doctrinal correctness and his incurable tendency to separatism in church life. Spangenberg's participation in private observances of the Lord's Supper and his intimate connection with Count Zinzendorf brought matters to a crisis. He was offered by the senate of the theological faculty of Halle the alternative of doing penance before God, submitting to his superiors and separating himself from Zinzendorf, or leaving the matter to the decision of the king, unless he preferred to "leave Halle quietly," The case came before the king, and, on April 8. 1733. Spangenberg was conducted by the military outside the gates of Halle.

At first he went to Jena, but Zinzendorf at once sought to secure him as a fellow labourer, though the count wished to obtain from him a declaration which would remove from the Pietists of Halle all blame with regard to the disruption. Spangenberg went to Herrnhut and found among the Moravians his lifework, having joined them at a moment when the stability of the society was threatened. He became its theologian, its apologist, its statesman and corrector, through 60 long years of incessant labour.

For the first 30 years (1733-62) his work was mainly devoted to the superintendence and organization of the extensive missionary enterprises of the body in Germany, England, Denmark, Holland, Surinam, Georgia and elsewhere. It was on an island off Savannah that Spangenberg startled John Wesley with his questions and profoundly influenced his future career. One special endeavour of Spangenberg in Pennsylvania was to bring over the scattered Schwenkfeldians to his faith. In 1741-42 he was in England collecting for his mission and obtaining the sanction of the archbishop of Canterbury. During the second half of this missionary period of his life he superintended as bishop the churches of Pennsylvania, defended the Moravian colonies against the Indians at the time of war between France and England, became the apologist of his body against the attacks of the Lutherans and the Pietists and did much to moderate the mystical extravagances of Zinzendorf, with which his simple, practical and healthy nature was out of sympathy. The second 30 years of his work

(1762-92) were devoted to the consolidation of the German Moravian Church. Zinzendorf's death (1760) had left room and need for his labours at home. At Herrnhut there were conflicting tendencies, doctrinal and practical extravagances, and the organization of the brethren was very defective. In 1777 Spangenberg was commissioned to draw up an idea fidei fratrum, or compendium of the Christian faith of the United Brethren, which became the accepted declaration of the Moravian belief. As compared with Zinzendorf's own writings, this book exhibits the finer balance and greater moderation of Spangenberg's nature. In his last years Spangenberg devoted special attention to education He died at Berthelsdorf, on Sept. 18, 1792. In addition to the Idea fidei tratrum. Spangenberg wrote, besides other apologetic books, a Declaration über die seither gegen uns ausgegangenen Beschuldigungen sonderlich die Person unseres Ordinarius (Zinzendorf) betreffend (Leipzig, 1751), an Apologetische Schlussschrift (1752), Leben des Grafen Zinzendorf (1772-75); and his hymns are well known beyond the Moravian circle.

BIBLIOGRAPHY —In addition to his autobiography (Selbsibiographie), see J Risler, Leben Spangenbergs (Barby, 1794); K. F Ledderhose, Das Leben Spangenbergs (Heidelberg, 1846); Otto Frick, Beitrage zur Lebensgeschichte A. G. Spangenbergs (Halle, 1884); Gerhard Reichel's article in Herzog-Hauck's Realencyklopadie (ed. 1906), s.v. "Spangenberg"; the article by Ledderhose, in the Allgemeine deutsche Biographie; also Moranylars Retthers.

SPANISH-AMERICAN ARCHITECTURE. The high quality as well as the great quantity of colonial architecture in Spanish America establish it as a major contribution of the New World to the history of civilization. The zeal and power of the Spanish church were abetted by the wealth of the colonies in the construction of sumptuous ecclesiastical buildings. Skilled Indian labour also contributed to the early development of large-scale programs in both religious and domestic architecture. Types of buildings and styles are Spanish in origin, although local conditions produced modifications. Occasional Indian influence in remote regions is limited chiefly to decorative details and to a flat primitive method of carving. In centres of European culture such as Santo Domingo, Mexico City, Ouito, Lima and Cuzco architectural styles are contemporary with those in Spain. Mediaeval traditions survive, however, especially in monastić structures, even in the 17th century, the persistence of late-Gothic ribs in the vaults of churches being the most striking feature. Spanish-Moorish elements (Mudejar), such as wooden ceilings in geometric patterns. coloured tiles, the rectangular frame of an arch (alfiz), and the trefoil arch, were popular throughout Spanish American architecture, and they account for much of its exotic character.

Sixteenth Century.- In Santo Domingo, site of the first Spanish settlement, is preserved the earliest cathedral (1521-41), which has a superb Spanish Renaissance façade and a Gothic interior. In Mexico, large building campaigns (c. 1550-1600) were carried out by Franciscan, Augustinian and Dominican friars. Their monasteries generally have a huge vaulted church of single nave, cloister and monastic buildings, based upon Spanish proto-types. The large atrium yard and the "open chapel" for religious services out-of-doors are special features developed in America to accommodate crowds of Indians, as at Acolman, Cuernavaca, Huejotzingo, etc. Portals display a wide variety of styles, including mediaeval and Renaissance elements and occasional Indian influences. The largest Mexican cathedrals, those of Mexico City (1563-1813) and Puebla (1575-1690), have the rectangular basilican plan and other features of the Andalusian Renaissance. Their long delayed completion, however, resulted in a mixture of styles. Important monuments of Peru were destroyed by earthquakes, the surviving structures of modest character being found in Ayacucho, on the shores of Lake Titicaca and in Sucre (Bolivia). Vaulted churches were virtually unknown in South America until the 17th century. In Quito (Ecuador) the Franciscan and Dominican monasteries are notable for their cloisters and Mudeiar ceilings, and the cathedral (1562-1572) is an example of Andalusian Gothic-Mudejar construction.

Seventeenth Century.—Notably sober is the architecture of the first half of the 17th century, preserving the late classical style of the Spanish architect of the Escorial, Juan de Herrera. This austerity characterizes San Agustín and Santo Domingo in Puebla as well as the façade of the cathedral. Most awesome is the cathedral (1598–1654) of Cuzco, Peru, rectangular in plan, and Herreresque in its sobriety except for the early Baroque portal. With the building of the Jesuit church there, the handsome façade being designed in 1664 by Diego Martínez de Oviedo, Cuzco created the first school of late Baroque architecture in the Americas. The city abounds in handsome churches and palaces, built of Andean stone in the second half of the 17th century, and it is in many respects unrivalled in America. At Lima the rebuilding of the monastery of San Francisco (1657–73) brought a new wave of Hispano-Mauresque (Mudejar) influence in the geometric designs of the plaster work. The main portal (1674) of the church inaugurated in that city the late Baroque type of façade, closely resembling a carved altarpiece.

In Bolivia the chief architectural centre was Sucre, where Gothic vaults pessisted, but otherwise both religious and domestic buildings adhered to simple classical designs. The Jesuit church in Bogotá, Colombia, owes its Italianate classicism to the architect, Father Coluccini, who came from Italy. The greatest masterpiece of Jesuit architecture in America is, however, the church in Quito, Ecuador. There the Mudejar patterns, which stand out in gold against a red background, make the interior (1605–89) of the church unforgettably sumptuous. More provincial, though extremely colourful Mudejar interiors, are characteristic of the monastic churches of Tunja (Colombia). Due to the splendid designs of its monastic buildings, Quito stands with Cuzco as one of the major schools of architecture in South America.

Bighteenth Century.—The final stage of Baroque architecture in Spanish America is generally distinguished by richly sculptured façades, whereas the interiors often remain sober settings for resplendently carved and gilded altarpieces. The late Baroque altar of spiral columns was imported from Spain about 1650-60. Its translation into stone on the façade of a church first occurred (1697-1704) in South America in La Merced at Lima, to be followed by San Agustín in Lima and three splendid churches in Cajamarca.

In this period appeared in southern Peru and Bolivia a school of architectural decoration characterized by native Indian contributions in the primitive manner of carving and in the introduction of non-European ornament. The crossbred style is known as mestizo, because it, like the people, is compounded of European and native Indian stock. Evidences of Indian contribution are also found in Mexico throughout the colonial period, and there exist parallel phenomena in Central America. The first examples of the independent Peruvian-Bolivian style are preserved in Arequipa where the façade (1508) of the Jesuit church represents a culminating point in the tapestrylike treatment of the walls. A masterpiece is Santiago at Pomata (about 1509–1722), but most extraordinary of all is the façade of San Lorenzo at Potosí. Among other fine examples are the façade (1700–07) of the Jesuit church at Potosí and San Francisco (1753–72) at La Paz.

Argentina lay in the outer periphery of the Spanish colonies, and its early architecture consisted of provincial chapels of ruble and adobe, with the exception of the Jesuit monastery (1654–79) at Córdoba. In the 18th century two Italian Jesuit architects, Blanco and Prímoli, established the spacious style of the Italian Baroque in the Jesuit estates of Alta Gracia and Santa Catalina near Córdoba, and in El Pilar at Buenos Aires.

Baroque architecture reached its climax in Mexico with lavishly carved façades in which the tapering pilaster (estipite) is a distinguishing feature. Introduced in the capital in the Sagrario façade (1749-68) under the architect Lorenzo Rodríguez, it spread like fire and reappeared in La Santísima, in the Jesuit semi-ary at Tepozotlán, in the churches of Guanajuato, etc. The school of Puebla maintained independence in producing an extra-ordinary array of brilliantly coloured exteriors of glazed tiles, both in churches and in countless palaces. Mixtilinear contours in doorways, windows, and roof levels create highly picturesque effects in Mexican buildings of this period.

Throughout Spanish America, cities were built on a gridiron

plan with rectangular plaza in the centre and covered sidewalks (portales) of Mediterranean tradition. Houses, large or small, were arranged about a central patio. Although handsome domestic buildings exist throughout the continent, special mention should be made of those in Mexico City, Puebla, Tunja, Potosí and Cuzco. Most remarkable civil edifices, such as the custom house and viceregal palace, survive in Mexico City, whereas elsewhere only the royal mint at Potosi (1753–73) and the government palace (1764) in Antigua, Guatemala, are comparable in importance. Spanish colonial architecture came to an abrupt end with the triumph of Neoclassicism (1800) Thereafter European revivalism prevailed until the advent (1930) of the international style of steel, concrete and glass with Argentina and Mexico in the vanguard.

BILLUGRAPHY—Hispanic Foundation of the Library of Congress, Handbook of Lain American Studier, vol. 3-16 (Cambridge and Gainsville, 1938-53); R C Smith and E. Wilder, Guide to the Art of Latin America (Washington, 1948); M J. Buschiazzo, Bibliografia de arte choind argentino (Buenos Aires, 1947); Angulo and Marco Dorta, Historia del arte hispanoamericano (Barcelona, 1-11, 1945, 1950); P. Kelemen, Baroque and Rococo in Latin America (New York, 1951); G. Kubler, Mexican Architecture of the Sixteenth Century (New Haven, 1948); M Toussaint, Arte colonial en México (Mexico City, 1948); H. E. Wethey, Colonial Architecture and Sculpture in Peru (Cambridge, 1940).

SPANISH-AMERICAN LITERATURE. For more than 300 years after its discovery Hispanic America was culturally as well as politically an Iberian colony. The conquistadors and the missionaries who accompanied them wrote the first Spanish-American literature in the letters and reports which they sent home telling of their victories with sword and cross. Foremost among these are the letters from Columbus to the Spanish court and the five dispatches, so-called Cartas de relación, sent by Hernán Cortés (1485-1547) to the emperor, Charles V. Longer accounts of the conquest and descriptions of the New World, La conquista de México v de la nueva España by Francisco López de Gomara (1510-60), Verdadera historia de la conquista de la Nueva España by Bernal Díaz del Castillo (1492-1584), and Sumario de la natural y general historia de las Indias by Gonzalo Hernández de Oviedo y Valdés (1478-1557) followed. The oppressed Indians found a champion in Fray Bartolomé de Las Casas (1474-1566) whose Brevisima relación de la destrucción de las Indias appeared in 1552. Later, one of their own blood, the Inca Garcilaso de la Vega (1540?-1616), told their story in his Comentarios reales (Pt. I 1609, Pt. II 1617).

Before the end of the 16th century Mexico and Lima had become centres of intellectual activity. A printing press was set up in Mexico in 1539 and charters for a university were granted both cities in 1551. The extent to which letters were cultivated at the viceregal courts may be inferred from the fact that in a contest held at Mexico in 1585 more than 300 poets took part. The outstanding poetic achievement of this period was the epic of the conquest of Chile, La araucana (1569-89), written by a young Spanish officer, Alonso de Ercilla y Zúñiga (1533-94), who himself had taken an active part in the exploit and been moved by the valour and dignity of his enemies. The same material was used by a native Chilean poet, Pedro de Oña (1570-1643), in his Arauco domado (1506) with less distinction. These epics and the long descriptive poem, La grandeza mexicana (1604) by Bernardo de Balbuena (1562-1627), are significant in that, though they follow the European fashion in poetic form-Ariosto's epics were then in vogue-they deal with genuine American themes of which the authors had expert, first-hand knowledge.

The cult of Góngora, which in the 17th century superseded in Spain that of the Italian poets, called forth the first important piece of literary criticism in America, the Apologético en Javor de D. Luis de Góngora (1694) by Juan de Espinosa Medrano, as well as the lyrics and prose selections of the anthology, Ramillete de varias flores poéticas (1675), collected by Jacinto de Evia (b. 1636). The great Mexican-born dramatist, Juan Ruiz de Alarcó, (c. 1580-1639)—generally counted among the poets of Spain, since his plays were all written and published in that country—is comparatively free from the affectations of this school. His gifted comparative, the "tenth Muse," Sor Juana Inés de la Cruz

(1651-95), shows its influence in some of her works, but the fame of this extraordinary woman rests chiefly on the simpler beauty of her autobiographical lyrics.

No hterature of outstanding value was produced in Spanish America during the 18th century. The later years of the century were years of political unrest. Revolutionary pamphlets imported from France urged the cause of independence. When the wais of liberation broke out in the first decades of the 19th century, America produced pamphleteers of its own, among them the fiery Benardo de Monteagudo (1785-1825) of Argentina and the Mexican satirist José Joaquín Fernández de Lizardi (1776-1827), publisher of the journal El pensador mexicano (1812) and author of the first real American novel, the picacesque tale El periquillo-sarmento (1816). Simón Bolívar (1783-1830), the great liberator, nourished from childhood on the works of Rousseau, wrote distinguished prose in his Discourses and letters composed during the campaigns.

In all parts of Spanish America the victories of the revolution called forth patriotic verse. La victoria de Junin. Canto a Bolivar by José Joaquin Olmedo (1784-1847) of Ecuador was the most successful of these poems. Among other talented poets who wrote in the cause of liberty were José María Heredia y Heredia (1803-29) of Cuba, best known for his ode to Niagara; José Fernánce Madrid (1784-1830) and Luis Vargas Tejado (1803-29) of Colombia; Juan Cruz Varela (1794-1839) of Argentina; and Anérés Bello (1781-1865, of Venezuela. Bello, who was to become later one of Spanish America's greatest scholars, is remembered, however, not for his political verse but for his Silva a la agricultura de la zona torrida.

At the close of the revolutionary period the poets of America came under the influence of the prevailing European literary fashion, romanticism. Standing, as it did, for freedom, individualism and emotional intensity, romanticism seemed made to fit Spanish-American conditions and temperaments. Many of the poets were political as well as literary "liberals" The young Argentine, Esteban Echeverría (1805-51), who had returned from a stay in Paris in 1830, published the first important romantic work, the poem of the pampas, "La cautiva" (in Rimas, 1837). Echeverría and his associates-among them. Juan María Gutiérrez (1809-78), compiler of the anthology, América poética, and José Mármol (1818-81), author of El peregrino, a South American Childe Harold, and of the famous political novel, Amalia (1851)-as political refugees from the tyranny of Rosas, carried the new fashion from Argentina to Uruguay and Chile. In Mexico Ignacio Rodríguez Galván (1816-42) and Fernando Calderón y Beltrán (1809-45) followed the Spanish romantics Espronceda and Zorrilla as lyric poets and dramatists. Though the favourite genre of the romanticists was lyric poetry, two important novels were produced during this period, Mármol's Amalia and the Maria of Jorge Isaacs (1837-95). Later phases of romanticism were represented in Mexico by Ignacio Manuel Altamirano (1834-93) and in Argentina by Olegario Victor Andrade (1838-83) and Juan Zorrilla de San Martín (1855-1931), author of the Indian epic, Tabaré.

Two indigenous literary genres without European prototype also were developed during the latter half of the 19th century. One of these was the so-called "gaucho poetry" of Argentina and Uruguay. The life of the gaucho had long been the subject of folk tale and ballad. It had been used in the Dielogues of Bartolomé Hidalgo (1788–1823). It had been given serious study in the great work of Domingo Faustino Sarmiento (1811–88), Civilización y barbarie: Vida de Juan Pacundo Quiroga. It now received epic treatment in José Hernández's Martín Fierro (1872) and La vuelta de Martín Fierro (1879). It formed the basis of Estanislao del Campo's masterpiece Fausto (1866).

The other genre, which appeared at about the same time, was the creation of the Peruvian Ricardo Palma (1833-1910), who in his famous Tradiciones peruanas (first series 1872) elevated the historical anecdote to the realm of art.

In 1888 a Nicaraguan poet, Rubén Darío, published a volume of poems and short stories called Asul which had a profound effect on the letters of the Spanish-speaking world. It was the basic work of the modernista movement, a cult of beauty which urged

the enrichment of poetry with new forms, new rhythms, new words. Precursors of the movement may be found in the Cuban poet and patriot José Martí (1853–95), in the Mexican Manuel Gutiérrez Nájera (1859–95) and in the Colombian José Asunción Silva (1865–96). Dario was its high priest and perhaps the greatest poet which Spanish America has produced. Other famous adherents of the movement were Leopoldo Lugones (1874–1938) of Argentina, Amado Nervo (1870–1919) of Mexico and Julio Herrera y Reissig (1875–1910) of Uruguay.

In reaction to the formalism and the escapist tendencies of the modernistas there soon appeared in Spanish America a movement which concerned itself with the subject matter of literature. This was variously known as "Americanismo," "Criollismo" or. "New Worldism" In its broadest aspect it was essentially a gospel of nationalism and racial solidarity. Its prophet was the Uruguayan José Enrique Rodó (1872–1917), the "Latin Emerson," who wrote his message in the essay Ariel (1899). It was introduced into poetry by José Santos Chocano (1875–1934) and into the drama by Florencio Sánchez (1875–1910) and the lesser playwrights of the teatro criollo of Argentina and Uruguay. It has been most fruitful in the development of prose fiction.

Indeed, the remarkable development of prose fiction in Spanish America is the most significant phenomenon of the 20th century. Some eminent poets have appeared, notable among them the former Chilean schoolmistress Gabriela Mistral (Lucila Godoy Alcayaga) (1889—), winner of the Nobel poetry prize in 1945; Delmira Agustini (1886—1914); Juana de Ibarbourou (1895—

); Alfonsina Storni (1802-1038); Enrique Banchs (1888-); Rafael Arévalo Martínez (1884-); Pablo Neruda ). But as the countries of South America have de-(1904veloped economically and industrially, their writers have become increasingly concerned with the inequalities and injustices in their social environment and have found the novel or the short story the best medium for the expression of this concern. All phases of contemporary life have been reflected in fiction: ranch life in the works of Carlos Reyles (1868-1938), Ricardo Güiraldes (1886-1927), Javier de Viana (1872-1926); life on the plains of Venezuela by Rómulo Gallegos (1884-); life in the tropical jungle by José Eustasio Rivera (1889-1928); life in the city by Manuel Gálvez (1882-); life in a Peruvian Indian village ); life in the Uruguayan forests by by Ciro Alegría (1909-Horacio Quiroga (1878-1937). In Mexico an influential group of "novelists of the revolution," Mariano Azuela (1873-1952), Gregorio López y Fuentes (1895-) and Martín Luis Guzmán ) dealt realistically with the agrarian, industrial, racial and religious problems resulting from the upheaval in Mexican society which began in 1910.

The Spanish Civil war (1936-39) and World War II brought a conflict of loyalties and increased emotional tension to many countries of Spanish America, but they produced no new literary trends that were immediately discernible. Prose fiction dealing with contemporary problems continued to be the favourite literary medium. There was evidence of a heightened awareness of the importance of political and racial problems and a strong conviction on the part of many writers that their countries have an important contribution to make toward the solution of these problems.

lems.

Bibliography.—Alfred Coester, The Literary History of Spanish America (New York, 1928); Arturo Torres Rioseco, The Epic of Latin American Literature (New York, 1942); Pedro Henriquez Ureña, Literature (Literature (Cambridge, 1945); E. Herman Hespelt et al., ed., An Anthology of Spanish American Literature (New York, 1946); Hispanic Foundation of the Library of Congress, Handbook of Latin American Studies (Cambridge and Gainsville, 1935-

SPANISH-AMERICAN WAR OF 1898. On Feb. 15, 1898, the U.S. battleship "Maine" was destroyed in Havana harbour by an explosion, with a loss of 266 lives. An American board of inquiry made an extensive examination of the wreck, and reported to the navy department on March 21 that the explosion was caused by an exterior mine, the principal reason for this decision being the upheaval of the ship's bottom. On April 20 President McKinley approved a resolution demanding the with-

drawal of Spain from Cuba and setting noon of April 23 as the latest date for a reply. Before this could be delivered by the American minister in Madrid, the Spanish government sent him his passports. On the 22nd the president declared a blockade of Cuban ports; on the 24th the Spanish government declared war; and on the 25th the United States congress declared that war had existed since the 21st. The joint resolution of congress of April 20 had declared that relinquishment by Spain of authority in Cuba was the object of American action; the struggle thus naturally centred about the island and all operations were thus at hand. The regular United States army, the only available force until war was declared and a volunteer force was authorized, had been assembled at Tampa, Fla., New Orleans, La., and Chickamauga, Ga., but until the control of the sea was decided, the army could not prudently be moved across the Strait of Florida The Spanish fleet under Pascual Cervera, which had left the Cape Verde Islands for the West Indies, was the real objective of the navy, and had to be settled with before any military action could be undertaken. Accordingly Rear-Admiral William T. Sampson left Key West early on April 22, and began the blockade of Havana and the north coast of Cuba. His North Atlantic squadron of 28 vessels of all kinds, of which the armoured cruiser "New York" (flag), the battleships "Iowa" and "Indiana," and the monitors "Puritan," "Terror" and "Amphitrite" were the most important, and which included 6 torpedo boats, was increased to 124 vessels by July 1.

Battle of Manila Bay .- In the Pacific, the American squadron—the protected cruisers "Olympia" (flagship of Commodore George Dewey), "Baltimore," "Raleigh" and "Boston," the small unprotected cruiser "Concord," the gunboat "Petrel," the armed revenue cutter "Hugh M'Culloch," with a purchased collier "Nanshan" and a purchased supply ship "Zafiro"-left Hong Kong at the request of the governor and went to Mirs bay, some miles east on the Chinese coast. Ordered (April 25) to begin operations, particularly against the Spanish fleet, which he was directed to capture or destroy, Dewey left Mirs bay on the 27th, and arrived off Luzon, in the Philippines, on April 30. The Spanish admiral Montojo anchored to the eastward of the spit on which are the village and arsenal of Cavite, in a general east and west line, keeping his broadside to the northward. His force consisted of the "Reina Cristina," the "Castilla" (an old wooden steamer which had to be towed), the "Isla de Cuba" and "Isla de Luzon" (protected cruisers of 1,050 tons), the "Don Juan de Austria" and the "Don Antonio de Ulloa" (gunboats of about 1,150 tons) and the "Marques del Duero" (of 500 tons).

Dewey passed into the Boca Grande, paying no attention to rumours of torpedoes, and at midnight passed El Fraile. When he sighted the Spanish squadron to the southward he stood down in column with the "Olympia," "Baltimore," "Raleigh," "Petrel," "Concord" and "Boston" at 400-yd. intervals. When within 5,000 yds. he ported his helm, and at 5:41 A.M. opened fire. He stood westward along the Spanish line, using his port batteries, turned to starboard and stood back, gradually decreasing his distance to 2,000 yds. At 7:35 Dewey withdrew and gave his men breakfast. Before he re-engaged at 11:16 the "Cristina" and "Castilla" bad broken into flames, so that the remainder of the action consisted in silencing the Cavite batteries and completing the destruction of the smaller Spanish ships. The victory was complete. All the Spanish ships were sunk or destroyed. The injury done U.S. ships was practically nil. The Spanish lost 167 killed and 214 wounded, out of a total of 1,875. The Americans had 7 slightly wounded out of 1,748 men in action. Dewey took possession of Cavite and awaited the arrival of a land force to capture Manila.

Santiago.—Cervera had left the Cape Verde Islands on April 29 with four armoured cruisers, the "Almirante Oquendo," "Inanta Maria Teresa" and "Vizcaya" (sister ships of 7,000 tons) and the "Cristobal Colon" (same size; differently equipped) and three torpedo-boat destroyers. On hearing (May 1) of Cervera's departure, Sampson went east to San Juan, Puerto Rico, with the armoured cruiser "New York," the battleships "Iowa" and "Indiana," the cruisers "Montgomery" and "Detroit," and one torpedo boat. He reached San Juan on the 12th. Cervera was not present, and Sampson at once started back for Havana. Cervera

reached Santiago de Cuba early on the 10th without being sighted en route. It was not until the end of the month that the American fleet was assembled before the harbour. An attempt was made to sink the collier "Merrimac" in the entrance channel, which was less than 200 ft. broad in parts available for ships. The preparations for a quick sinking were chiefly carried out by naval constructor Richmond P. Hobson, who went in, in the early morning of June 3, with a crew of seven men. The steering gear was disabled by a shell. and the ship drifted too far and was sunk in a broad part of the channel where it did not block the egress of Cervera's squadoron.

On June 6 the hatteries at the entrance were bombarded and their weakness was ascertained. Sampson thereupon placed, every evening, a battleship close in, with a searchlight turned on the channel, making it impossible for the Spanish squadron to escape by night. The port of Guantánamo, 40 mi. east of Santiago, was occupied and was used thereafter as a base and coaling station.

The Land Campaign .- When war was declared the total military forces of the United States consisted of 27,822 regulars and 114,602 militia. An act of April 22 had authorized the president to call upon the states and territories for men in proportion to their population. A first call was made for 125,000 men, and a month later a second call for 75,000. On April 26 large additions to the regular army were sanctioned for the war The quotas were filled with extraordinary rapidity, and in May 124,776 had volunteered. The troops were concentrated chiefly at Chickamauga, Ga., at Camp Alger, Va., and at Tampa, Fla., which was selected as the point for the embarcation of the expeditionary force for Cuba, and where Maj-Gen. W. R. Shafter was in command. After the arrival of Cervera at Santiago, the blockade of his squadron and the request (June 7) of Admiral Sampson to send a land force for co-operation, the troops embarked on June 7 and 8, but a start was not made until the 14th. On the 19th the fleet of 32 transports arrived off Santiago. The whole force consisted of about 17,000 officers and men, 16 light field guns, a train of heavier pieces, and about 200 vehicles. From the 22nd to the 27th the army was landed at Daiquiri, 18 mi. E. of Santiago, on a rough coast with scarcely any shelter from the sea; after the first day Siboney, 7 mi. nearer Santiago, was used as well as Daiguiri. With the exception of three volunteer regiments (the 1st Volunteer Cavalry, known as the Rough Riders, of which Theodore Roosevelt was lieutenant-colonel; the 2nd Massachusetts and the 71st New York Volunteers), these troops were composed almost wholly of regulars, most of whom had served on the plains against the Indians. Soon afterward more volunteers arrived.

No opposition was made to the landing. The American troops (commanded by Maj.-Gen. Joseph Wheeler until the 29th, when General Shafter landed) pushed forward, but the advance was slow and a week elapsed before Shafter was ready to fight a battle in front of Santiago. Here the defenders, under Gen. Arsenio Linares, held two positions, the hill of San Juan, barring the direct road to Santiago, and the village of El Caney, to the north-ward of the American position of El Pozo. The plan of attack on July 1 was Shafter's, but owing to illness the actual command was exercised by the subordinate generals, Joseph Wheeler, H. W. Lawton and J. F. Kent. General Lawton's division was to attack and capture El Caney, and thence move against the flank and rear of the defenders of San Juan, which would then be attacked in front by Kent and Wheeler from El Pozo. But Lawton for nine hours was checked by the garrison of El Caney, in spite of his great superiority in numbers (4,500 to 520); at 3 P.M. the final assault on El Caney was successfully delivered by Gen. A. R. Chaffee's brigade. Only about 100 of the Spanish garrison escaped to Santiago; about 320 were killed or wounded, including Gen. Vara del Rey, who was killed. In the meantime Wheeler and Kent had an equally stubborn contest opposite San Juan hill, where, in the absence of the assistance of Lawton, the battle soon became a purely frontal-fire fight, and the rifles of the firing line had to prepare the attack unaided. The strong position of the Spaniards, gallantly defended by about 700 men, held out until 12:30, when the whole line of the assailants suddenly advanced, without orders, and carried the crest of the Spanish position. On the American side over 1.500 men out of 15,000 engaged, including several of the senior officers, were kılled or wounded. On the Spanish side, out of the small numbers engaged, more than 50% were out of action. Linares himself was severely wounded

Though victorious, the American army was in danger: after great fatigue under a tropical sun by day, the time spared at night from digging trenches was spent on a rann-soaked ground; the soldiers' blankets and heavy clothing had been cast aside; and there was insufficient food. Brisk firing was continued on July 2 and 3, with a considerable number of casualties to the Americans. On the morning of the 3rd a demand was sent to the Spanish commander to surrender, with the alternative of a bombardment of the city to begin on the 4th.

Naval Battle of Santiago .- On the morning of July 3 Sampson, in his flagship the "New York," left the fleet to confer with General Shafter at Siboney with regard to combined operations at the harbour entrance At 9:31, when he had gone about 5 mi, the "Maria Teresa" was seen coming out. The ships in front of the port were the yacht "Gloucester," the battleships "Indiana, "Oregon." "Iowa" and "Texas," the armoured cruiser "Brooklyn" and the vacht "Vixen." The "Iowa" hoisted the signal "Enemy coming out." All at once stood in toward the Spanish ships, which were standing westward along shore, and began a heavy fire. The "Maria Teresa" (flagship) was followed at 800-yd. intervals by the "Vizcaya," "Colon" and "Oquendo." They were firing vigorously, but most of their projectiles went far beyond the American ships. The "Brooklyn" (flag of Commodore W. S. Schley, the senior officer present) made a turn to starboard, which seems to have caused the "Texas" to stop and back, and to have given the "Colon" the opportunity of passing almost unscathed. "Maria Teresa" and "Oquendo" had taken fire almost at once, and were run ashore about 61 mi, W. of Santiago, burning fiercely. The "Vizcaya" and "Colon" were still standing westward. The "New York," Sampson's flagship, had passed, and stood on signalling the "Iowa" and "Indiana" to go back and watch the port, lest an attack be made on the American transports. The "Vizcaya" hauled down her colours off Aserraderos, 15 nautical miles west of Santiago, and was there run ashore burning. The "Iowa" was ordered to stop and rescue her men, and the "Oregon," "Brooklyn" and "Texas" (and behind them the flagship) settled down to the chase of the "Colon," about 6 mi. ahead. She was, however, slacking her speed, and at 12:40 the "Oregon" opened with her 13-in. guns at a range of 9,000 yds., as did also the "Brooklyn," with her 8-in When the "Oregon" had fired five shells, the "Colon" hauled down her colours, and was beached at the mouth of the Rio Turquino. The whole Spanish fleet was destroyed; Admiral Cervera was taken prisoner. More than 500 Spaniards were killed or wounded, and the survivors (except a few who escaped to Santiago) were prisoners. On the American side only one man was killed and ten were wounded, and no ship received serious injury.

After the naval victory, combined operations were arranged for attacking the batteries of the harbour, but little more fighting occurred, and eventually a preliminary agreement was signed on the 15th, and the besiegers entered Santiago on the 17th. The exposure of the campaign had begun to tell in the sickness of the Americans; yellow fever had broken out to some extent; and no less than 50% were attacked by the milder forms of malarial fever. The army, indeed, was so weakened by illness that the general officers united in urging its removal from Cuba.

Fall of Manila.—On May 7 a telegram had been received from Dewey at Manila: "I control bay completely, and can take city at any time, but I have not sufficient men to hold." Maj-Gen. Wesley Merritt, to whom was assigned the command of the troops for the Philippines, first requested a force of 14,000, and afterward asked for 20,000 men. On May 25 the first troops, 2,491 in number, under Brig.-Gen. T. M. Anderson, sailed from San Francisco. On June 20 possession was taken of the Island of Guam, and on June 30 the ships arrived in Manila bay. A second detachment of troops, 3,586 in number, under Brig.-Gen. F. V. Greene arrived on July 17; on July 25 General Merritt, who had been appointed governor-general, arrived; and on the 31st the five

transports with which he had left San Francisco arrived with 4.847 men, making nearly 11,000 men at Manila, with 5,000 more on the way. General Merritt moved his forces from Cavite, and established an entrenched line within a thousand yards of the Spanish position at Manila On Aug. 7, a joint note from Dewey and Merritt, announcing that bombardment might begin at any time after 48 hours, was sent to the Spanish captain-general, Fermin Jaudenes, who replied that he was surrounded by the insurgents, and that there was no place of refuge for the sick and for the women and children. A second joint note demanding surrender was declined by the Spanish commander. Preparations were made for an attack There were 13,000 troops within the city fortifications, but with the strong fleet in front, and with the beleaguering force of Americans and insurgents ashore, resistance was hopeless. When the combined assault of army and navy was made on the 13th there was no great resistance, and a white flag was hoisted at II o'clock. The total loss of the U.S. during the whole campaign was 20 killed, 105 wounded.

Puerto Rico.-Immediately after the surrender of Santiago (July 17), preparations were made for the invasion of Puerto Rico with 3,500 troops which had been sent as reinforcements to Santiago, but had not landed. They were largely reinforced and left Guantánamo, under Gen Nelson A. Miles, on July 21 The towns on the south side of the island were occupied, practically without resistance. The attitude of the population was friendly, and opposition was not met until advance was begun northward. The troops were divided into four columns, advancing from Guanica around the western end of the island to Mayaguez; from Arrovo at the eastern end to meet the San Juan road at Cayey; from Ponce by the fine military road, 70 mi., to San Juan; and the fourth column by way of Adjuntas and Utuado, midway of the island. The various movements involved several skirmishes On Aug. 12 operations were begun by the "Newark" and other vessels against Manzanillo. But during the night news arrived of the signing of the peace protocol on the 12th, and of an armistice.

The total American loss was—in the navy, I officer, 17 men killed; in the army, 29 officers, 440 men. The health of the American feet was kept remarkably. Its average strength during the I14 days of hostilities was 26,102; the deaths from disease during this time were 56, or at the rate of 7 per 1,000 per year As nearly the whole of the service was in the tropics, and in the summer or wet season, this is a convincing proof of the efficiency in sanitary administration. The army did not fare so well, losing by disease during May, June, July and August, 67 officers and 1,872 men out of an average total of 227,4494. Its larger proportion of illness must of course be ascribed, in part, to its greater hardships. The lack of proper preparation by the war department and the ignorance and thoughtlessness of the volunteers were the principal reasons for the high death rate in the army.

For the terms of the peace and the results of the war see UNITED STATES; PHILIPPINE ISLANDS; CUBA; PORTO RICO.

The literature of the Spanish-American War is voluminous. See the War Notes of the Office of Naval Intelligence, Washington, the appendix to the report of the Bureau of Navigation and reports of other government departments for 1898. F. E. Chadwick's The Spanish-American War (2 vol., 1911) is the standard work. Good histories are H. C. Lodge, The War with Spain (1899); and H. W. Wilson, The Downfall of Spain (1900). See also W. A. M. Goode, With Sampson through the War (1899); J. Wheeler, Santiago Canpaign (1899); Theodore Roosevelt, The Rough Riders (1899); C. D. Sigsbee, Personal Narratives of the Battleship Maine (1899); R. A. Alger, Spanish-American War (1900); Gomez Nuñez, La Guerra hispano-americana (1900); John D. Long, The New American Navy, 2 vol. (1903); and George Dewey, Autobiography (1913).

SPANISH BROOM, a handsome shrub with long switchlike green, few-leaved or leafless branches and large yellow sweet-scented papilionaceous flowers. It is a member of the pea family (Leguminosae), and known botanically as Spartium junceum. It is a native of the Mediterranean region and the Canary Islands, and is often cultivated, especially in California where it blooms almost throughout the year. The whole plant, but especially the flower shoots and seeds, has a bitter taste and tonic and diuretic properties and was formerly used medicinally. The fibres of the young stems were used in making nets, carpets, mats, baskets, etc.;

the flowers yield a vellow dve.

SPANISH LANGUAGE. "Spanish," one of four tongues still spoken in Spain (the others are Catalan, Basque and Galician), is historically Castilian, the speech of Castile Its acceptance as the language of the nation resulted largely from the union of the crowns of Castile and Aragon in 1474 and from the centralizing policy thereafter pursued by Madrid. Discovery and conquest in the New World imposed it as the speech also of the vast territories that once constituted Spanish America, where it is still known as Castilian, and of the Philippines. It is spoken today by about 85,000.000 people.

The Iberian peninsula was linguistically more diversified in the middle ages than it is today. Apart from Arabic in the south and Basque astride the western Pyrenees, there coexisted five major derivatives of Vulgar Latin (Galician-Portuguese, Asturian-Leonese, Castilian, Navarro-Aragonese and Catalan) and a number of lesser dialects. Mozarabic, spoken by Christians living under Moslem sway, was cut off from the trends of linguistic and cultural development to the north and became notably archaic. Castilian, originating in Cantabria (adjoining the Basque frontier) in the early 8th century, soon revealed innovating tendencies consonant with the temperament and enterprise of a people which, shaking off the tutelage of León, in the middle of the 10th century raised the status of its territory from county to kingdom, with Burgos as capital, and found itself thereafter in the van of the reconquest. The taking of Toledo, the ancient capital of Visigothic Spain, in 1085 greatly enhanced the cultural prestige of Castilian and also extended a sway that the next great wave of Christian advance, in the early 13th century, was to carry to the south coast. Thereafter Castilian made steady gains to east and west, reducing Leonese and Navarrese to the status of spoken dialects, and, while not wholly supplanting the other tongues, was from the 16th century generally understood throughout Spain. That same century, which witnessed the incorporation of Portugal in the Spanish dominions, had already seen Castilian recognized as a second tongue there too. More than 600 Portuguese authors are on record as having written in Castilian.

Spanish derives, like the other Romance tongues, from Vulgar Latin, the essentially nonliterary speech of the Roman legionaries and colonists who began the romanization of the peninsula toward the end of the 3rd century B.C. Little is known of the lost "Iberian" tongues or of the extent to which Basque, the one survivor, has evolved from the speech that the Romans found and failed to dislodge. It is on the testimony largely of Basque that tentative prestratum influences are advanced. These include: the substitution of aspirate h for initial Latin f, a development found beyond the peninsula but peculiar, within it, to Castilian; the passage of plosive intervocalic b, d, g to fricative; the pronunciation of s as apico-alveolar and of v as bilabial; the palatalization of nn, ll, ct. The terminations -orro, -arro, -urro are of Basque or Iberian origin, as are the topographical terms vega, nava, páramo; the termination -iego derives from a Celtic or pre-Celtic -aecu. Early Germanic loan words, which number about 800 (plus the ending -engo), are mostly common to Romance, dating from frontier contacts with the Roman empire rather than from the period of Visigothic dominion in the peninsula. The long Moslem occupation bequeathed about 4,000 terms, commonly recognizable by the article prefix al-, many place names and the suffix t. There was a marked influx of French terms in the 12th and 13th centuries, as of Italianisms in the 15th and 16th. The discovery of America introduced many indigenous "Indian" words. The Renaissance also brought about the reintroduction of a spate of Latinisms, mostly abstract terms either lost in the Vulgar Latin of Spain or given a concrete meaning, whence many doublets (artejo and artículo, cadera and cátedra). Later borrowings came chiefly from French (literary and social terms) in the 18th century and from English (politics, sport) in the 19th and 20th. These extraneous elements, promptly assimilated to Spanish speech norms, are predominantly names of things borrowed. In phonology, morphology, syntax and idiom the language remains faithful to its Vulgar Latin origins and all but impervious to foreign influences. By the 18th century Castilian had achieved a stability

in its essential structure that has scarcely altered since. Literary developments dating from the late 19th century greatly enhanced its vigour and flexibility; and today, still respected as the norm throughout the Spanish-speaking world, Castilian has won recognition too as one of the world languages of international diplomacy and administration.

Phonology .- The sonority that is the first characteristic of spoken Castilian derives in part from the voicing of Latin intervocalic surds (apotheca > bodega); in part from a rich intonation extending over more than an octave, its mean falling below that of French or Italian, but chiefly from a yowel-consonant balance that places the language midway between the extreme vocalism of Portuguese and the extreme consonantalism of Catalan. vowels are the basic five, together with a more open e and  $\rho$ . der the accent these latter give ie (earlier ia) and ue (earlier ua, uo), diphthongization being impeded by a following yod (yodh) but not, as in French and Italian, by a closed syllable. Latin internal atonic vowels fell early, proparoxytones thus proclaiming themselves learned forms (ánima for alma, rápido for raudo, -ículo for -ejo). Final e fell after single consonants (cantar, paz); mediaevally there was much apocope too of o and a. Latin diphthongs au, ai, oe, ae gave o, e, e, e; the rejection of Latin hiatus produced new diphthongs (Juan, Santiago) Synaloepha is pronounced, a sequence of up to five or six vowels coalescing in a single syllable ("Y el móvil ácueo a Europa se encamina"). There are no nasal vowels, although nasalization may be induced (mão), and no mixed vowels as in French Unstressed vowels are never relaxed to the point of losing their identity.

Early consonantal changes include, in addition to those already mentioned: the loss of Latin finals, save l, r, s (miel, entre, menos) and, in monosyllables, n (en, con); the reduction of double consonants, save nn, U, rr, to singles (bucca, boca); the passage of initial cl-, fl-, pl- to palatal \(\lambda\) (llave, llama, llano); the palatalizing of guttural plus dental (dixi > dije, restagnare > restañar, factum > hecho) and of ly, ny (palia > paja, vinea > viña); the reduction of c'l, g'l, ly beyond the palatal \( \lambda \) of the rest of the peninsula to ž (oculu > ojo, cilia > ceja); and the advancing of guttural c before a front vowel to prepalatal \$\hat{s}\$ or \$\hat{z}\$, these sounds resulting also from the fusion of ty, cy (platea > plaça, liciu > lizo). A second period of active change in the 16th and early 17th centuries affected chiefly the palatal and dental sibilants, the voiced in each pair (ś, ź; ŝ, ẑ; š, ž) giving way to the voiceless; ŝ then evolved further into the interdental  $\theta$  (taza, dice), and  $\tilde{s}$  into the velar  $\chi$  (Quijote, coger). Voicing may still be induced by assimilation (esmola, hazlo). The h- coming from Latin f- lost its aspirate.

Morphology .- Noun and adjective derive from the Latin accusative, a, as corresponding to the first declension (which largely absorbed the fifth), o, os to the second (and fourth), other endings to the third. Only sporadic survivals remain of the other cases, which are better preserved in the pronoun (ille > él, illi > le, cuius > cuyo). The weakening of ille to the article (el) led to its reinforcing as demonstrative (accu-ille > aquel). neuter survived only in the article (lo bueno) and in the pronoun (esto, ello); neuter noun forms became masculine or feminine according to ending, as pignus > peño(s), pignora > prenda(s). In the verb the Latin third conjugation (-ere) was absorbed by the second (-ére). Traces survive in strong preterites (dije, hice); the present infinitive can be discerned in the far- of haré and the present indicative in vamos, vais. The past participle -udo, common until the 13th century, was discarded thereafter. The adoption for verbs in -er of the preterite and past-participle endings of those in -ir, with the substantial agreement in their tense endings throughout, has largely merged these two conjugations in one. All new verbs, except incipients in -ecer (-escere), are of the first conjugation (telefonear, sintonizar). The degree of preservation of Latin tense endings makes the subject pronoun unnecessary save for emphasis or to distinguish in the third person between Vd. "you" (usted, a contraction of vuestra merced), él and ella; it also contributes to a striking freedom of word order. The use of the "personal a" (before a personal or personified direct object) may be extended to guard against ambiguity ("Al otoño sigue el invierno"

instead of "El invierno sigue el otoño").

Syntax .- The aspects of most interest concern the verb. To the normal evolution of Romance tense values Spanish adds (1) a future subjunctive amare (a fusion of Latin amavero and amaverim), now falling into disuse; and (2) a form amara (Latin amaveram) which may be equivalent to the conditional indicative amaria, to the imperfect subjunctive amase, or (literary) to the pluperfect indicative había amado. From Latin sedere and stare Spanish evolved two words "to be" (ser, estar), connoting greater and lesser degrees of permanence, estar with the present participle gives a continuous tense (estoy viendo). From the 16th century haber became restricted, apart from its use as the impersonal "to be," to the role of auxiliary, tener replacing it as the transitive "to have" Tener is itself one of a number of verbs (quedar, llevar, resultar, etc.) which, employed as semiauxiliaries, add greatly to the flexibility and subtlety of verbal expression. The infinitive may be used as a noun: abstractly in the singular, with subject and object and modified by an adverb; concretely in 'he plural, with an adjective (el trabajar bien, el hacer yo esto, los subires y bajares de la vida). The present participle derives from the Latin gerund (cantando). The subjunctive is used more subjectively than in French, frequently alternating with the indicative to suggest nuances of implication. Constructions with the passive are avoided in favour of active or reflexive (le fusilaron, se le fusiló).

Orthography.—Spanish, if less than the perfect "phonetic" language, shows a close conformity between sound and spelling, I, rr, ch, qu (before front vowels) are single sounds; c is guttural k and (before e, i) interdental \(\theta\) (spelled z before a, o, w); g before e or i is uvular \(\chi\) (also spelled j before any vowel); x may be ks, s or gaz, b, d, g are plosives or fricatives; h is mute. Otherwise sound and symbol agree, and all letters are pronounced. Stress falls normally on the penultimate syllable when the word ends in a vowel, n or s, on the ultimate with other endings. Exceptions bear the acute accent (cámara, cárcel, carrón), which serves also to distinguish the more important of words spelled alike (\(d\)^0 (\(rho^0\)^0, \(d\)^1 (\(rho^0\)^0, \(d\)^1 (\(rho^0\)^0); this acute accent, the tilde of \(\vec{n}\) and the diaeresis of give, gui- are the only diacritics. Exclamation and interrogation marks are written inverted at the beginning as well as normally at the end of interjection or question.

BIBLIOGRAPHY.—C. H. Grandgent, Introducción al latin vulgar, tans. by F. de B. Moll, and ed. (Madrid, 1952); E. Bourcia. Eléments de linguistique romane, 4th ed. (Paris, 1946); W. Meyer-Lübke, Introducción a la linguistica romance, trans. by A. Castro (Madrid, 1920); Conde de la Viñaza, Biblioteca histórica de la filología castellana (Madrid, 1893); A. Bello and R. J. Cuervo, Gramática de la lengua castellana, 24th ed. (Paris, 1936); R. Menéndez Pidal, Manual de gramática histórica española, 8th ed. (Madrid, 1960), and Documentos linguisticos de Castilla (Madrid, 1919); J. D. M. Ford, The Old Spanish Sibilants (Cambridge, Mass., 1900); W. J. Entwistle, The Spanish Language together with Portuguese, Catalan and Basque (London, 1936), New York, 1938); V. Garcia de Diego, Manual de dialectología española (Madrid, 1940) and Gramática histórica española (Madrid, 1940) and Gramática histórica española (Madrid, 1940) and Gramática histórica española (Madrid, 1951); R. Lapesa, Historia de la lengua española, 21th ed. (Madrid, 1950) and Manual de entonación española, 17th ed. (Madrid, 1952) and Manual de entonación española (New York, 1944); the Real Academia Española, Diccionario de la lengua española, 17th ed. (Madrid, 1947); A. Cuyša and A. Llano, Appleton's New English-Spanish and Spanish-English Dictionary (New York and London, 1393).

SPANISH LITERATURE. Spanish literature falls into three divisions: Castilian, Catalan and Galician. Galician, for linguistic and historical reasons, is more conveniently dealt with under Portuguese. In the two Senecas, Lucan, Martial and Quintilian—as also in Prudentius—Spain had contributed much to Latin literature before the separation of the Romance languages; while the writings of Spanish Moslems and Jews form an important branch of the literature of Arabic.

## CASTILIAN LITERATURE

By the time of the Moslem invasion (711) the Latin spoken in the Iberian peninsula was already in process of transformation into Romance. By the 10th century, the Glosas emilionenses and the Glosas silenses reveal traces of a vernacular already substantially developed. Mocádem, a blind poet who flourished near

Córdova at the beginning of the century, was recorded 200 years later as having taken "expressions in vulgar Arabic or Romance, called them markaz and built on them his zéjels or muwassahas After 1948 numerous examples of the markaz, or theme stanza. written in a Romance idiom transliterated into Hebrew or Arabic. were recovered from Hebrew and from Arabic muwassahas dating from the 11th century onward. These provided not only the earliest texts in Mozarabic (the Romance dialect of Spaniards living under the Moslems) but also evidence of a popular poetry that may have begun in the time of Mocádem or earlier and can be seen now to explain much in the traditional lyric types (e.g., the villancico) of the later middle ages and the Renaissance. poem as a whole was generally a love song sung by the woman (comparable to the later Galician cantiga de amigo), and the motif in Romance was a cry of passion on which the whole was an elaboration or to which it led up.

Heroic Poetry (11th and 12th Centuries) .- The earliest surviving monument of Spanish literature and one of its most distinctive masterpieces is the Poema de mio Cid, an epic poem (cantar de gesta) of the middle of the 12th century (the existing manuscript is an imperfect copy of 1307). This work of 3,730 irregular lines (from 11 to 18 syllables, with marked caesura and traces of a four-beat accentual rhythm) grouped in assonating laisses tells of the fall from and restoration to royal favour of the Castilian noble Ruy Díaz de Bivar, known by the Arabic title of sids ("lord"), who lived from 1040 to 1099. The historical setting and personages, the topographical detail, the realism of tone and treatment and the proximity in time of the anonymous poet to his hero have allowed the advancing of "historicity" as a first characteristic of the poem and of the Castilian epic in general The latter two of its three cantares, however, while equally convincing in detail, are untrue to recorded history; the conception of the whole is essentially poetic and is handled with much imaginative artistry; and the according of a mere seven lines to the Cid's greatest achievement, the taking of Valencia from the Moslems after a nine-months' siege in 1094, makes clear the subjective scale of values. However, the poem caught the popular imagination and lived on in later epic, chronicle, ballad and drama, helping to fix the popular conception of the Castilian character. The only other surviving epic text (apart from a 100-line fragment of uncertain filiation on Roncesvalles, of the early part of the 13th century) is the wholly fanciful and decadent Cantar de Rodrigo of the 14th century, telling of the Cid's early manhood; it was from this that the later legend of the Cid took shape.

Frequent allusions in the vernacular chronicles to the heroic narratives of minstrels (juglares) make it clear that this mester de juglaría was much richer than the scarcity of surviving manuscripts would suggest. Thanks to the same vernacular chronicles, which from their beginning late in the 13th century accepted these narratives as being of historical validity and prosified them at length in their pages, it has been possible to reconstruct the themes and even, on occasion, fragments of the poetic text of epics on Los siete Infantes de Lara, Fernán González (both set in the 10th century), El Cerco de Zamora (again involving the Cid and perhaps artistically the best) and others. Bernardo del Carpio provides a hero of the days of Roncesvalles in defense of the national prestige against the French Carolingian epic; the remaining themes are an integral part of the feudal history of 10th- and 11th-century Castile, close to the time of telling and less probably related in their origins to the very different French epic than to a remote Visigothic past.

Learned Narrative Poetry (13th and 14th Centuries)—A new school of erudite poetry, much indebted to France and linked not with the itinerant juglar reciting to popular audiences but with the monastery and a literate public, became known as the mester de clerecia. Regularly adopting the French alexandrine in the set mould of the cuaderna via or "fourfold way" (four-line single-rhyme stanza) and dealing with religious, didactic or pseudo-historical matter, it was a product of the study. The school is best and probably first exemplified in Gonzalo de Berceo (d. after 1246), the earliest Spanish poet known to us by name, a cleric of the same San Millán de la Cogolla that had produced the

Glosas emilianenses, in La Rioja. Apologizing for his inadequate Latinity, he versiend unwearynigly in the vernacular the lives of Spanish saints, the miracles of the Virgin and other devotional themes with an ingenuous candour and an accumulation of picturesque and affectionately observed detail which largely atone for his prolixity (about 13,000 lines) and his fidelity to his sources. Also of the 13th century and in the same form are the Libro de Alexandre, much more erudite and pretentious, the Libro de Apolno, a romantic tale of Greek extraction, and the Poema de Pernán Gonçález, a clerical reworking of a lost epic on the 10th-century count of Castile who won his county's independence from León.

The Beginnings of Prose.—A major influence on prose was exercised by Arabic. The gates of oriental learning and story were opened to Spain by the capture from the Moslems of Toledo (1085), which became a centre of translation from oriental languages. In 1120 Pero Alfonso, a Jew converted to Christianity, introduced Indian fable to the non-Arabic reader with his Disciplina clericalis, a collection of tales translated into a barbarous Latin. The translation from the Arabic of the "beast fable" Kailia e Dimma (1251) is the first essay in storytelling in the Spanish language. The romance of the Seven Sages (or Sendebar) was translated under the title of Libro de los engamos e assayamientos de las mageres (1253), and other collections of eastern stories followed.

Alphonso the Wise .- The middle of the 12th century saw the recovery of Córdova, Valencia and Seville by the Christians, the kingdom of Granada alone remaining in Moslem hands. An indication of the more propitious intellectual atmosphere resulting was seen in the founding of the first universities (Palencia c. 1212, Salamanca c. 1243); and under the personal stimulus of Alphonso X of Castile and León (Alfonso el Sabio, "the Wise:" reigned 1252-84) literature achieved official prestige. Alphonso, in whose chancery Castilian replaced Latin as the language for public documents, may be called the father of Castilian prose. He organized a vast enterprise of translation and compilation aimed at fusing in the vernacular all available knowledge, classical, oriental, Hebrew and Christian. The works undertaken, often under his personal editorship, included the great legal code Las siete Partidas (a mine of curious information on the life and customs of the time) and compilations from Arabic sources such as the Libro de saber de astronomía, the Tablas alfonsies, the Lapidario and the Libro de los juegos. With the Primera Crónica general, covering the history of Spain from its first settlers, and the Grande e general Estoria, an attempt at universal history from the creation, Alphonso was the founder of Spanish historiography in the vulgar tongue: the former work, carried by Alphonso to A.D. 711 and completed in the following reign, gave rise to a whole series of chronicles over the following two centuries and was the most influential single work of the Spanish middle ages; the latter work did not reach later than the parents of the Virgin Mary. Himself a poet. Alphonso was responsible too for one of the greatest collections of mediaeval poetry and music, the Cantigas de Santa Maria in Galician (then the accepted vehicle for lyrics).

The 14th Century.—The period of translation and compilation was succeeded by one of brilliant original creation. It is best represented in the prose of Alphonso's nephew the infante Don Juan Manuel (1282-c. 1349) and in the poetry of Juan Ruiz, archpriest of Hita (c. 1283-c. 1350). Juan Manuel's Libro de Patronio, known also as El Conde Lucanor (1335), a collection of 50 tales each pointing a moral, still drew heavily on Arabic sources; but by its individuality of style and treatment, the connecting thread of plot and the relating of fable to the day-to-day problems of life in high position, it ranks high in the beginnings of Spanish fiction. The same author's Libro del caballero e del escudero and Libro de los estados, both betraying indebtedness to the Catalan Raimon Lull (Ramón Llull), likewise pursue in the guise of fiction a doctrinal purpose, the education of a prince.

Earlier, under the influence in part of the matière de Bretagne (see ARTHURIAN LEGEND; TRISTAN), which from the turn of the 13th century had been circulating in Spain in translation, there had appeared (c. 1305) the first Spanish novel of chivalry,

El Caballero Cifar, the work possibly of the archdeacon Fernán Martínez. Cıfar's squire Ribaldo was a distant precursor of Sancho Panza and thus an early token of the constant impinging of the real on the ideal so characteristic of Spanish literature. Contemporary with this was the creation, also related to the Breton cycle, of the Amadis de Gaula (c. 1304-12), destined to father a progeny that held the imagination of kings, courtiers and scholars through the 16th century Sentimental idealism, lyrical atmosphere and supernatural adventure notwithstanding, the weight of evidence is against the traditional ascription to Portugal, where the work is first found mentioned c. 1450; the author may have been a Galician troubadour, João de Lobeira living in exile at the Castilian court.

Juan Ruiz, archpriest of Hita, a man of the people, was the most intensely alert and individualized of early writers. His Libro de buen amor (1330, expanded in 1343) represents a collection of the most disparate elements-Ovid, Aesop, the Pamphilus de amore, the Carmina Burana and the liturgy-with a strong suggestion of Moslem ways of thinking in the mingling of eroticism with devotion and the invitation to the reader to interpret for himself the author's very equivocal teachings But the diversity of adventure was presented as a satiric autobiography and stamped with the author's exuberant personality; and his Trotaconventos, ancestress of Celestina, is the first great character creation in Spanish literature. The dominant metre was still the cuaderna via, handled with a narrative vigour and a plasticity that it had never known before; but the interspersing of the text with lyrics, religious, pastoral-farcical, amorous or satirical, of great metrical variety pointed to the approaching supersession of the "fourfold way."

Continuing evidence of the exotic strands that were being woven into the texture of Spanish letters may be found in the Poema de Yucuf (assigned to the same 14th century) and in the rabbi Sem Tob's Proverbios morales (c. 1355). The former, an Aragonese version in cuaderna via of the story of Joseph, is based not on the Bible but on the Koran and is written in Arabic characters; it is the chief representative of the so-called alianiado ("barbarian") literature, Spanish in language, Arabic (or Hebrew) in tone and script. The Proverbios of Sem Tob (Shem Tobh), comprising 725 alexandrine couplets with internal as well as end rhyme, introduced to Spanish the grave sententiousness of Hebrew poetry with extreme aphoristic concision; his chief sources were the Old Testament, the Talmud and Ibn Gabirol (Avicebron) The principal surviving manuscript, much later than the date of composition, is in Hebrew characters. Sem Tob was a poet too in the Hebrew tongue.

The chancellor Pero López de Ayala (1332–1407) dominates the later part of the 14th century both in poetry, with his Rimado de palacio, the last major relic of the cuaderna via, whose 8,200 lines distilled the essence of a lifetime of experience and disillusion in high places, and in prose as a historian of things seen. His chronicles of the four reigns (the last incomplete) of Peter I. Henry II, John I and Henry III of Castile infused new life in the vernacular into the tradition of the Latin cronicón and greatly stimulated the writing of personal, contemporary history. An early humanist, he translated and imitated Livy and Boccaccio together with Boethius, St. Gregory and St. Isidore.

The 18th Century.—The early part of the 15th century witnessed a first tentative renewal of Spanish poetry under Italian influence, which was to extend and to produce ever deeper effects over the next 150 years. The contrast is strong, during the long reign of John II (1406–54), between the social anarchy of a feudalism in its death throes and the cultivation of politic letters, which was now becoming an expected mark of birth and breeding. Collections such as the Cancionero made for the king c. 1445 by Juan Alfonso de Baena, containing 583 poems by 55 poets ranging from highest nobles to humblest versifiers on the fringes of their service, show not merely the now decadent tradition of the Galician-Portuguese troubadour school but the new stirrings of a much more intellectual poetry which used symbol, allegory and classical allusion in the treatment of themes of high moral, philosophical or political intent. Francisco Imperial, son of a Genoese

settled in Seville, drew on Dante in the first years of the century to present a challenge which Íñigo López de Mendoza, first marqués de Santillana (1398-1458), Juan de Mena (1411-56) and others duly took up. Santillana, like Juan Manuel and Pero López de Ayala, was poet and scholar as well as soldier and statesman, a collector of the masterpieces of foreign literatures and a stimulator of translations. His Prohemio e carta al condestable de Portugal (c. 1449), the earliest work of literary history and criticism in Spanish, draws upon his reading in Italian, French, Catalan, Provençal, Galician and Portuguese as well as in the classics in translation. Imperial had already sought to acclimatize the Italian hendecasyllable. Santillana's 42 sonnets "fechos al itálico mode" marked the beginnings of the formal enrichment of Spanish poetry at the dawn of a new age, though these, like his long poems La Comedieta de Ponza, the Diálogo de Bías contra Fortuna, or La Defunsión de don Enrique de Villena, which in thought and structure likewise show the poet at school in Italy, are today neglected in favour of his charming canciones, decires and serranillas of native inspiration, his role as precursor is still outstanding.

Juan de Mena's vast allegorical poem of the drama of history past, present and to come (El Laberinto de Fortuna, known also as Las Trezientas, c. 1444) was a more conscious attempt to rival Dante; felicitous often in isolated narrative passages out of Spain's herorc past, it is weighed down by pedantry and by over-Latinization of syntax and vocabulary. His metre, the common vehicle of learned poetry throughout the 15th century, is the verso de arte mayor, characterized less by its variable length (9-14 syllables, with 12 as the norm) than by its two hemistichs and strong ternary rhythm; accentual verse will not be found again in Spanish until the 15th century. The other outstanding name in the century's poetry is Jorge Manrique (c. 1440-79), who achieved immortality with one poem, the Coplas a la muerte de su padre.

In prose the age saw the first appearance of books of travel, notably the accounts of a journey to Samarkand (1493-06) of Henry III's ambassador Ruy González de Clavijo (Historia del gran Tamorián) and of the travels in Europe and the near east (1435-39) of Pero Tafur (Andanças e viajes por diversas partes del mundo). Contemporary history took on a biographical dress in two admirable collections of portraits of eminent Castilians, Fernán Pérez de Guzmán's Generaciones e semblanzas (part of a larger Mur de historias, c. 1450) and Hernando del Pulgar's Claros Varones de Castilla (1486).

The Renaissance and the Siglo de Oro.—The unification of Spain under the "Catholic kings" and Columbus' discovery of the New World, following the introduction of printing (1474) and concurrent with the full play of cultural traffic with Italy (where Naples had been since 1443 a dependency of Aragon), may be taken as opening the era of the Renaissance in Spain. With the exception of the more popular veins associated with oral tradition, the mediaeval poetic achievement lapsed into oblivion: the Poema de mio Cid and the corpus of the mester de clerecta were not to be recovered and printed until 1779, the Auto de los reyes magos (sole surviving fragment, from the early 12th century, of mediaeval dramatic activity) not until 1863. National heroic themes survived through ballad and chronicle, early beneficiaries of the printing press.

What conferred on Spanish literature its distinctive mark in this period was, however, the wealth of new experience born of the overseas adventure, reflected not merely in historical and scientific writing but also in the detached and questioning attitude, so strikingly exemplified in the theatre, to the rediscovered norms of classical authority. The first Spanish humanists were also the first grammarians and lexicographers of any Romance tongue: the Gramdstace asstelland (1492) of Antonio de Nebrija (Lebrija) was written under the sense of impending imperial responsibilities. Juan Luis Vives (1492—1540), a figure of European eminence, the brothers Juan and Alfonso de Valdés and others among the best brains and noblest minds of contemporary Spain were friends or followers of Erasmus, whose writings circulated in translation from 1520 until their suppression after his death in 1546, and

whose influence has been seen in St. Ignatius of Loyola, founder of the Society of Jesus, and even, a generation later, in Fray Luis de León

The masterpiece of the early Renaissance is the Tragicomedia de Caluxio y Melibea (c. 1499), a novel in dialogue form by a converted Jew, Fernando de Rojas. The dominant character, a go-between elaborated from Juan Ruiz's Trotaconventos and depicted with a realism unsurpassed in Spanish letters before or since, soon caused the work to be popularly rebaptized La Celestina, thereby obscuring its significance as a tragedy of idealism in the new world of the senses liberated by the Renaissance. The analysis of passion and the dramatic conflict with nemesis that its pursuit involves were worked out with such psychological intensity on the intersecting planes of the noble and the ignoble, of mediaeval and Renaissance, as to make of the work the first indubitable and universal masterpiece of Spanish prose. It gave rise to innumerable sequels and imitations and was in due course translated into most European languages.

Romancero and Early Drama .- Spanish ballads (romances) form the strongest link in a chain of tradition that runs unbroken from mediaeval heroic epic to 20th-century poetry and diama; they lie at the heart of the national consciousness; and their expansion and capacity for survival, from Salonica to Chile, from the Low Countries to North Africa, accurately reflect the farflung boundaries of Spain's prestige in its age of greatness. The ballad form is clear: the 16-syllable line with equal hemistichs (or two octosyllables) and a single assonance, suggesting a regularizing of the old epic versification, though it is doubtful whether we may infer from this that the romancero originated in the fragmentation of the decadent epic. The earliest datable ballads treat of frontier incidents (late 14th century) or lyrical themes (early 15th century), and it has been shown that only 5 out of about 35 "old" ballads on the Cid bear relation to known epic sources, while two-thirds of the whole vast corpus are lyrical in character and betray French or other exotic influence. It is on the ballads on mediaeval heroic themes, nevertheless, that the peculiar importance of the kind in Spain hinges. they formed everyman's source book on national history and on the national character. Circulating first as pliegos sueltos, the traditional ballads were collected in the Cancionero de romances (Antwerp, c. 1550) and in the Silva de varios romances (1550) and thereafter repeatedly. Soon the form was taken up and exploited for lyrical purposes in the romances artísticos of the most famous poets of the age, to remain ever afterward the chosen medium for popular narrative verse.

The origins of drama in Spain may be presumed, in default of evidence, to have been like those of drama in France and England. A tradition of religious performances in the vernacular is supported by references in legal and other documents and by the fragmentary Auto de los reyes magos, already mentioned; and one may infer, as also from a passage in Las siete Partidas, the existence of a secular drama interpreted by juglares. Juan del Encina (1468-c. 1529) marked the first stage in the emancipation of the drama as we know it from ecclesiastical leading strings, by way of performances for a noble patron. The representaciones and églogas in his Cancionero (1496) began as pastoral-religious, cast in a rustic dialect, sayagues, which was later accepted as a convention; but he soon turned to the debating of purely secular themes or to the vividly depicted farce of the Auto del repelón. Three plays dating from a long stay in Italy (Églogas de Fileno y Zambardo, de Cristino y Febea and de Plácida y Vitoriano) show Encina's conception of drama transformed by the experience from an ingenuous mediaevalism to one of bold Renaissance experimenting in the realm of sensuous indulgence, fortified by classical myth and allegory.

Encina's Portuguese disciple Gil Vicente (c. 1465-c. 1536), a court poet at Lisbon who wrote 11 of his 44 plays entirely and 17 of them partly in Spanish, showed a great advance in naturalness of dialogue, acuteness of observation and humour of situation. His weakness lay in plot, his peculiar distinction in a lyricism that expressed itself in the finest Spanish poetry of the period and in a vivid, plastic representation of allegory (as in the trilogy of the Barcas) that looks forward to Calderón. Bartolomé de Torres

Naharro (d. after 1530), who settled at Naples, published there in his Propalladia (1517) six of his eight comedies, all again performed before a noble audience. These show a sense of plot and a first awareness of dramatic theory with the division in form into five acts (soon to be reduced to three) and in kind into comedias a noticia and comedias a funtasia (the former realistic, as the Comedia soldadesca and the Tinellaria, satirizing respectively an army of occupation and the servants' hall in a cardinal's palace; the latter romantic and novelesque, the Comedia serafina and the Himenea being of particular interest as foreshadowing the cloakand-sword comedy with the pundonor or "point of honour" as theme).

The emergence of the drama to the market place and the creation of a public were largely the work of Lope de Rueda (c. 1510–65), who from 1551 toured Spain with his modest troupe, his still more modest properties and a repertoire of his own composing F8s four prose comedies all owned Italian models and were clumsy in construction: it is in the ten comic pass (interludes performed between the acts of longer plays) that his dramatic merit resides, and with it the distinction of fathering the one-act play which, constantly renewing itself, has today some claim to be held the most living and popular of all dramatic forms in Spain.

The first dramatist to realize what might be made of the romancero in the theatre, in the sense of stirring the public's most responsive chord, was Juan de la Cueva (c. 1550-c. 1610): most of his 14 comedies and tragedies (1583) were taken, it is true, from classical antiquity and written in the manner of Seneca, but in three of them (Los siete Infantes de Lara, El Reto de Zamora, La Libertad de España por Bernardo del Carpio) he turned to themes of Spain's early heroic story, already familiar in ballad, and thereby set an example that accounts in large part for the immense fertility of the comedia and for the close accord thenceforth established between dramatist and public. Juan de la Cueva was not an accomplished dramatist, but he helped to found a drama "national" in supject-matter and free from pseudoclassical norms.

The 16th-Century Lyric .- The earlier attempt to Italianize Spanish poetry had failed through an overambitious intellectualizing of theme, on a basis of pedantic imitation, at a time when language and metrics were still incapable of sustaining the burden. A century later Juan Boscán (d. 1542), by reintroducing Italian metres (sonnet, ottava rima, canzone, tercet, blank verse), prepared the way for a much greater poet, his friend Garcilaso de la Vega (1503-36), with whom the lyric was reborn. The importance of the new metres went much beyond the formal. in Garcilaso the most significant novelty is the verse paragraph of the silva (a free combination of hepta- and hendecasyllables), allowing a new concern with the analytical expression of thought and emotion. To a mastery of the poetic process derived from close study of Petrarch, Boccaccio and Sannazaro and also of Theocritus, Virgil, Tibullus and Horace he added the gift of infusing an intense personal note into the most characteristic Renaissance themes. His meagre output of eclogues, elegies and sonnets, published posthumously in 1543, won him recognition for centuries as "the prince of Castilian poets" and largely determined the course of lyric poetry throughout the siglo de oro.

Fray Luis de León (1527-91), adopting chiefly Garcilaso's lira stanza (7, 11, 7, 7, 11) for poems charged with a deep emotional sincerity, typified a so-called "Salamanca school," with its emphasis on content over form. Fernando de Herrera (c. 1534-97) headed a contrasting school of Seville which, deriving equally from Garcilaso, was concerned rather with Petrarchan subtleties of refined sentiment; in a quartet of remarkable odes he gave vibrant expression to heroic themes of the day. A movement of protest in defense of the short native metres, associated chiefly with the name of Cristóbal de Castillejo, was greatly reinforced after 1550 by the printing of romanceros and by the evolving drama which, while employing much metrical variety for the procuring of specific effects, found in the octosyllable the accepted vehicle for narrative and description. Throughout the 17th century poets were to write in both the old and the new, their practice still allowing a notable degree of equation between the old and "verse"

and between the new and "poetry."

For epic poetry the metre was the octava real (ottava rima) and the models Ariosto and Tasso, with the reserve that the themes and the heroes to be sung were those of overseas conquest and expansion or of defense of the empire and of the faith at home. Alonso de Ercilla y Zúñiga came nearest to achievement with his Araucana (1569–90), telling at first-hand of native resistance to the conquest in Chile; its defects sprang from a wavering concept of epic theory, now martial-heroic unrelieved, now amorous-fantastical with admixtures of prophecy and pedantry. Bernardo de Balbuena's Bernardo, on a familiar mediaeval theme, and Lope de Vega Carpio's Dragontea (Drake) and Corona trágica (Mary Stuart) may stand for the multitudinous activity in a kind that laid its compulsion on every poet of ambition.

History.-Prose before the Counter-Reformation produced some notable Lucianesque dialogues, from the pen especially of Alfonso de Valdés (Diálogos de Lactancio y un arcediano and de Mercurio y Carón, both 1528). His brother Juan wrote in Naples a Diálogo de la lengua (c. 1535) which, though not published till 1737, is still a document of the highest critical value. In style these stand at the other extreme from the Relox de principes and the Cartas familiares of Antonio de Guevara (c. 1480-1545), which enjoyed a European notoriety in their day as the Spanish counterpart of euphuism. History in the tradition of Alphonso the Wise continued to be cultivated, patriotism waxing higher as Spain's imperial greatness cast its shadow over Europe; its last great flowering was seen in the Historia de España of Juan de Mariana (c. 1536-1624), the translation of which from its original Latin (1592) into Spanish (1601) by the author himself marked the final triumph of the vernacular for all literary purposes. Diego Hurtado de Mendoza gave in his Guerra de Granada (c. 1572) an extreme example of the concern to write history upon the classical model; the Anales de la corona de Aragón (3562-79) of Jerónimo de Zurita exalted by contrast serious documentation and impartiality over style.

But the real landmarks in historical writing came from the New World and showed the transmuting of vital experience into literature with a vividness till then unknown in Spain. The letters of Columbus, the Cartas de relación of Hernán Cortés and many another narrative by humble conquistadores void of literary artifice or pretension opened up new horizons to the reader and, as in the attempt to capture exotic landscapes in words, enlarged the resources of the language. Most engaging of them all was the Historia verdadera de la conquista de la Nueva España, written in old age by Bernal Díaz del Castillo (1492-c. 1581), who had a phenomenal memory, an infallible eye for the telling detail and a passion for distributive justice. Bartolomé de las Casas (1474-1566), "father of the Indians," wrote history for noble yet partisan purposes: on his Brevisima Relación de la destruyción de las Indias rests a large measure of responsibility for the leyenda negra which Spain's enemies were for so long after to use against it.

Mysticism.-The great period of Spanish mysticism coincided closely with the Counter-Reformation, though it had its antecedents. Raimon Lull had been a notable precursor in 13thcentury Catalonia; and the Dialoghi di amore (1535) of the expatriate Spanish Jew Judas Abrabanel ("León Hebreo"), which both in Italian and in Spanish translation exercised a profound influence on 16th-century Spanish thought, allowed the infiltration of many a Platonic image and doctrine. The literary importance of the mystics derives not only from their subject matter but also from the consideration that in the constant striving to transcend the limitations of language there were liberated resources of expression, especially in the sphere of psychological probing, till then unknown. In the Libro de su vida, in the Libro de las moradas and in the Cartas of the untutored St. Theresa (1515-82) many of the novelist's greatest gifts can be appreciated in embryo. Fray Luis de León, humanist and theologian, did not attain to the highest flights of the mystic ascent, but in his prose De los Nombres de Cristo, as in his poems, he moves by his passionate devotion, his sincerity and his profound feeling for nature, the whole finding expression in a style of singular purity. St. John of the Cross (1542-91) rests on a pre-eminence unparalleled in Spanish literature by virtue of three mystical poems (Noche oscura, Cántico expiritual, Llama de amor viva) of which his prose writings were long and involved expositions The poems throb with religious ectasy and represent the most exalted expression in Spanish of the most exalted of human experiences, mystic union.

The Novel .- Popular taste in the novel was dominated for a century by the monstrous progeny of the Amadis de Gaula, which had achieved print in 1508 These interminable romances kept alive certain ideals of mediaeval chivalry, but, having lost touch with life at every point, represented pure escapism and in due course evoked, along with moral censure, various literary reactions The pastoral novel was one Akın to the ecloque naturalized from Italy by Garcilaso, it was modelled on Sannazaro's Arcadia and inspired by nostalgic echoes of the golden age Its shepherds were courtiers and poets who, no less than the knights-errant, turned their backs on material reality, with the purpose, however, of exploring the more freely, against an idealized and carefree setting, the realm of the emotions. In Spain the first and best example was the Diana (c. 1559) of Jorge de Montemayor; to the vogue it started, Cervantes with his Galatea and Lope de Vega with his Arcadia alike subscribed. In Gaspar Gil Polo's Diana enamorada (1564), which was outstanding among the many sequels and imitations, the story became little more than framework for a lyrical anthology.

A more positive reaction against the inflated tales of chivalric prowess was seen in the picaresque novel (q.v.) initiated in 1554 with the brief, anonymous Lazarillo de Tormes. The word picaro, of doubtful origin, does not appear in the text; the kind, native to Spain, was to exert influence in many foreign literatures. The picaro was the antihero, innocent of ideals and concerned only to keep alive, who lived on his wits and, as he passed from master to master, saw and depicted life from underneath. Important for its part in guiding fiction back to direct observation of life, the picaresque formula had nothing to contribute to the development of the novel as an art form. The seed sown by the Lazarillo did not in fact bear fruit for nearly 50 years; and with the Guzmán de Alfarache (1599) of Mateo Alemán, whose interminable moralizings showed the Counter-Reformation's influence on literature at its heaviest, and Quevedo's Buscón (1626), where realism has become a cynically grotesque caricature of all human values, the kind, though it continued abundant throughout the 17th century, may be held to have given what it had in it to give.

Miguel de Cervantes Saavedra (q.v.; 1547-1616), the culminating figure in his country's literature, produced in Don Quixote (1605-15) the prototype of the modern novel and still its greatest exemplar. Nominally a satire on the already moribund romances of chivalry, the conception allowed of the presentation of reality on two levels, the "poetic truth" of Don Quixote and the "historic truth" of Sancho Panza. In pursuing the constant interaction of these equally valid but rarely compatible attitudes to life Cervantes revealed the true scope of the novel as a philosophical commentary on existence, and in tracing the constant interplay of character between master and squire-in contrast with the static characterization of previous fiction-he established psychology as one of the touchstones of excellence. In the Novelas ejemplares (1613), 12 tales of which the 5 belonging to the romanticadventure type of the Italian novellieri may be discounted, Cervantes particularized his claim to be the first to write novelas (short stories) in Spanish by differentiating between those which interest by the action and those whose merit lies in the mode of telling, "making something out of nothing."

Later Drama.—The comedia achieved its formula and its splendour in the genius of Lope de Vega (1562-1635) toward the close of the 16th century, to fill thereafter with an incredible fertility of invention the 100 years prior to the death of Calderón in 1681. Its manual was Lope's own Arte nuevo de hacer comedias en este tiempo (1600), which firmly rejected the "rules," opted for a mixed kind (comedia is in Spain an all-embracing term) and for metrical variety and made of the vulgo the ultimate arbiter of taste. This was essentially, therefore, a "social" drama, ringing a thousand changes on the accepted foundations of society, respect

for crown. for church and for the human personality, the latter symbolized in the "point of honour" that Lope commended as the best theme of all "since there are none but are strongly moved thereby." The pundonor was in truth a matter largely of convention, "honour" being equivalent, in a very limited and brittle sense, to reputation. Here too the drama was social; characters, to merit esteem, had perforce to abide by all the prescriptions of their fellows. It followed that this was a drama less of character than of action or of intrigue, which rarely if ever grasped the true essence of tragedy or knew the cathartic function. What the great Spanish playwrights did possess was a remarkable sense of stage-craft and the ability to make the most intricate plot grip to the end, however arbitrary the final typing or untying of the knots.

Lope, the "prodigy of nature," as Cervantes called him, who claimed authorship of 1,800 plays, some composed within 24 hours, and of whom we still possess around 500, swept public and fellowdramatists alike into vassalage by his powers of creation. Little that he wrote was perfect, but he had an unerring sense for the theme and the detail that could move an audience, conscious of being on the crest of its country's greatness, to respond to a mirroring on the stage of some of the basic ingredients thereof. Because of him the comedia became a vast sounding board for every chord in the Spaniard's consciousness, a "national" drama in the truest sense. His plays have been classified into religious, mythological, pastoral, novelesque and the like. In reality only two groupings matter: the native historical, and the capa y espada ("cloak-and-sword") plays of contemporary manners. Lope ransacked mediaeval chronicle, the romancero, popular legend and song for heroic themes, chosen for the most part as throwing into relief some aspect of the national character or of that social solidarity on which the Spain of his own day rested. Fuente Ovejuna, Peribáñez y el comendador de Ocaña, El Caballero de Olmedo, La Estrella de Sevilla (concerning the authorship of which there is now some doubt) count among the best.

The cloak-and-sword play, a type which weighed more and more in the comedia after Lope, was pure diversion, written to a number of hollow conventions with much disguising, mistaking of identities, duelling, falling in and out of love and false alarms about "honour" and a duplicating of the plot below stairs between gracioso (the gallant's humorous or would-be humorous lackey) and lady's maid. Though contemporary, it could in no sense be held to give a true picture of society, but it gave pleasure by its infinite resource and dexterity, its sparkling dialogue, its tripping convolutions in the relations between the sexes and its constantly implied paean to the Carpe diem in an irresponsible world. The essentially lyrical character of much of the comedia further explains its charm.

The greatest of Lope's immediate successors was Tirso de Molina, pen name of Fray Gabriel Téllez (c. 1584-1648), whose El Burlador de Sevilla, though far from his best play, achieved fame as presenting the Don Juan legend on the stage for the first time. La Prudencia en la mujer figures among the greatest of Spanish historical dramas, as El Condenado por desconfiado does among theological, while his cloak-and-sword comedies include some of the liveliest of the kind. In the delineation of character, especially feminine character, Tirso had few equals. Juan Ruiz de Alarcón (c. 1581-1639) struck a distinctive note which some have sought to relate to his Mexican birth and upbringing, others to his physical deformity. His 20 plays were sober, studied and imbued with serious moral purpose; La Verdad sospechosa inspired Corneille's Le Menteur. The dramatic conflict between love and honour posed in Las Mocedades del Cid by Guillén de Castro (1569-1631) was the source similarly of Corneille's Le Cid. But moral purpose and dramatic conflict are infrequently to be found among the plays of Antonio Mira de Amescua, Luis Vélez de Guevara, Juan Pérez de Montalbán and the many others who with more or less distinction, if with dwindling originality, bridged the transition from Lope to Calderón.

Culteranismo and Conceptismo.—In poetry and prose the early 17th century was marked by the rise and spread of two interrelated movements. The one, known as culteranismo, of which Luis de Góngora (1561–1627) was the archpriest, resumed, as one of its facets, earlier attempts to ennoble the language by re-Latinizing

it. In Góngora's Soledades and Polifemo y Galatea this process was not only carried to extremes in vocabulary, syntax and word order, so that the reader too must needs be something of a Latinist, but expression was garbed in the full panoply of classical myth and allusion and further complicated by every subtlety of which metaphor is susceptible. Yet this poetry was something other than a deliberate cult of obscurity. Theme and treatment make clear the attempt to achieve a poetry not merely "pure" but timeless, to do for Spanish what the lyric poets of antiquity had done for Greek and Latin, to write poems which, rediscovered after the lapse of hundreds or thousands of years, could be acclaimed still fresh and immortal. Indeed after 300 years Góngora was so rediscovered; but for his age his example invited many who lacked his genius to imitate slavishly his procedures. Gongorism disfigures many a good play by Calderón.

The twin affectation was conceptismo, which played on ideas as culteranismo did on language. The conceptista purveyed thought and sought to shock the reader into attention by the subtlety and also by the violence of his conceits. Aiming always at the semblance of profundity, the quintessential, his style was concise and epigrammatic and demanded for comprehension not the wellstocked mind but one infinitely nimble and alert. Conceptismo thus belonged properly to prose, inclined to satire, since it was much concerned with stripping off appearances, and found its most adequate outlet in the essay. Francisco de Quevedo (1580-1645), the master satirist of his age in the literary, the political and the social sphere and one of Spain's greatest wielders of language, was, in Los Sueños, its outstanding exponent. Baltasar Gracián (1601-58), its preceptist, reduced all its refinements to an exact code in his Agudeza y arte de ingenio, as in a series of treatises (El Héroe, El Discreto, El Oráculo manual y arte de prudencia) he sought to codify also the art of worldly living. Gracián, if doubtfully a philosopher, was a thinker, and his allegorical novel El Criticón, a pessimistic interpretation of life as a "daily dying," was to influence La Rochefoucauld, Schopenhauer and Nietzsche.

Calderón.-Pedro Calderón de la Barca (1600-81) spanned the century of Spain's decline, and his drama constitutes a studied expounding of patterns of behaviour (the pundonor) or of belief. He wrote 80 autos sacramentales (symbolical plays performed on Corpus Christi day), and these, together with La Vida es sueño, La Devoción de la cruz and El Mágico prodigioso, which gave what dramatic tension was possible to a highly intellectualized exposition of Catholic dogma, make of him the perfect literary representative of the Counter-Reformation. In the so-called "honour" plays-El Médico de su honra, A secreto Agravio secreta venganza, El Pintor de su deshonra and El mayor Monstruo los celos—the cold logic with which an unreal code is pursued to the extreme becomes repugnant. El Alcalde de Zalamea, a reworking of a play by Lope, is perhaps his most successful play on the human level. La Vida es sueño, to the extent that it raises profound philosophical issues on a plane of universality, has given him his great fame abroad.

Francisco de Rojas Zorrilla (Del Rey abajo, ninguno) and Agustín de Moreto (El Desdén con el desdén) stand out among those who revolved in the orbit of Calderón. After his death Spanish drama lay dead for the next hundred years. Culteranismo and conceptismo, though symptoms rather than causes, had played their part too in the stifling of imaginative literature, and by the close of the century nothing but the shell remained of the greatness that had been the siglo de oro.

The 18th Century.—With the advent of the Bourbon dynasty in 1700 and its establishment after the War of the Spanish Succession a profound renewal of the country's intellectual life took place. Numerous academies were created, the most influential being the Real Academia Española founded in 1713 to maintain the purity of the language (Diccionario de autoridades, 1726-39; Gramática de la lengua castellana, 1771). Men of letters once again went to school abroad and discovered how far Spain had deviated from the intellectual courses of western Europe.

Moreover, a new spirit of inquiry into the national heritage was to carry back to Luis de León, to Herrera and to Garcilaso an awareness that in the early decades of the century had seemed

limited to Góngora, Quevedo and Calderón (worst of models for an imitative generation) and was indeed to go back earlier still, to unearth the forgotten mediaeval literature. Gregorio Mayáns y Siscar (1600-1781), sometime royal librarian, edited Juan Luis Vives (in Latin), Juan de Valdés and Luis de León and, in a study of Cervantes, initiated Cervantine criticism. The Augustinian Enrique Flórez, embarking on the vast Teatro geográfico-histórico de la iglessa de España better known as España sagrada (29 vol., 1747-73; increased to 52 vol by 1918), helped resurrect the whole cultural background of mediaeval Christian Spain. A landmark of even greater importance was the publication for the first time in Tomás Antonio Sánchez's Poesías castellanas anteriores al siglo XV (1779-90) of the Poema de mio Cid, the works of Gonzalo de Berceo, the Libro de Alexandre and Juan Ruiz's Libro de buen amor. From all this critical activity there resulted a debate between old and new which, waged throughout the middle decades of the century, compelled either side to reason its position and marked the birth of a new critical approach to literature.

Two names stand out: Ignacio de Luzán, educated in Italy and well-grounded in foreign literatures, whose Poética (1737) introduced to Spanish readers the aesthetic of Muratori, Boileau and René Le Bossu and launched the great polemic; and Benito Feijóo (1676-1764), a Benedictine whose Teatro crítico and Cartas eruditas (8 vol. and 5 vol., 1726-60) comprised more than 280 essays ranging over the entire universe of human knowledge. Assailing error, prejudice and superstition wherever he found them and so bitterly assailed in his turn that the king intervened to protect him, Feijóo made a monumental contribution to the intellectual emancipation of Spain Imaginative prose produced the Noches lúgubres of José Cadalso (published posthumously in 1792), looking forward to romanticism; and the Fray Gerundio (1758-68) of Francisco José de Isla, a satire in the guise of biographical fiction on affectation in the pulpit, which looked back to the picaresque novel.

Poetry, moribund for nearly 100 years, raised a timid head at length in a small group at Salamanca, led by the Augustinian Diego González, which toward 1775 turned for inspiration to Luis de León, just as two decades later a group at Seville sought to revive the glories of Herrera; and again, though the lines were now more blurred, Salamanca stood for content, Seville for form. Juan Meléndez Valdés (1754–1817), who learned to think from John Locke and to feel from Edward Young, best exemplified the combination of new influences at work. A conscious artificer rather than a great poet—though the nearest to such among the Salamancans—he helped poetry through the painful apprenticeship necessary to its rehabilitation.

For drama, the second half of the century saw the great battle of the "rules," meaning chiefly the unities that the siglo de oro had spurned. La Raquel (1778) of V. A. García de la Huerta, combining a traditional Spanish theme with neoclassic construction, showed of what the reformist school was capable. The same author's yeat compilation of earlier drama, the ré-vol. Theatro hespañol (1785-86), made apparent in its total omission of Lope, Tirso and Alarcón how unsubstantial were the grounds on which condemnation rested.

It fell to Ramón de La Cruz (1731-94) to bridge the gap, unwittingly but very effectively, by his fecund resurrection on a somewhat ampler scale of the earlier paso or entremés of Lope de Rueda, Cervantes and Luis Quiñones de Benavente (1589-1651). Based on acute satirical, though in the main good-humoured, observation of the contemporary Madrid scene, his one-act sainetes could not, in their brevity, transgress the unities or offend the purist; at the same time they delighted the vulgo and brought the drama back from the realms of pseudoantiquity to the function of commenting on life and society. Leandro Fernández de Moratín (1760-1828) applied the lesson to the full-length play and produced in El Viejo y la niña, La Comedia nueva and El Si de las niñas comedies imbued with deep social seriousness which, written to a meticulous observance of the unities, were still good theatre. The Comedia nueva, a remorseless flaying of such writers as L. F. Comella (1751-1812) who had reduced to absurdity what they fondly believed to be the Calderón tradition, absolves one from any among the best prose of the 18th century.

Romanticism .- The first third of the 10th century proved but a prolongation of the 18th the Napoleonic wars and their long aftermath casting a blight on letters The inspiriting odes of a Nicasio Gallego or a Manuel José Quintana or the impassioned prose of a Gaspar Melchor de Tovellanos, one of the noblest figures of the age (1744-1811), show neoclassic objectivity and proportion set aflame with the emotion of outraged patriotism. War against France did not mean the repudiation of French literary influences. The thousands of liberals driven into exile by Ferdinand VII after 1823 sought refuge for the most part in France (some too in England). Having drunk there the heady wine of romanticism, they flocked back to Spain on Ferdinand's death in 1833.

Such fortuitous contacts were far from being the sole source of Spanish romanticism. The ground for this had been prepared in Cadiz from 1814 in a notable debate on literary values initiated by the German I. N. Böhl de Faber: in Barcelona with the founding in 1823 of the review El Europeo, its three editors a Catalan, an Englishman and an Italian; and in Madrid with Agustín Durán's critical essays on the drama of the siglo de oro and his vast Colección de romances antiguos (1828-31). Romanticism in France, moreover, was largely a revolt against native literary tradition and a turning abroad, notably to Spain, for new sources of inspiration; whereas in Spain it implied the rejection of an alien neoclassicism and to that extent a return to the spirit of its own earlier classics: All the formal characteristics of Spanish romantic drama -the mingling of kinds, the rejection of the unities, metrical variety (this now extended to the inclusion of prose)-had characterized the drama of Lope and his contemporaries, who had moreover treated many of its themes (taken preferably from the Spanish middle ages). It is from a study of these themes that the novelty and significance of the new school becomes apparent. Whereas the drama of the siglo de oro had rested directly on social solidarity, romantic drama was in revolt against society: its protagonist staked everything on his right to be himself, especie única, and, deliberately flouting every convention, defied society to stand in his way. In France, tragedy was by romanticism deflected into drama; in Spain, drama into tragedy,

The movement in Spain, coming to fruition a generation later than elsewhere in Europe, knew a correspondingly short and chequered life. The six plays that epitomize its dramatic achievement fell within the decade 1834-44: Francisco Martínez de la Rosa (1787-1862), La Conjuración de Venecia; Mariano José de Larra (1809-37), Macias; Angel Saavedra, duke de Rivas (1791-1865), Don Álvaro o la fuerza del sino; Antonio García Gutiérrez (1813-84), El Trovador; Eugenio Hartzenbusch (1806-80), Los Amantes de Teruel: José Zorrilla y Moral (1817-93) Don Juan Tenorio; so too the poetry of José de Espronceda (1808-42). Rivas' Don Alvaro came nearest, in the theatre, to expressing a "philosophy" of romanticism; and the preface, from the pen of Antonio Alcalá Galiano, to his Moro expósito to supplying a foundation of precept. But the movement never possessed either the consistency of a school, or a leader, or a corpus of doctrine. Espronceda was the one romantic who lived his romanticism, if with an element of Byronic posturing; his Estudiante de Salamanca, Canciones and unfinished Diablo Mundo were the only subjective lyricism of value that the period produced and marked too a milestone in the enlargement of poetic form. In comparison, the Romances históricos of Rivas and the Cantos del trovador of Zorrilla were little more than exercises, brilliant within the limitations of their kind, in the retelling of picturesque legend. In prose Larra, Rivas, Espronceda and others tried and failed to acclimatize the historical novel after Sir Walter Scott, a form that never struck roots in Spain. Larra, the outstanding prose writer and most critical mind of his generation, dissected society pitilessly in his Articulos de costumbres, which, with the Escenas matritenses (1836-42) of Ramón de Mesonero Romanos and the Escenas andaluzas (1847) of Serafín Estébanez Calderón, helped to prepare the ground for the resuscitation of the novel.

Post-Romantic Poetry.-Three poets bestride the third quarter of the century and, in their diversity, reveal how one of ro-

need to read their handiwork. Moratin's dialogue here ranks manticism's major services was its liberation of the individual personality, whereby literature was set free from compulsory subscription to any school or doctrine. Gustavo Adolfo Bécquer (1836-70), accounted a romantic, was concerned only to give expression to his own tortured emotions. His 76 brief Rimas, which owe something to Heinrich Heine, bear the stamp of a deeply moving sincerity. In his Leyendas Bécquer proved himself too a prose stylist in a richly poetic and imaginative vein. Ramón de Campoamor (1819-1901) affected the epigrammatic in his Doloras, Pequeños poemas and Humoradas, names indicative of a sustained attempt at originality and at bringing poetry back into the realm of ideas. The contemporary fame as a thinker of this bourgeois, utilitarian mind has not withstood the lapse of time; but he had a gift of mildly ironic observation, and later dramatists on occasion found in a quatrain by him matter for a play. Gaspar Núñez de Arce (1834-1903) likewise endowed poetry with a purpose, the social purpose of stimulating the civic virtues and defending the body politic against dangerous heresies. His Gritos del combate represented a noble if despairing attempt, at times overdeclamatory in tone, to stem the tide. Among somewhat later poets were Salvador Rueda (1857-1933; Cuadros de Andalucia, Aires españoles), an exuberant local colourist who has been taken as a precursor of modernism; José María Gabriel y Galán (1870-1905; Castellanas, Extremeñas, Campesinas), a laudator temporis acti singing the traditional virtues of the Castilian countryside; and Rosalía Castro (1837-85), a true poetess of Galicia, whose one volume of poems in Castilian, En las orillas del Sar (1884), invited comparison with Bécquer.

The 19th-Century Novel and Drama,-The last-named poets, each identified with his patria chica, shared with the novelists a quality that was to characterize Spanish fiction on its rebirth. For more than two centuries, from long before the period of afrancesamiento, the kind in which Spain had made its most striking contribution to world literature had been virtually extinct. The revival during the romantic period of the cuadro de costumbres was a pointer to where the native bent lay, and some novelas de costumbres timidly reidentified the novel with realistic social observation. It was Fernán Caballero (pen name of Cecilia, daughter of Böhl de Faber) who, with La Gaviota (1849), determined the particular technique of observation that was to rehabilitate the novel. This simple tale of romantic disillusion captivated less by its plot than by its Andalusian setting and by vividness of colour and detail. Twenty-five years later, coinciding with the restoration of the Bourbon monarchy (1874), came the beginning of the great period of the regional novel.

Pedro Antonio de Alarcón (1833-91), a waverer between the esoteric-romantic and the pedagogic, achieved his masterpiece in El Sombrero de tres picos, a sparkling tale of Andalusian peasant malice. A fellow-Andalusian, Juan Valera (1824-1905), brought much psychological insight and a classical note of cultured detachment to four novels (Pepita Jiménez, Las Ilusiones del doctor Faustino, El Comendador Mendoza and Doña Luz) which depended less on local realism, acutely observed though this was, than on the author's knowledge of men and women. José María de Pereda (1833-1906), graduating through a long series of Escenas montañesas, emerged as the greatest of the school. His realism in depicting his native Santander was no longer merely picturesque but a powerful re-creation of nature as the abiding reality, more important than the individual and therefore than the plot. Sotileza and Peñas arriba, perhaps his best novels, revealed a champion too of traditional values-religion, the family, country life-in a dissolving society typified by the big city.

Emilia Pardo Bazán (1851-1921) attempted, in two novels of Galicia, Los Pazos de Ulloa and La Madre naturaleza, to combine the Spanish Christian outlook with French naturalism, which she had already examined curiously and with many reserves in La Cuestión palpitante. The attempt made clear the incompatibility, and in later novels (La Quimera, La Sirena negra) the return to a genuinely Spanish realism, in which spiritual values also found their place, was complete. Armando Palacio Valdés (1853-1938) was the novelist of Asturias even when, as in the perennially popular La Hermana San Sulpicio, the stage was transferred to

Andalusia or, in La Alegria del capitán Ribot, to Valencia. He likewise experimented, in mid-career and somewhat half-heartedly, with naturalism (La Espuma, La Fe) but was saved by his most engaging quality, humour.

Besides this cult of regionalism, the fecundity in the novel of Benito Pérez Galdós (1843-1920) created a world in itself. Coming to Madrid from the Canary Islands in 1862, Galdós was better placed to see Spain from outside, in the round; and, after living through one of the most turbulent chapters in Spanish history, he addressed himself to the task of imaginatively re-creating its antecedents, beginning with the war against Napoleon. The 46 vol. of his Episodios nacionales, written from 1873 to 1879 and from 1898 to 1912, embraced 70 years of the country's record, from Trafalgar to the early years of Alphonso XII, and taught generations of Spaniards much of whatever history they knew. Other series (Novelas de la primera época, Novelas españolas contemporáneas) completed the revelation of Spain to Spaniards; embodying the author's liberal and challenging views, they constituted a concerted campaign to regenerate and Europeanize Spanish society and thought. Gloria, La Familia de León Roch, Fortunata y Jacinta, Angel Guerra, Misericordia are individual excellences in the rich endowment of this giant among Spanish novelists.

The drama in the later 19th century, disorientated after the brief romantic efflorescence, produced few outstanding works and no clear conception of goal or function. Manuel Tamayo y Baus (1829-98), who began by oscillating between, and even attempting to' fuse, classical tragedy and romantic drama, gradually evolved from verse to prose and from the historical-heroic to the contemporary-social; he achieved fame by the isolated Un Drama nuevo (1867), a powerful portrayal of a Yorick compelled to act on the stage his own personal tragedy. Adelardo López de Ayala (1829-79) used considerable technical gifts to pillory bourgeois vices (El Tejado de vidrio and Consuelo). The Nobel prize for literature (1904) set a seal on José Echegaray (1832-1916), whose 63 plays fall into two main groups: in the first, imbued with a violent neoromanticism, drama became melodrama with a constant striving after effect and a basic falsity of character, passion and situation alike; the second comprised a serious, often tragic drama of social problems in which Ibsen could be seen as one of several foreign influences (El gran Galeoto, O Locura o santidad, De mala Raza, El Hijo de don Juan), though here too passions were apt to be torn to shreds and dénouements to rely on the violent dispatch. Joaquín Dicenta, still close to Echegaray in his search after effect, brought the drama nearer to earth with an unpleasantly realistic study of working-class conditions in Juan José (1805). Failure to master the problems involved in the change of medium robbed Galdós of full success in the theatre, to which he turned increasingly in his concern to stimulate the social conscience (Realidad, La Loca de la casa, Electra, El Abuelo).

The Generation of 1898.—Once again, as in 1700, the turn of the century brought about a radical change in literary values and directions. Over the previous two decades and more a mood of scathing analysis had been developing with the growing conviction that behind the peace and order of a nominally representative regime much rottenness lay concealed. Galdós sensed and gave voice to the disquiet; and it evoked, in Angel Ganivet's Idearium español (1897), one of the most searching analyses of the Spanish character ever written. With 1898 came the brief and disastrous war with the United States, which left Spain stripped of the last vestiges of its trans-Atlantic and Pacific empire. The imperial cycle begun in 1492 had ended in ignominy, and thinking Spaniards embarked on an analysis of their country's ills, a scrutiny of its possible destiny and an attempt to shock the national mentality out of its aboulia. Among literary consequences were the informing of the novel with a new seriousness of purpose and the emergence of the essay-critical, psychological, philosophical-to a new importance. These novelists and essayists constitute the "generation of '98." Rarely in agreement in their diagnosis or on the treatment proposed for the patient, they reinvigorated Spanish letters to a point where these again commanded respect abroad and, as part of the process, laid Spain open to English, French, German, Russian and other influences on a scale never known hafava

Miguel de Unamuno (1864–1936) dominated the literary scene for a generation. In him the national problem was intertwined with his obsession with the personal problem of immortality. The former he studied acutely in his essays En Torno al casticismo and in the Vida de don Quijote y Sancho, the latter in his most important work, Del Sentimiento trágico de la vida. A deliberately provocative rather than systematic thinker, he aimed at sowing spiritual disquiet. The novel was to him an extension of the essay, as the theatre was of the novel, a medium for discussion of the fundamentals of personality, hence stripped of externals and as timeless as the Soledades of Góngora (Niebla, Abel Sánchez, Tres Novelas ejemplares y un prólogo).

) concerned Azorin (pen name of José Martinez Ruiz, 1874himself with the re-interpretation of earlier literary values and of the Spanish countryside (El Alma castellana, La Ruta de don Quijote, Clásicos y modernos). An artist in criticism and a miniaturist of fine sensitivity, he contributed powerfully to the deflation of the hollow rhetoric that had vitiated much of 19th-century writing. José Ortega y Gasset (1883-) brought to the analysis a mind formed in Germany in the study of neo-Kantian thought. From criticism and psychology (Meditaciones del Quijote, El Espectador) he passed to national problems (España invertebrada), then to international (El Tema de nuestro tiempo, La Rebelión de las masas). His Revista de Occidente, founded in 1923 and directed to keeping Spain abreast of contemporary foreign thought, proved a major intellectual force.

) repudiated tradition, religion and the Pío Baroja (1872cult of the individual and sought to be an arch-European, fixing his gaze on the future and making a cult of action for social purposes. The Memorias de un hombre de acción (a series of novels set in the early part of the 19th century) are thus less characteristic than his numerous trilogies on the contemporary scene (La Raza, La Lucha por la vida, Agonías de nuestro tiempo). Insensitive to art for art's sake, Baroja often depresses the reader through his concern to arouse discontent with material conditions; but his novels, full of rude vigour and a fierce independence of spirit, are seedbeds of ideas. There was rude vigour too, together with richness of colour and greater narrative skill, in Vicente Blasco Ibáñez (q.v.; 1867-1927), a survivor into the 20th century of the regional novelist (Flor de mayo, La Barraca, on his native Valencia) who wrote also on contemporary social problems (La Bodega, La Horda) from the standpoint less of the generation of '98 than of the anarchist and who won international renown with novels of World War I (Los cuatro Jinetes del Apocalipsis, Mare nostrum). Ricardo León (1877-1943) was a conscious stylist who sought to recapture the traditional Christian values of a society threatened with materialism (Casta de hidalgos, Alcalá de los Zegries, El Amor de los amores).

The 20th Century.-In Ramón Pérez de Ayala (1881the novel is at once a satisfying art form and a forum for philosophical discussion tinged with Asturian humour. Troteras y danzaderas recaptures something of the vein of Juan Ruiz. Belarmino y Apolonio, a projection of the old debate between faith and reason, makes its characters almost symbolic, as do Tigre Juan and its continuation El Curandero de su honra on the traditional theme of honour. Gabriel Miró (1879-1930) was a lyric poet in prose, with gifts of description and evocation (Figuras de la pasión del Señor, Años y leguas) which retard the action of his novels (La Novela de mi amigo, El Libro de Sigüenza, Nuestro Padre San Daniel) but have given him the reputation of a supreme artist in words. In the work of nearly all these writers can be seen qualities and tendencies incompatible to some extent with the basic art of the novel, which as a kind was already in decline in 1936. The civil war of 1936-39 dealt a heavy blow to imaginative writing in general. Novelists of promise who made their name later were: Camilo José Cela, La Familia de Pascual Duarte (1942); Carmen Laforet, Nada (1944); and Juan Antonio de Zunzunegui. La Quiebra (1947).

The drama also achieved new vigour with the new century under the stimulus of Jacinto Benavente (1866—), another Nobel prize winner (1922) and Spain's greatest playwright since Calderón. With him the drama returned to reality, after the extravagances of Echegaray, by way of social criticism, declamatory verse giving way to prose, melodrama to comedy, formula to experience, impulsive action to dialogue and the play of minds. After a first period of effervescence and irony, Benavente showed a preoccupation with aesthetics as he mastered his medium, and later with ethics. Los Intereses creados, Los Malhechores del bien, La Noche del sábado, La Malguerida are evidence of the extent to which he broadened the scope of the theatre. By contrast, Gregorio Martínez Sierra (1881-1947) remained true to a more traditional Spanish atmosphere, in which idyllic sentiment, though deep-rooted always in Spanish realities, breathed a sensuous joy in nature and in life (Teatro de ensueño, Canción de cuna, El Reino de Dios, Nuestra Esperanza). The brothers Serafín (1871-1938) and Joaquín (1873-1944) Álvarez Quintero, writing as one, were pure costumbristas. If they contributed nothing new to dramatic art, the infinite joie de vivre of their long succession of Andalusian comedies never failed to entertain (La Puebla de las mujeres, El Centenario, La Señora de Alfaqueque). Among other dramatists of note are Manuel Linares Rivas (El Abolengo, 1904, La Garra, 1914) and José López Pinillos ("Pármeno"), author of Esclavitud (1918) and Embrujamiento (1923).

The poetic drama was cultivated with success by Eduardo Marquina (1879—1946), who found inspiration in the heroic past (Las Hijas del Cid, En Flandes se ha puesto el sol); by Jacinto Grau (1877—; El Conde Alarcos, El Hijo pródigo); by Francisco Villaespesa (El Alcázar de las perlas, 1911); by Ramón del Valle-Inclán (Cuento de abril, 1910; Voces de gesta, 1912); and by Luis Fernández Ardavín (La Dama del ermiño, 1921; La Maja, 1928). Federico García Lorca (c. 1898—1936) stands far above any of these. His drama (Bodas de sangre, Yerma, La Casa de Bernarda Alba) was poetic in more than the formal sense, presenting the elemental passions with an intensity that made the characters poetic symbols of man's tragic impotence to arrest his fate.

One other vein of dramatic activity, commonly held to fall below criticism, adds persisting vitality to a long and honourable descent. It is the género chico ("small kind"), heir to earlier paso, entremés and sainete, which within the limitations of the short sketch, frequently with music, achieves a great variety of dramatic effect and for almost a century has charmed the vulgo whose way of life supplies it with setting and theme. Ricardo de la Vega (1839-1910) and Carlos Arniches (1866-1943) span that century between them and are outstanding in the kind, which the brothers Quintero likewise notably enriched.

Rubén Darío, Latin America's greatest poet, brought with him to Spain in 1892 the movement known as modernismo, of which he was the leading exponent. In its ideas modernism was a reaction against 19th-century bourgeois materialism and a search for other and, more specifically, for aesthetic values in life. In literature it was a reaction against naturalism drawing heavily in its poetic norms on French symbolism and parnassianism alike, with elements of a revived romanticism. Endowed with great technical virtuosity, Darío enriched beyond measure the musical resources of Spanish verse, notably in the sphere of rhythm; and under his influence poetry in Spain experienced a renewal comparable only with that effected by Garcilaso almost four centuries earlier.

Though so nearly coincident in time with the movement represented by the "generation of '98," modernism had scarcely any contact with it. Initially it stood for the cult of the ivory tower, wherein the poet took refuge from his fellows and from life and sought self-realization in the pursuit of esoteric beauty. It produced, however, one prose writer, the novelist Ramón del Valle-Inclán (1869-1936), whose four Sonatas typify the four seasons of his hero's life. Valle-Inclán later wrote historical novels (the trilogy La Guerra carlista, the two books of La Rueda ibérica), but here too his vision was purely aesthetic. For the rest, the modernists were poets; and predominantly they were Anadausians, the old contrast still holding between the attraction of form, which interested them, and that of content, with which the northerners of the "generation of '98" were concerned.

Juan Ramón Jiménez (1881- ), beginning to write under the aegis of Darío, soon discovered poetry to be for him not a with-

drawal but the whole of life, reality itself, and his style, initially ornate, became more and more bared, with a turning to blank verse, as he strove to capture the poetic essence of each passing moment. Using and gradually winnowing all the resources of modernism, he became the poets' poet and a powerful influence on the younger generation. The brothers Machado exemplify well the Andalusian-Castilian dichotomy: Manuel (1874-1947), always at heart of his native Seville, was the modernist, with a detached Bohemian attitude to life and the attitude to poetry of the craftsman; Antonio (1875-1939) early lost his heart to Soria, in Old Castile, and his best poetry, written with an infinite simplicity, almost poverty, of artifice, dealt with the recesses of the poet's soul or with the unchanging soul of Castile. Unamuno, Valle-Inclán and Pérez de Avala all figure in the tale of modern poetry, though their poems were but the prolongation in another medium of their prose works. Of the three Unamuno, the least accomplished technically, is the most rewarding as he seeks to distil into verse the intensity of his spiritual striving.

The poetic stature of García Lorca grew steadily after his death in 1936. As in his plays, he is a poet of fundamentals and has shown of what starkness of feeling and effect the copla and romance of secular tradition are still capable. His Romancero gitano (1928) and Poema del cante jondo (1931) reveal the potency of the inspiration that he drew from Andalusian ways and folklore; the former won a wider public throughout the Spanishspeaking world than any other work of poetry of the 20th century. The other major poets of the middle of that century were still those of the pre-civil war generation, contemporaries of García Lorca and heirs, as he was, to Dario and Juan Ramón Jiménez. Pedro Salinas (1892-1951), Jorge Guillén (1893-), Gerardo ), Vicente Alei-Diego (1896-), Dámaso Alonso (1898xandre (1900-), Rafael Alberti (1902-), Luis Cernuda, (1904-) and Manuel Altolaguirre (1906-). The civil war dealt hardly with them too, driving some into exile, stifling the inspiration of others; in the main, their best work was already done. The immediate postwar generation was characterized by its minority groups, fugitive reviews and dispersive tendencies.

minority groups, fugitive reviews and dispersive tendencies.

Bibliografia de la literatura hispánica (Madrid, 1956 fil); J. Fitzmaurice-Kelly, A New History of
Spanish Literature (Oxford, 1946); J. Gegador y Frauca, History of
Spanish Literature (Oxford, 1946); J. Cejador y Frauca, Historia de
la lengua y literatura castellana, 14 vol. (Madrid, 1915-22); G. T.
Northup, An Introduction to Spanish Literature (Chicago, 1925);
L. Pfandl, Geschichte der spanischen Nationalliteratur in ihrer
Blittezett (Freiburg, 1929; Spanish trans, Barcelona, 1933); A. F. G.
Bell, Contemporary Spanish Literature (New York, 1925) and Castilian
Literature (Oxford, 1938); E. Mérimée, A History of Spanish Literature, Eng. ed. by S. G. Morley (New York, 1935) and Castilian
Literature aspañola, 6th ed. (Madrid, 1940); G. Diaz-Plaja, ed.,
Historia general de las literatura española, 3rd ed., 3 vol.
(Barcelona, 1940); J. Hurtado and A. González Palencia, Historia de
la literatura española, 6th ed. (Madrid, 1940); G. Diaz-Plaja, ed.,
Historia general de las literatura sispánicas, 3 vol. (Barcelona, 1949
fil); G. Brenan, The Literature of the Spanish People (Cambridge,
1951); J. Marias and G. Blelberg, ed., Diccionario de literatura
española (Madrid, 1949); C. Barja, Libros y autores clásicos (Bratleboro, 1939), modernos (Los Angeles, 1933), contemporáneas (New
York, 1935); S. de Madariaga, The Genius of Spain and Other Essays
or Contemporary Spanish Literatura (Oxford, 1933); J. B. Trend,
Alfonso the Sage and other Spanish Essays (Boston and London, 1926);
M. Menéndez y Pelayo, Estudios y discussos de ortica historica y literaria, 7 vol. (1941-42), ortgenes de la novela, 4 vol. (Madrid, 1905-15;
reprinted 1943), and Historia de las diedas estéticas en España, 5 vol.
(Madrid, 1883-91; reprinted 1946-47).

## CATALAN LITERATURE

Early Poetry.—The Catalan language is properly to be regarded as a branch of Peninsular rather than of southern Gallo-Romance. It shows nonetheless many traces of kinship with Provençal, and the literature in its origins used the langue d'oc and all the poetic forms cultivated by troubadours north of the Pyrenees: Guillem de Bergadá, Hug de Mataplana, Ramon Vidal de Besalú, Guillem de Cervera, Cerverí de Girona were genuine Provençal poets in the same sense as were those of Limousin, Quercy or Auvergne. Ramon Vidal (late 12th-century) was preceptist as well as poet; his Dreita Manera de trobar became the code for Catalan poets writing in a tongue based supposedly on Limoges and known as lemost. This conventional language of poetry was not proof against the contagion of the spoken tongue,

and there resulted a composite idiom well illustrated in Raimon Lull (Ramón Llull, c 1232-1315) who, for all the earnestness of his later religious verse (Lo Desconort, of 69 12-line stanzas in monorhyme, Lo Consili), never wholly divested himself in his poetry of his troubadour beginnings. Ramon Muntaner (1265-1336), writing plain Catalan in prose, is still a troubadour in verse. In the later part of the 14th century, there was apparent a gradual waning of Provençal influence and a turning instead for inspiration to northern France, whence derived a new cult of long narrative poems on novelesque themes, including the matière de Bretagne. With the themes came the metre, known as noves rimades, a sequence of octosyllabic rhymed couplets. There exist poems of this class by Pere March, Guillem de Torroella, Bernat Metge; other poems, anonymous, include the Llibre dels set savis de Roma, of over 3,000 lines, the Facet o Libre de cortesia of half that length, and several which carry the new interest in the langue d'oil even to the incorporation on occasion of passages of French poetry. Another form, the codolada, was native in origin; used also for narrative but more especially for satire, it combined, again in rhyming couplets, an eight-syllable line with a four-syllable one.

The 15th-Century.—The 15th century is the great period of Catalan poetry. It dates from the institution at Barcelona in 1395, under the auspices of John I of Aragon (1387–95), of a "Consistory of the Gay Saber" on the model of that of Toulouse, with "jocs florals" which produced in themselves little poetry of note but typified a new and propitious atmosphere of royal encouragement. This continued under Martin I (1395–1410) and Ferdinand I (1412–16) and contributed much to the emancipation of style from alien influences. As the century advanced, Valencia emerged as a new focus of literary activity; many of the great

names of the age, in prose and verse, were Valencians.

With Joan Berenguer de Masdovelles, Francesc Ferrer, Pere Torroella, Pau de Bellviure, Antoni Vallmanya and, above all, the Petrarchan Jordi de Sant-Jordi and Ausiàs March there developed a school which, as regards versification, is noted for its almost exclusive use of eight-line decasyllabic cobles with crossed or "chained" rhymes and a final four-line tornada and, in inspiration, shows a turning away from France to Italy, where from 1443 an Aragonese court held sway in Naples. The Cants d'amor and Cants de mort of Ausiàs March (1379-1459), the most inspired and profound, if also the most difficult, poet of his age in the peninsula, contain the finest verses ever written in Catalan; they exerted great influence in 16th-century Castile and still do on modern Catalan poets. Very different in class and spirit is the Spill de les dones of Jaume Roig, a bitter and caustic satire upon women of more than 16,000 four-syllable lines which derives a very piquant interest from its really authentic element, the vivid picture of contemporary Valencian life and manners. Joan Roic de Corella is the third great Valencian lyricist, heir to Sant-Jordi and March and perhaps the best representative of the Renaissance spirit, which flowered more fully there than in Barcelona. After this bright period of efflorescence, Catalan poetry faded rapidly, the victim largely of political circumstance. From the union of Aragon with Castile there resulted a predominance of Castilian throughout Spain which inflicted a death blow on Catalan letters. The fact that it was a Catalan, Joan Boscà i Almogàver (in Castilian Juan Boscán), who inaugurated in the Castilian tongue a new school of poetry, and that Castilians regard him as a landmark in the history of their Renaissance muse, is important and revealing; by the year of publication of Boscán's works (1543), Catalan poetry had already been dead for half a century.

Mediaeval Prose.—The earliest prose works in Catalan are later than the poems of the first troubadours of the Provençal school. Though the oldest document dates from c. 1100 (the text of an oath imposed on certain barons by a bishop of Urgel), and the Homilies d'Organyà are attributed to the 11th century, literary prose goes back no further than the close of the 13th. Beginning as history, written close to, and often by prime movers in, the events that it describes, it has the advantage of being entirely original, the language being the true everyday speech found in charters from about the time of James I's accession to the Aragonese throne in 1213. Its four great 14th-century chronicles

are the crowning ornament of mediaeval Catalan prose. Two of them—that of James I, apparently compiled shortly after his death in 1276 with the help of memoirs dictated by himself, and that of Ramon Muntaner (1265–1336), relating at length the expedition of the Catalan company to the Morea and the conquest of Sardinia by James II—are distinguished alike by the artistic skill of their narration and by the quality of their language, inviting comparison with Villehardouin, Joinville and Froissart. Bernat Desclot's chronicle deals particularly with the reign of Peter the Great (1276–85). The account of the reign of Peter the Ceremonious (1336–87) is ascribed to Bernat Descol but was planned and revised by the king himself. The four works collectively present the perfect expression of the spirit and the greatness of mediaeval Catalonia.

Raimon Lull, the Doctor Illuminatus, born in Majorca, stands on an eminence apart through his vast encyclopaedic production, totalling about 180 works in Catalan. Arabic and Latin and covering every branch of mediaeval knowledge and thought. His Libre de contemplació en Déu (1272) marks the beginning of Catalonia's golden age of literature; an exhaustive theological treatise, it is also a mine of information on contemporary society. Blanquerna, his literary masterpiece, is a social-biographical romance which lays the foundations of Catalan fiction. Fèlix de les merauelles del món and the Libre del orde de cauayleria are other doctrinal works with a narrative framework. Inserted in the Blanquerna is the Libre d'amic e amat, a brief masterpiece of mysticism. A century later, Francesc Eximenis (1340-1403) represents something of the same intellectual amplitude, if without the originality or driving force, in Lo Crestià, planned as a comprehensive work in 13 books on theology, morals and politics for the layman but surviving in 4 books which were perhaps the only ones written. From its pages emerges a vivid picture of the mediaeval scene. The Libre de les dones, at once a book of devotion and a manual of domestic economy, is similarly informative on women's way of life at the time.

At the close of the 14th century Bernat Metge inaugurates the so-called "classical age." Well versed in Italian literature, he translated in Valter e Gruselda Boccacio's story of Griselda from the Latin version of Petrarch; in Lo Sommi (1398), a work which clothes scholastic learning with much poetic imagination, he achieved the stylistic masterpiece of Catalan prose. Joanot Martorell's chivalric romance Trant lo Blanc (1460) was notable in its kind for the theme, drawn from Muntaner, of the real adventures of the Catalans in the near east (hence the sparing of it in the famous scrutiny of Don Quixote's library). The anonymous Curial e Güelfa, of the end of the century, draws similarly on Desclot and is the only other Catalan novel in this vein. The beginnings of the drama are represented by the Misteri d'Elcla, a 75th-century Assumption play based on an earlier Representació; sung throughout to traditional music, it is still performed on

Aug. 14 and 15 every year at Elche.

The 16th-18th Centuries .- With the loss of political independence, literary and linguistic independence was lost, and Catalan fell to the level of a patois, kept alive over the next 200 years in the countryside and in the pulpit. The 16th century furnishes a single poet worthy of the name: Pere Serafi, some of whose Cants d'amor (1565), written in imitation of Ausias March but less obscure, are graceful enough to merit remembrance. In prose only scholars, chiefly antiquaries and historians, still wrote in Catalan; such were Miquel Carbonell, compiler of the Chrôniques d'Espanya (1513), Francesc Tarafa (Crònica de cavallers catalans) and Anton Beuter, of whose Cronica general de toda España the first part (dealing with Valencia) appeared in Catalan in 1538. Forty years of research and abundant documentation give interest to the Crònica universal del Principat de Cathalunya of Jeroni Pujadas, of which likewise only the first part (1609) was written in Catalan. Thereafter the eclipse was almost complete. Catalan remained only as the language of folk songs and ballads: in these (collected in the Romancerillo catalán [1853] of M. Milà i Fontanals) it lived on until the reawakening at the beginning of the 19th century.

The Renaixença.—In 1814 appeared the Gramàtica y apologia de la llengua cathalana of Josep Pau Ballot i Torres, a forerunne

of the literary and linguistic renaissance which marked the age of romanticism in Catalonia. The pioneers of the rehabilitation of Catalan for literary purposes soon discovered, however, the inadequacies for the expression of their spiritual and intellectual needs of the ancient tongue that they sought to resurrect. The very popularity of the satirical poems and farces of a Josep Robreño (1780-1838) was a serious obstacle, because of the corruption of the language in which they were written, as was the later advocacy by Frederic Soler (1839-95) of "Catalan as now spoken" in opposition to literary refinement. The development of modern Catalan literature has been directly dependent on the studied enrichment and purifying of the language as a vehicle for contemporary thought; in this the Institut d'Estudis Catalans, founded in Barcelona in 1907, played a notable part. B. C. Aribau's patriotic Oda (1833) and the poems of Joaquim Rubió i Ors (1818-99) and Victor Balaguer (1823-1901) prepared the way, as did the reinstitution in 1859 of the jocs florals, for the imagination and mysticism of Jacint Verdaguer (1845-1902), a great epic poet (L'Atlàntida, Canigó) whose gift is still essentially lyrical. Miquel Costa i Llobera (1854-1922) cultivated with much distinction a classical perfection of form; formal beauty is also the mark of his fellow-Majorcan Joan Alcover (1854-1926). In Joan Maragall (1860-1911) Catalonia found its first truly great modern poet, one who looked forward rather than back and whose poetry is suffused with deep spiritual intent. In this spiritual quality, as also, if less happily, in his theory of inspiration as absolving from the need for perfection of form, he exerted a powerful influence on later poets. Josep Carner (1884- ), Josep-Ma (1886- ) and Josep-Maria de Sagarra (1894-), Josep-Maria López-Picó ) are outstanding names, among many of distinction, in the poetry of the

The foundations of modern Catalan prose were laid by the critical writings of Rubió i Ors, Francesc Pi i Margall, president of the Spanish republic of 1873, and Josep Torras i Bages, archbishop of Vich (La Tradició catalana, 1892). Fiction reached a modest level of achievement late in the century with Josep Pin i Soler (1842–1927), Narcis Oller (1846–1930) and Emili Vilanova (1840–1905). One of the best and most influential writers in prose was the essayist Eugeni d'Ors ("Katonius," 1882—), part of whose Glossari (1906–17) had already been translated into Castilian before the author abandoned Barcelona for Madrid and began himself to write in that tongue. His philosophical novel La ben Plantada is one of the most notable works in modern Catalan literature.

In the theatre Catalan dramatists have produced plays of considerable originality. Angel Guimerà (1847-1924) achieved a European reputation with Terra baixa, which inspired a German and a French opera (Tiefland, La Catalane) and was translated into 12 languages. Beginning with historical tragedy (Gala Placidia, Judith de Welp), Guimerà turned to rural drama in La Boja, to comedy in La Baldirona and La Sala d'espera and to modern tragedy in Martha Rosa and La Festa del blat. The many social dramas of Ignasi Iglésias, inspired originally by the early works of Gerhardt Hauptmann, included one nearly a masterpiece, Els Vells: passing later under the influence of Maeterlinck (Foctollet, Cendres d'amor), he eventually cultivated pure comedy (Girassol). Adrià Gual, author of several works of fantasy, did his best work as director of the Teatre Intim, founded in Barcelona in 1898, which familiarized the public with the great drama of all countries and ages. The painter Santiago Rusiñol achieved repute in the theatre too with a number of vivid and imaginative plays (L'Alegria que passa, La bona Gent, El Mistic).

Hardly had Catalan literature thus won itself once more a place in the sun, when there supervened two calamities, the dictatorship (1923-29) of Primo de Rivera, who banned the use of any language other than Castilian, and the civil war of 1936-39. The expatriation of many intellectuals led to the development of a considerable publishing activity in Catalan in Mexico City and Santiago de Chile.

Bibliography.—J. Massó i Torrents, Revista de bibliografia catalana (Barcelona, 1900-07) and "Bibliografia dels antics poetes catalans," Anuari de l'Institut d'Estudis Catalans (Barcelona, 1913-14); J. Amade,

Bibliographie critique pour l'étude des origines et des premières manifestations de la renaissance littéraire en Catalogne au xixº siècle
(Toulouse, 1925). M. Gacia Silvestre, Història sumària de la literatura' catalana (Barcelona, 1932); J. Rubió, "Literatura catalana"
(to end of 14th century) in Historia general de las literaturas listofineas,
ed, by G. Diaz-Plaja, vol i (Barcelona, 1949), M. de Montoliu, Manual
d'història critica de la literatura catalana moderna (to 1860, Barcelona,
1922) (W. C. An)

SPANISH MOSS (Tillandsia usneoides), the name given to a plant of the family Bromeliaceae which hangs in long festoons from the branches of trees in tropical and subtropical American forests, being especially conspicuous on the live oak in the southern United States. The whole plant is covered with scaly hairs for the absorption of water, giving it a grey colour. It is used like horse-hair. From its appearance, which resembles a lichen, it is sometimes called old man's beard.

SPANISH SUCCESSION, WAR OF THE, the name given to the general European war which began in 1701 and ended with the treaties of Utrecht and Rastatt in 1713-14. Its monotonous round of marches and sieges is often quickened by the genius of three great soldiers, Marlborough, Eugene and Villars, while Peterborough and Galway, Catinat and Vendôme, though less highly gifted, were men of unusual and conspicuous ability. As usual in these wars, manoeuvres, threats and feints played the principal part in field warfare. The tangible assets, at the conclusion of peace, the effective seizure of fortresses and provinces was in most cases the principal object with which kings and princes made war. Nevertheless, the object of this war, at least in the case of England and Holland, was less to add a few cities and districts to their own domains than to cripple the power of Louis XIV. The ambition of the Grand Monarque, by placing on the throne of Spain his grandson Philip, had brought into politics the fear not merely of a disturbance but of an entire overthrow of the balance of power. Thus the instrument of Louis's ambition, his magnificent army, was (above all for England) an object in itself and not merely an obstacle to the attainment of other objects. Many of the allies, however, had good reason to fear for their own possessions, and others entered the alliance with at least the hope of acquiring a few material gains at small expense. On the side of the allies therefore, throughout the war, there was a perpetual struggle between offensive activity and defensive passivity. The action of Louis XIV in the matter of the Spanish succession had been foreseen, and William III of England devoted his last years to providing against the emergency by the formation of a coalition to deal with it, and the production of a claimant for the Spanish throne, the archduke Charles. The coalition naturally grew out of the Grand Alliance (see Grand Alli-ANCE, WAR OF THE) and consisted of Austria, some of the German states, Great Britain, Holland, Denmark and Portugal. On the other side Louis XIV was supported by Spain-where Philip, recognized as heir by the dying Charles II, had been promptly installed-Bavaria and Cologne. A doubtful ally was the duke of Savoy, whose policy was to secure and aggrandize himself by adhering at each moment to the stronger party.

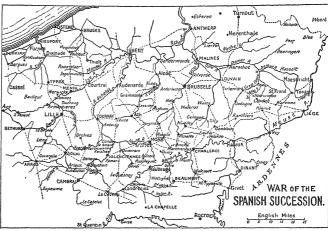
Italy, Chiari 1701 .- The war began, to all intents and purposes, with the handing over of the fortresses in the Spanish Netherlands to the French in March 1701. England and Holland at once began their preparations, but neither state was able to put an army in the field in the year-England because its peacetime army was insignificant, and Holland because it dared not act alone. In Italy, however, the emperor took the initiative, and an Austrian army under Prince Eugene, intended to overrun the Spanish possessions in the peninsula, assembled in Tirol in the early summer. The French army under Catinat blocked the defile of Rivoli, but Eugene reconnoitred passages over the mountains between Roveredo and the Vicenza district in neutral Venetian territory. On May 27, taking infinite precautions as to secrecy and requesting the Venetian authorities to offer no opposition so long as his troops behaved well, Eugene began his march by paths that no army had used since Charles V's time, and on the 28th his army was on the plains. Catinat was surprised, for he had counted upon Venetian neutrality, and when, in the search for a passage over the lower Adige, Eugene's army spread to Legnago

and beyond, he made the mistake of supposing that the Austrians intended to invade the Spanish possessions south of the Po. He thinned out his line to cover all the front as far as that river. But Eugene found an unguarded spot. With the usual precautions of secrecy (deceiving even his own army), he crossed the lower Adige in the night of July 8-9. Catinat at once concentrated his scattered army backward on the Mincio. while Eugene turned northward and regained touch with his old line of supply, Roveredo-Rivoli. For some time Eugene was in great difficulties for supplies, as the Venetians would not allow his barges to descend the Adige. At last, however, he made his preparations to cross the Mincio close to Peschiera and well beyond Catinat's left. This was executed on July 28 and Catinat fell back quietly to the Oglio. But his army resented his retreat before the much smaller force of the

Austrians and, early in August, his rival Tessé reported this to Paris, whereupon Marshal Villeroy, a favourite of Louis, was sent to take command. The new commander was the least competent of all the French senior officers. Before long he attacked Eugene in a well entrenched position at Chiari (Sept. 1) and was thoroughly defeated. In the winter a fresh mishap befell the French. Eugene surprised Cremona on the night of Feb. 1, 1702, and, after a confused fight, drew off, taking with him Villeroy as a prisoner. The rest of the French army retreated, while Eugene quietly resumed his winter quarters and his blockade of Mantua.

Marlborough's First Campaign .- With the year 1702 the real struggle began. Villars and one or two others of Louis's counsellors urged the king to concentrate his attention on the Rhine and the Danube, where, they pointed out, was the centre of gravity of the coalition. This advice was disregarded, and with political aims, the largest French army was employed on the side of the Meuse, while the Rhine front was entrusted to smaller forces acting on the defensive. In Italy the balance of power remained unchanged, except that one of Louis's best generals, Vendôme, was sent to replace the captured Villeroy. In the Low Countries, Ginkel, earl of Athlone, the interim commander of the allies (English, Dutch and minor German states), was at the outset outmanoeuvred by the French (Boufflers), and the momentary threat of a French invasion had a lasting effect on the Dutch authorities, whose timidity thereafter repeatedly ruined the bestlaid schemes of Marlborough, who was obliged to submit to their obstruction and their veto. This handicap, moreover, was not the only one under which Marlborough suffered. Unless it is realized and borne in mind that the great captain was struggling against factiousness and intrigue in England and against jealousies, faintheartedness and disagreements among the states who lent their contingents to his miscellaneous army, the measure of his achievements in ten years seems small. But in fact it was marvellous. Under 18th-century conditions of warfare, and with an army so composed that probably no other man in Europe could have held it together at all, obstructed and thwarted at every turn, he yet brought Louis XIV and France to the very edge of ruin.

In this theatre of war the French, in concert with the garrisons of the Spanish Netherlands, had fortified a line of defense more than 70 mi. long from Antwerp to Huy, as well as another line, longer but of only potential importance, from Antwerp along the Scheldt-Lys to Aire in France. Beside the "lines of Brabant" Boufflers held all the Meuse fortresses below Huy except Maestricht. Marlborough concentrated 60,000 men (of whom 12,000



DRAWN BY BARTHOLOMEW & SONS, LTD , EDINBURGH

only were British) about Nijmwegen in June, and early in July, having made his preparations, he advanced directly by Harnont on Diest. Boufflers hastily fell back, in order to regain the Brabant lines. Marlborough, with the positive object of bringing his opponent to battle at a disadvantage, won the race and awaited the arrival of Boufflers's tired army to strike it a paralyzing blow. But at the critical moment the Dutch deputies forbade the battle, content to see the army that had threatened Holland with invasion driven off to a safe distance without bloodshed (July 22). After this experience Marlborough thought it prudent to pacify the Dutch by besieging the Meuse fortresses. several of which fell in rapid succession (Sept.—Oct.). Boufflers fell back within the defended area of the lines of Brabant, and the campaign closed with the capture of Liège by the allies (Oct. 12). Marlborough was created a duke on his return to England in November.

**Friedlingen.**—On the Rhine the campaign was, except for two disconnected episodes, quite uneventful. The Imperialists under a methodical general, the margrave Louis of Baden, gathered in the Neckar country and crossed the Rhine above Speyer. Catinat, now old and worn out, was sent to Strasbourg to oppose the threatened invasion of Alsace, and, like MacMahon in 1870, he dared not assemble his whole force either on the Lauter or on the Ill. The margrave invested Landau (July 29) and with a covering army occupied the lines of the Lauter about Weissenburg, which Catinat did not attack. Hence Landau, valiantly defended by Melac, had to be surrendered on Sept. 12. But at the same time the elector of Bavaria took the side of France, surprised Ulm, and declared a local war on the house of Austria and the "circles" of Swabia and Franconia. The margrave then, in order to defend his own country, hurried to Kehl with the greater part of his army, leaving a garrison in Landau and a corps of observation on the Lauter. To co-operate with the elector, Catinat had made up a corps out of every available battalion and squadron and placed it under Lieutenant-General Villars. This corps drew away into Upper Alsace and the margrave followed suit until the two armies faced one another on opposite sides of the Rhine near Huningue. Villars crossed the Rhine and won the first victory of his brilliant career at Friedlingen (opposite Huningue). Soon afterward he placed his army in winter quarters in Alsace, and Louis of Baden disposed his troops in two entrenched camps opposite Breisach and Strasbourg respectively. In Italy Vendôme, superior in numbers but handicapped by instructions from Versailles and by the necessity of looking to the Italian interests of King Philip, gained a few minor successes over Eugene.

In the next two years Bavaria was the centre of gravity of the French operations, and only campaigns of the methodical and non-committal kind were planned for Italy and the Low Countries. In this year began the Camisard insurrection, in the Cevennes, which necessitated the detachment of a considerable body of troops from Vendôme's army in Italy.

In the Netherlands the French field army was behind the lines of Brabant, the Spanish troops in the lines of Flanders (Antwerp-Ghent-Aire). Together the two considerably outnumbered Marlborough (90,000 against 50,000), but the duke managed to be first in the field. After capturing Bonn in May, Marlborough's plan was to break the immensely long line of defence of the French and Spaniards by the capture of Antwerp. One Dutch corps under Coehoorn was to assemble in the Sluvs-Hulst region, and another under Opdam at Bergen-op-Zoom while Marlborough, after manoeuvring Villerov's field army out of the way, was to join them before the fortress. Marlborough executed his own share of the movement with his usual skill, but the Dutch generals enabled the French to emerge from the manoeuvre with a handsome victory. Great projects were now entertained by the French, nothing less than the capture of Vienna by a Franco-Bavarian-Hungarian army being the intention. The elector of Bavaria insisted that Villars should cross the Black Forest and join him, which Villars was unwilling to do thus early in the year, as two-thirds of his officers were as usual on leave or detached on recruiting duties. Courtier though he was, the marshal would not stir even in spite of the king's orders until he was ready. At the end of April, leaving Tallard alone to defend Alsace against the margrave of Baden, Villars plunged into the defiles of the Black Forest and on May 8 joined the elector at Ebingen. All seemed favourable for the advance on Vienna, but at the last moment the elector half repented of his alliance with the enemies of Germany and proposed instead a junction with Vendôme in Italy by way of Tirol. This proposal came to nothing, the Tirolese were soon roused to revolt by the misconduct of the ill-disciplined Bavarians, and Vendôme, who, like Luxembourg, was a giant in battle and a sluggard in camp, would not stir.

Hochstett, 1703.-Villars had posted a protective force at Ulm to contain the Margrave's army should it turn back upon him, and this, after an engagement at Munderkingen (July 31) induced the cautious Louis to return to the Rhine. Five weeks later, however, the Margrave returned in full force, and moving by the right bank of the Danube reached Augsburg on Sept. 6. The elector, returning from his futile Tirol expedition, had already rejoined Villars at Dillingen, and the marshal persuaded him to attack the Austrian army that covered Vienna before the two imperial generals could join forces. The result was the battle of Hochstett (Sept. 20) in which the elector and Villars won a great victory, at a loss of only 1,000 men to the enemy's 11,000. Rarely indeed had an 18thcentury general so great an opportunity of finishing a war at one blow. But even Villars saw no better use for the victory than the unimpeded junction of his own army and Tallard's and winter quarters in Württemberg. But Tallard remained on the Rhine, and Villars in disgust applied to be recalled. The Margrave, entrenched as usual, kept the field for another month and then retired to the Lake of Constance, where, in a still unexhausted district, he spent the winter. Tallard meanwhile invested Landau which surrendered on Nov. 12. Old Breisach, besieged by Vauban, capitulated on Sept. 6. Thus in Germany, though the grand advance on Vienna had come to nothing, the French had won important successes and established an army in Bavaria. In Italy, on the other hand, Vendôme, although no longer opposed by Eugene, achieved nothing,

Rhine and Danube Campaign, 1704.-The campaign of 1704, though in the Low Countries and in Italy practically nothing was done, is memorable for what was perhaps the greatest strategical operation in the 18th century, Marlborough's march to the Danube. At the outset the elector and Marsin (Villars' successor) were on the Iller, between Ulm and Memmingen, Tallard between Strasbourg and Landau, Villeroy as usual between the Brabant lines and the Meuse. On the other side the Margrave Louis was in the Stockach-Engen region. Responsible for guarding

the whole of the Middle Rhine as well as for opposing the elector he was weak everywhere, and his defence of the Rhine was practically limited to holding the "lines of Stollhofen," a defensive position near Buhl in Baden. With Breisach and Kehl in their own hands, the French were more or less closely in touch with their comrades in Bavaria, and Tallard convoyed a large body of recruits for Marsin's army through the Black Forest defiles. But in doing so he lost most of them by desertion, the Margrave's army dogged his march, and in fact no regular line of communication was established. Marlborough's purpose at any rate was quite definite-to transfer a large corps from the Low Countries to Bayaria and there in concert with the allies in that quarter to crush the elector decisively, but rather than be burdened with Dutch counsellors he chose to forgo the assistance of the Dutch troops. These were left under Overkirk to defend the Meuse, and English and English-paid troops alone took part in the venture

Mariborough's March to the Danube.-Marlborough calculated that as he progressed up the Rhine the French would collect to prevent his crossing, instead of themselves passing over to join the elector and Marsin. Thus the expedition would reach the Neckar mouth, without its true purpose being suspected, and once there Marlborough would vanish from the ken of the defenders of the Rhine, to reappear on the Danube where he was least expected. On May 12 the army crossed the Meuse at Ruremond, on the 23rd it reached Bonn, on the 29th Mainz. On June 1 the puzzled French noted preparations for bridging the Rhine at Philipsburg. But two days later the English had turned to their left into the valley of the Neckar. On June 10 Prince Eugene and on the 13th the Margrave appeared at the duke's headquarters to concert operations. It was arranged that the margrave was to join Marlborough and that Eugene should command the Stollhofen and other forces on the Rhine, for Tallard, it seemed, was about to be joined by Villeroy1 and Marlborough knew that these marshals must be kept west of the Rhine for the six weeks he allowed himself for the Bavarian enterprise. The Margrave's army duly joined Marlborough's on June 22 at Ursprung, 12 m. north of Ulm, where the elector and Marsin were encamped. The endurance of Marlborough's corps, as displayed in the long march from Ruremond, was not the least extraordinary feature of the operation. For 18thcentury troops such performances were generally provocative of desertion, and involved the ruin of the army that attempted it. But Prince Eugene, we are told, was astonished at the fine condition of the army. On the French side meantime all was perplexity, and it was not until a week after the Margrave and Marlborough had joined, that Villeroy's main body from the Meuse started for Alsace to watch Eugene's corps, or rather the Stollhofen-Buhl position. This meant conceding both the initiative and the superiority in numbers to Marlborough,

Campaign on the Danube, 1704 .- The duke had now manoeuvred himself with brilliant success from one theatre of war to another, and had secured every advantage to himself. From before Ulm he sidled gradually along the north side of the Danube in the hope of finding an unguarded passage. He and the Margrave exercised the general command on alternate days, and when on his own day he arrived opposite Donauwörth, knowing Louis's caution, he thought that direct attack was better than another two days' extension to the east. Moreover he needed a walled town to serve as a magazine. In the late afternoon of July 2 the army was flung, regardless of losses, against the entrenched hill of the Schellenberg at Donauworth, where the elector had posted a strong detachment. The attack cost 6,000 men, but it was successful, and of the 12.000 Bavarians on the hill only 3,000 returned to their main body, which had now moved from Ulm to Lauingen. Passing the river, the allies besieged and took the small fortress of Rain, and thence moved to the neighbourhood of Augsburg, thoroughly and deliberately devastating the countryside so as to force the elector to make terms. The best that can be said of this barbarous device, is that Louis XIV had several times practised it. Its most effective condemnation is that military devastations, in these purely political contests, were entirely

<sup>1</sup>Even Villeroy it appears rose to the situation thus far, but the king only allowed him to send 25,000 men to Tallard.

unprofitable. Louis had already found them so, and had given up the practice. In the present case Mariborough's own supplies ran short, and his convoys were harassed. The movements of the two armies were but trifling. Mariborough, though superior, was not decisively superior, and his opponents, well entrenched near Augsburg, waited for Tallard and (in vain) for Villeroy. Mariborough marked time until Eugene should join him.

There were now five armies in the field, two allied and three French. The centre of gravity was therefore in Villeroy's camp. If that marshal followed Tallard, even Eugene's junction with Marlborough would not give the latter enough force. If Tallard alone joined the elector and Eugene Marlborough, the game was in the hands of the allies. But none of the possible combinations of two armies against one were attempted by either side. Eugene when informed that Tallard was on the move slipped away from Villeroy to join Marlborough. Tallard and the elector, aware of Eugene's march, were content to join forces peaceably at Augsburg. Villeroy, in whose hands was the key of the situation, hesitated and finally tried in vain to detain Eugene (who was already far away) in the Stollhofen lines. The last stage of the campaign was brief. Marlborough and Eugene had in mind a battle, Tallard and Marsin a war of manoeuvre to occupy the few weeks now to be spun out before winter quarters were due. The two allied armies met in the Danube valley on Aug. 6. If the enemy remained on the south side Eugene was to cross, if they recrossed to the north bank Marlborough was to follow suit. The margrave Louis of Baden had been sent off to besiege Ingolstadt as soon as Eugene had come within a safe distance. When therefore the French and Bayarians were reported opposite Eugene on the north side, Marlborough crossed at once, and without waiting for the margrave the two great soldiers went forward. On Aug. 2 (see Blenheim) they attacked and practically destroyed the armies of Tallard, Marsin and the elector.

Campaign of 1705.—The campaign of 1705 was uneventful and of little profit to either side. Marlborough's army had returned to the Low Countries. Villeroy had also returned to Brabant and retaken Huy. With him was the now exiled elector of Bavaria. On July 18, after a series of skilful manoeuvres, Marlborough forced the lines of Brabant at Elissem near Tirlemont, but not even the glory of Blenheim could induce the Dutch deputies to give him a free hand, or the Dutch generals to fall in with his schemes. King Louis was thus able to reinforce Villeroy betimes from Villars's Lorraine army, and the campaign closed with no better work than the razing of the captured French entrenchments. On the Rhine Villars, with a force reduced to impotence, carried on a spiritless campaign against the Margrave Louis. In Italy there was serious fighting. Here Vendôme's army engaged in the attempt to subdue Victor Amadeus of Savoy and was so far successful that the duke implored the emperor for aid. Eugene was sent with new reinforcements, opposed to which was a force under Vendôme's brother Philippe, called the Grand Prior. This man, a lazy dilettante, let himself be surprised by Eugene's fierce attack on the line of the Adda. The day was restored however, and the Austrians beaten off, thanks to Vendôme's opportune arrival and dauntless courage (battle of Cassano, August 16). Nevertheless, the subjugation of Piedmont was put off until the next year

Ramillies, 1706—1706 was a bad year for the French. At the very outset of the campaign in the Netherlands, Villercy, hearing that some of the allied contingents that composed Marlborough's army had refused to join, ventured out from his new defensive lines along the Dyle and moved towards Namur. Marlborough hurried forward to intercept him before he could reach the shelter of the Meuse fortresses and was able (May 12) not only to win but also to profit by the glorious victory of Ramillies (q.v.) on the 12th of May.

In Italy the campaign had, as before, two branches, the contest for Piedmont and the contest between the French forces in Lombardy and the Austrian second army that sought to join Victor Amadeus and Starhemberg. The latter, repulsed by Vendôme at Cassano, had retired to Brescia and Lake Garda, Vendôme followed, and in April 1706, profiting by Eugene's temporary absence,

completely (battle of Calcinato, April 19), and he hustled the fragments of the Imperialist army back into the mountains, where Eugene had the greatest difficulty in rallying them. Until the middle of June Vendôme completely baffled all attempts of Eugene to slip past him into Piedmont. He was then, however, recalled to supersede Villeroy in Belgium, and his feeble successor entirely failed to rise to the occasion. Philip of Orleans, with Marsin, was besieging Turin. As soon as he knew of Vendôme's departure Prince Eugene emerged afresh from the mountains, and, out-manoeuvring the French in Lombardy, hurried towards Turin. Victor Amadeus, leaving the defence to the Austrian and Piedmontese infantry, escaped through the besiegers' lines and joined his cousin with a large force of cavalry. On Sept. 7 they attacked the French lines round Turin. Owing to the disagreements of their generals, the various corps of the defenders, though superior in total numbers, were beaten in detail. Marsin was killed and Orleans retreated ignominiously to Pinerolo. The battle of Turin practically ended the war in Italy.

Both in the north and in the south the tide had now receded to the frontiers of France itself. But it is from this very point that the French operations cease (though only gradually it is true) to be the ill-defined and badly-joined patchwork of forays and cordons that they had hitherto been. In the place of Tallards, Marsins and Villeroys Louis made up his mind to put his Villars, Vendômes and Berwicks, and above all the approach of the allied armies roused in the French nation itself a spirit of national defence which bears at least a faint resemblance to the great uprisings of 1792. For the gathering of this unexpected moral force 1707 afforded a year of respite. Marshal Tessé formed a strong army for the defence of the Alpine frontier. In Germany Villars not only pricked the bubble reputation of the lines of Stollhofen, but raided into Bavaria, penetrating as far as Blenheim battlefield before he gave up the attempt to rouse the Bavarians again. The Imperialists and Piedmontese in the south succeeded in turning the Alpine barrier, but they were brought to a complete standstill by Tesse's gallant defence of Toulon (August) and finally retired over the mountains. In Belgium the elector of Bavaria, who was viceroy there for King Philip, and was seconded by Vendôme, remained quiescent about Mons and Gembloux, while Marlborough, paralysed more completely than ever before by the Dutch, spent the summer inactive in camp on the Gheete.

Campaign of 1708.—In 1708 Eugene foresaw this shift of the centre of gravity and arranged with Marlborough to transfer his army which was ostensibly destined for the Rhine campaign to Brabant, since the French was markedly superior in numbers to Marlborough's and hardly inferior to Marlborough's and Eugene's combined. King Louis had put his young grandson and heir, the duke of Burgundy, at the head of the great army which assembled at Valenciennes, and gave him Vendôme as mentor. But the prince was pious, mild-mannered, unambitious of military But the prince was pious, mid-mannered, unamous glory and also obstinate, and to unite him with the fiery, looseliving and daring Vendôme, was, as Saint-Simon says, "mixing fire and water." At the end of May Vendôme advanced to engage Marlborough before Eugene should join him. As the French came on towards Brussels, Marlborough, who had concentrated at Hal, fell back by a forced march to Louvain. Vendôme having thus won the first move, there was a pause and then the French suddenly swung round to the west, and began to overrun Flanders, where their agents had already won over many of the officials who had been installed by the allies since 1706. Ghent and Bruges surrendered at once, and to regain for King Philip all the country west of the Scheldt it only remained to take Oudenarde. On the day of the surrender of Ghent Marlborough was moving to interpose himself between the French and their frontier, and one long forced march brought his army almost within striking distance of the enemy. But though Eugene himself had joined him, Eugene's army was still far behind. Vendôme soon moved on Oudenarde. But scarcely had he begun this investment when Marlborough was upon him.

Oudenarde.—The duke discussed the situation with Eugene.

Mariborough was half inclined to wait for Eugene's troops, for time, had only enough energy remaining to take Mons before he he knew that Vendôme was no ordinary opponent, but Eugene counselled immediate action lest the French should escape, and relying on his own skill and on the well-known disunion in the French headquarters, Marlborough went forward. As he approached, the enemy gave up the siege of Oudenarde and took up a position at Gavie, 7 m. lower down the Scheldt. Here the dissensions in the French headquarters became flagrant. Vendôme began to place part of the army in position along the river while the duke of Burgundy was posting the rest much farther back as another line of defence. The allied main body, marching with all speed, crossed the Scheldt at all hazards. In the encounterbattle which followed (see Oudenarde) Marlborough separated, cut off and destroyed the French right wing. The French retreated in disorder on Ghent (July 11) with a loss of 15,000 men. Marlborough was prevented from carrying out his desire for a prompt move on Paris after Oudenarde. For the moment Berwick, recalled from Alsace, manoeuvred about Douay, while Vendôme remained near Ghent, and between them Marlborough's and Eugene's armies devoted themselves to the siege of Lille. In this town, one of Vauban's masterpieces of fortification, the old Marshal Boufflers had undertaken the defence, and it offered a long and unusually gallant resistance to Eugene's army. Marlborough covered the siege. The French generals limited their efforts first to attempting to intercept a huge convoy of artillery and stores that the allies brought up from Brussels for the siege. and secondly to destroy another convoy that was brought up from Ostend by the General Webb known to readers of Esmond. The futile attack upon the second convoy is known as the action of Wynendael (Sept. 28).

On Dec. 8 the brave old marshal surrendered, Eugene complimenting him by allowing him to dictate the terms of capitulation. Ghent and Bruges were retaken by the allies without difficulty, and, to add to the disasters of Oudenarde and Lille, a terrible winter almost completed the ruin of France. In despair Louis negotiated for peace, but the coalition offered such hard terms that not only the king, but his people also, resolved to fight to the end.

1709, Malplaquet.-When spring came round Marlborough proposed to make a daring thrust toward Paris, masking the fortresses, but this scheme was too bold even for Eugene, who preferred to reduce the strong places before going on. Lille having been successfully besieged, Tournai was the next objective, and the allies suddenly and secretly left their camps before Lille as if for an attack on the Douai lines (June 26-27). But before noon on the 27th they had invested Tournai. A few days afterwards their siege guns came up from Menin by water (down the Lys and up the Scheldt) and the siege was pressed with intense vigour. But it was Sept. 3 before the citadel capitulated. Then Marlborough, free to move again, transferred his army secretly and by degrees to the river Haine, and burst through the French lines almost unopposed. Mons was weakly held, and Marlborough hoped by the rapidity of his operations to take it before Villars could interrupt him. But Villars also moved quickly, and his eager army was roused to enthusiasm by the arrival of Boufflers, who, senior as he was to Villars, had come forward again at the moment of danger to serve as his second in command. Thinking that the allies were somewhat farther to the east than they were in fact, the French marshal marched secretly, screened by the broken and wooded ground, to the south of the fortress, and occupied the gap of Aulnois-Malplaquet (Sept. 9) to work feverishly to entrench himself. Marlborough at once giving up the siege of Mons brought his army forward to attack as rapidly as his brigades came on the scene. At this crisis the duke submitted the question of battleunwillingly, as one may imagine-to a council of war, and Eugene himself was opposed to fighting an improvised battle when so much was at stake, and it was not until the 11th that the duke delivered his attack on the now thoroughly entrenched position of the French. The battle of Malplaquet (q.v.) was by far the most desperately contested of the war. In the end Boufflers, who took command when Villars was wounded, acknowledged defeat and drew off in good order. Eugene was wounded, and Mariborough, after the most terrible experience in any soldier's life-

retired into winter quarters. The loss of the French is given variously as 7,000 and 12,000. The allies sacrificed no less, probably more, than 20,000 men.

Campaign of 1710.-In 1710 Villars lay entrenched behind a new series of lines, which he called Ne plus ultra and which extended from Valenciennes to the sea. Marlborough made no attempt to invade France from the side of Mons, for Villars at the head of the army which had been through the ordeal of Malplaquet was too terrible an opponent to pass by with impunity. In England, too, the anti-Marlborough party was gaining the upper hand in the queen's council. So Marlborough took no risks, and returning to the Lille side, captured Douai (June 26) and Béthune (Aug 26). No attack was attempted upon the lines. In Dauphiné, Berwick repulsed the Austrians and Piedmontese.

The year 1711 was Marlborough's last campaign, and it was remarkable for the capture of the Ne plus ultra lines by manoeuvres that must be recorded as being the ne plus ultra of the 18th century way of making war by stratagem. În May the sudden death of the emperor completely altered the political outlook. for his successor Charles was the coalition's claimant to the throne of Spain, and those who were fighting for the "Balance of Power" could no more tolerate a new Charles V. than they could see Louis XIV. become a Charlemagne.

In accordance with a strategic policy of passive endurance the marshal Villars remained on the defensive behind his lines, and Marlborough determined to dislodge him. What force could not achieve, the duke trusted to obtain by ruse. The lines extended from the sea along the Canche, thence to Arras, and along the Sensée to Bouchain on the Scheldt. As the western part of the lines, besides being strong, were worthless from the invaders' point of view because their capture could not lead to anything, Marlborough determined to pass the barrier between Arras and Bouchain. On July 6 Marlborough marched away to the west, as if to attack the lines between Arras and the headwaters of the Canche. Villars followed suit. The plot of the comedy now thickened. Marlborough lost his usual serenity, and behaved in so eccentric a manner that his own army thought him mad. He sent off one part of his forces to Béthune, another back to Douai, and ordered the small remainder to attack the lines between the Canche and Arras, where, as every one knew, Villars's whole army was massed. In the night of Aug. 4-5 the main army slipped off westward, at the highest possible speed. The Scarpe was crossed and then the pace was increased, though thousands of the infantry fell out and scores died from exhaustion. Five hours ahead of the French army the allies crossed the great lines unresisted. The troops concentrated at Cambrai when Marlborough, declining Villars's offer of a battle, manoeuvred farther to the east and invested Bouchain. The siege, covered by a strong "line of circumvallation" which Villars did not attempt to attack, ended with the surrender of the place on Sept. 13, and so terminated a series of manoeuvres so extraordinary as to be almost incredible. In December Marlborough was dismissed from the service in disgrace.

But Holland and Austria determined to make one last effort to impose their own terms on Louis. Eugene's army, which had been used in 1711 to influence the imperial election instead of to beat Villars, was brought back to the Low Countries. Reading the meaning of Marlborough's fall, he quietly made preparations to take over the various allied contingents into Imperial or Dutch pay. So when England seceded, Ormonde only marched away with 12,000 sullen men, while 100,000 remained with the prince.

Misfortunes at Versailles helped Eugene in his first operations, for two successive heirs apparent to the crown died within a month and all was in confusion, not to speak of the terrible misery that prevailed in the country. But the old king's courage rose with the danger and he told Villars that if the army were beaten he would himself join it and share in its fate. Villars, though suffering still from his Malplaquet wound, took command on April 20, and spun out time on the defensive until the end of May, when Ormonde's contingent withdrew. Eugene, as the defection of England had made further operations near the sea unprofitable, took Le Quesnoy (July 4) and moved thence on to Landrecies, which was closely invested. Then followed the last serious fight of the war, the battle of Denain, which saved the French monarchy and completed the disintegration of the coalition.

Denain .- In order to protect his camps around Landrecies, Prince Eugene constructed the usual lines of circumvallation with such speed that Villars, on coming up, found that they were too formidable to attack. Villars anxiously looked out for an opportunity of breaking through. At Denain, the besiegers' route crossed the Scheldt and he resolved to attack them there. The enterprise, like Marlborough's forcing of the Ne plus ultra lines, involved an extraordinary combination of force and fraud-for the point of attack was far away and the opposing army almost within cannon-shot Some days were spent by Villars in deceiving Eugene and his own army as well, as to his real intentions. Then on the night of July 23 the French army moved off silently, and by 9 AM on the 24th had completely deployed on the north bank of the Scheldt. Eugene galloped away to bring up his army from Landrecies. But, long before it arrived, Villars's troops stormed the lines. A mass of Dutch troops—spiritless since Malplaquet-were huddled into the narrow avenue between the twoentrenchments and forced back against a broken bridge. Their generals were taken. The broken mob of fugitives tamely surrendered. Eugene arrived on the other bank with some brigades of the imperial infantry, but failed to reopen the passage. Villars followed up his victory at once, capturing Marchiennes and St. Amand, and in these places all Eugene's reserve stores, pontoons and guns. On Aug. 2 Eugene broke up the siege of Landrecies and retreated by a roundabout route to Mons, while Villars's lieutenants retook Douai and Bouchain (September-October). Before the next campaign opened the treaty of Utrecht had been signed, and although the emperor continued the struggle alone for another year, the enfeebled combatants were content to accept Villars's captures of Landau (July 22, 1713) and Freiburg (Nov. 21) as decisive. The treaty of Rastatt, between Austria and France, was signed on March 7, 1714, Eugene and Villars being the negotiators.

See J. W. Fortescue, Hist, British Army, vol. i. (London, 1899); lives of Marlborough (especially Frank Taylor's); the Austran official Feldzing des Prinsen Eugen (Vienna, 1871–1892); Roder v. Diersburg's Markgraj Ludwig von Baden (Karlsruhe, 1850); Arneth's Prinz Eugen; Mémoires militaires relatifs à la succession d'Espagne (1835; ed. De Vault); detailed histories of the French army, and monographs in the French general staff's Revue d'histoire.

# NAVAL OPERATIONS AND MILITARY OPERATIONS IN SPAIN

The great campaigns fought in the Rhine delta and in North Ltaly, often tend to obscure the fact that the principal objective of both sides during the war was Spain. The French could reach the theatre of operations quite easily by land, but the Austrian Imperialists had to rely entirely on Anglo-Dutch fleets to make their efforts effective. On the formation of the Grand Alliance, considerable difference of opinion arose as to how the English fleet should be used, William III, and Mariborough being in favour of a concentration in the Mediterranean, while many of the sailors advocated oceanic operations on the Atlantic coast of Spain and Portugal, and on the east coast of America.

Allied Victory at Cadiz .- Admiral Sir George Rooke was put in command of the combined fleet, consisting of 30 English ships of the line, and 20 Dutch under Admiral van Almonde, and carrying 13,000 English and Dutch troops under the Duke of Ormonde. Rooke was instructed to seize Cadiz as a base for future operations in the Mediterranean. Inevitable complications, however, arose. It was judged inexpedient to compel the Spaniards to acknowledge the Archduke Charles as their rightful king, by means of a bombardment, and they, being not unnaturally somewhat backward in receiving the candidature of an Austrian Prince, lent no support to the Anglo-Dutch arms. Consequently the attempt on Cadiz could not be pushed too vigorously and may be said to have failed. Rooke was already steering north again when he learnt that the Spanish treasure fleet had entered Vigo Bay, protected by Admiral Châteaurenault with a French squadron. The Allies at once determined to prevent the French obtaining the treasure by capturing it themselves, and, entering the bay, Or-

monde's troops were landed to attack the forts, while Rooke pushed forward a special advance squadron and forced the boom which the French had laid across the entrance to the inner harbour (Oct. 12, 1702). In the furious engagement which followed, Rooke sank and captured the 24 French warships and the 17 Spanish galleons, and recovered bullion worth two million pounds.

Portugal Joins Allies.—In 1703 Portugal joined the Allies so that Lisbon could be used as a naval base, but Admiral Clowdisley Showlel was sent to the Mediterranean too late to achieve any object, and many of his ships on their return were destroyed in the Channel during the great storm of Nov. 27. Great efforts were made in 1704 to bring about something decisive. Rooke sailed in February and landed the Archduke Charles at Lisbon, together with 2,000 English and Dutch troops to co-operate with the Portuguese in an invasion of Soain.

Rooke carried his fleet through the Straits, hoping to be able to make an attack on Toulon in concert with the duke of Savoy, who had recently joined the alliance. This, in conjunction with Marlborough's march across Germany to Blenheim, would have been a fine counterstroke to the French thrust at Vienna, but as often happened afterwards, Savoy failed to co-operate. An attempt was made to win over Barcelona to the archduke's cause, but the governor refused to admit the allied forces. Meanwhile, the Comte de Toulouse succeeded in bringing the French Brest fleet into the Mediterranean and though Rooke sighted him, his ships were too foul to catch the French, who entered Toulon unopposed, and so united their principal Atlantic and Mediterranean forces. Rooke therefore passed the Straits and met Shovell and the Dutch between Cape St. Vincent and Cadiz, and then reentered the Mediterranean to watch for the French.

Gibraltar Taken by Allies.—At this juncture the allied leaders took the memorable decision to capture Gibraltar and so advance their sphere of activity 300 miles beyond Lisbon. After lengthy preparations the attack was begun by Admiral George Byng, who bombarded the fortress with a special squadron on July 23 (1704), while Prince George of Hesse-Darmstadt, the Imperial representative, landed 1,800 English marines and cut off the fortress on the land side. Gibraltar being only weakly held, an attacking force was soon landed from the ships, and the place surrendered next day.

Hardly was this great success achieved than Toulouse was reported sailing south-west to recapture the fortress. Rooke left Prince George and 900 marines in Gibraltar and went in search of Toulouse, having had to spend some time watering his fleet at Tetuan. On Aug. 9 the fleets were in sight of each other, but the French retreated and then attempted to double back again close inshore. Rooke, however, sighted them slipping past and brought them to action off Malaga on Aug. 13, each side having about 50 ships of the line. The French were decisively beaten.

The allies returned to Lisbon to refit, leaving Prince George with all the marines and some ships, guns and stores to defend Gibraltar. He was soon attacked by land and sea in overwhelming force, but was relieved by Admiral Leake, who arrived from Lisbon where he had been left in command by Rooke, who had gone home. Entering the bay on Oct. 25, the day on which the final attack was to take place, he destroyed the French flottila, enfiladed the Franco-Spanish entrenchments on shore, and revictualled and reinforced the garrison. The French now sent Marshal Tessé with a siege train to command the attack by land, and Prince George was again hard pressed, but Leake again reinforced and revictualled him in December. At last, on March 10, 1705, Leake destroyed de Pointis' force at Marbella, and Tessé raised the siege.

Allies Invade Spain.—The Allies now took the offensive, Shovell and Lord Peterborough coming out from England as joint commanders. Picking up Leake at Lisbon and Prince George at Gibraltar, they sailed to Barcelona and besieged it. It was finally captured and occupied on Oct. 3, 1705, but Prince George was killed during the assault. Philip, the Bourbon candidate, hurried to Catalonia with Marshal Tessé to recapture it, and a squadron put out from Toulon. Leake, however, was able to foil all the French efforts and forced them to raise the siege on April 30, 1706.

Leake, who was again left in command of the fleet, made good use of his time by capturing Cartagena (June 1, 1706) and Alicante (Aug. 24, 1706), and then sailing to the Balearic Islands and capturing Mallorca (Majorca) and Iviza in September.

Meanwhile, the allied troops advanced from Portugal and captured Madrid (June 26, 1706) and proclaimed the archduke Charles. The Castilians, however, did not relish invasion by the Portuguese, and being rallied by Berwick, compelled the allies to retreat southeast to Valencia, on the coast

Closing Operactions.—In July and August combined operations were again attempted against Toulon, but again Savoy defaulted, and Shovell, returning with 12 of the line, was wrecked on the Scilly Isles on Oct. 22, 1707, together with several other ships which were lost with all hands. Leake now exercised the permanent command-in-chief and operated in the Mediterranean with great success, reducing Sardinia for the Imperialists in August 1708. In September General Stanhone captured Minorca.

The war in Spain languished owing to the increasing exhaustion of both sides and the apathy of the Spaniards. Stanhope, however, in 1710 persuaded the Imperalisit troops to join him in another invasion, and they actually succeeded in bringing the archduke Charles to Madrid. Previous conditions, however, reasserted themselves, and the allies were again driven east to the coast by the duc de Vendôme, the new general of the Franco-Spanish forces

Stanhope was defeated and captured on Dec. 9, 1710, at Brihuego, and the Imperialists were only just able to make good their retreat to Barcelona, which they held till the Peace of Utrecht, though the Catalans themselves heroically defended it against Berwick till Sept. 12, 1714. At sea, Admiral Wager captured a Spanish treasure fleet off Cartagena in May 1708, and Duguay Trouin captured an English convoy off the Lizard on Oct. 20. In 1710 Commodore Martin's squadron, assisted by American Colonists, captured Nova Scotia.

Bibliography.—O. Troude, Batailles Navales de la France (1867); J. S. Corbett, England in the Mediterranean, 2 vols. (1917); Geoffrey Callender, Life of Sir John Leake, 2 vols Navy Record Society (1920) contains a bibliography. (G. A. R. C.; W. C. B. T.)

SPANNER (WRENCH) is a tool for turning nuts, setscrews, coachscrews, spindles, including those of hydrants and valves. (Spanners in the U.S. are called "open-end wrenches," except for the English "box spanner," which in America is a "socket wrench.") The principal forms are the straight wrenches, single-ended or double-ended, the angle, which enables a nut to be turned in a confined space, and the socket wrenches (box spanners) enabling the nut to be readily turned from above or from the side, without slip. Socket wrenches are light and strong, being assembled in sets.

The structural wrench has a long handle terminating in a tapered end. The platelayer or track wrench is also very long, but with parallel handle; it gives great power for dealing with fish-plate bolts. The pin and the hook wrenches turn circular nuts, the one with a pin entering a drilled hole on the nut, the other with a hook catching in a slot. The cap wrench or axle-spanner grips on four surfaces of a road wheel nut. A ratchet wrench permits resetting of the handle without removing the wrench, giving short strokes of the handle. Power-operated wrenches or "nut runners" are employed for quick loosening and tightening. Two common adjustable wrenches are the monkey wrench (and its specialized companion, the pipe wrench) having one jaw adjustable in line with the axis of the handle, and the adjustable open-end wrench (commonly called the crescent) which has one jaw adjustable across the axis of the handle. Chain wrenches are used to turn large diameter pipes.

SPARK or SPARKING PLUG: see Motor Car and Motor Car Engines: Their Operation and Care.

**SPARK PHOTOGRAPHY** derives its name from the type of illumination employed. The light for the photograph is produced by a small electric spark of extremely short duration and great intensity.

This method finds many applications in the photography of rapidly moving objects; for example, the earliest known spark photograph was an ordinary snapshot of a newspaper clipping fastened to the surface of a rapidly spinning disk. The size of the spark is so small that it can be used to project a silhouette directly on the photographic film, and, in ordinary practice, the conventional camera with its lens is not required. One common arrangement of the equipment is shown in the accompanying diagram. There, the object to be photographed, a bullet, travels between the spark and the plate, and the spark is fired by a trigger circuit when the bullet passes in front of the plate.

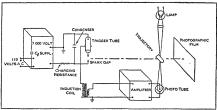


FIG. 1.—SCHEMATIC WIRING DIAGRAM OF SPARK PHOTOGRAPHY AP-

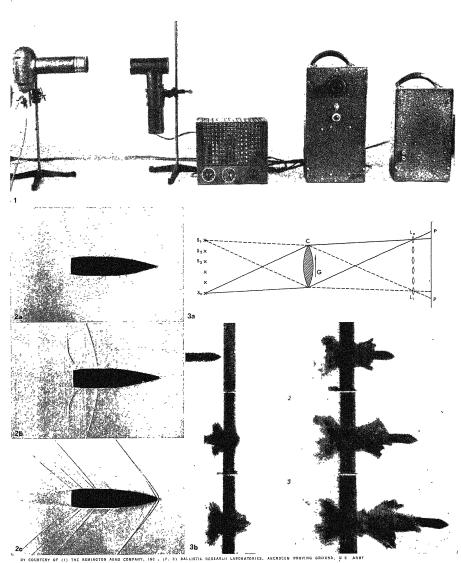
The spark itself is generated by the discharge of a high-voltage capacitor across a gap between two electrodes. The circuit consists of the condenser, the gap and an electronic switch element which prevents discharge until the instant desired. Electrical energy is slowly stored in the condenser over a relatively long period of time and is discharged with sudden violence through the gap at the instant the switch is effectively closed by a control signary.

Many designs of gaps and switches were devised for different applications. The operating capacities and voltages also varied widely, ranging from 4,000 volts with 1 microfarad to 40,000 volts with 0.01 microfarad. But, in general, the circuit produces a spark sufficiently intense to give good exposures at 4 ft. to 20 ft. and of so short a duration that the effective part of the light lasts only 1 or 2  $\times$  10  $^{-6}$  sec. Also, the light is rich in ultra-violet radiation, thus further increasing its photographic effectiveness.

Firing the spark at the desired time during the brief period the moving object is in front of the plate is usually the most difficult feature of this photographic system, and many ingenious methods of triggering were developed. The function of the trigger circuit is to send a control signal to the discharge switch element at the proper instant. This operation must be extremely precise; a tolerance of 10<sup>-5</sup> sec. is common. The particular method chosen depends on the application. Occasionally, processes external to, but related to, the moving object are used, such as the muzzle blast or the recoil in the case of ballistic photography near the gun, but ordinarily some property of the object itself starts the trigger operation.

The simplest of all methods is the make or break contact. If the object is made of steel, a solenoid pickup can be used; if it can be charged to a high potential, an electrostatic pickup is suitable; if the geometry of its motion can be arranged so that it cuts the path of a beam of light, a photoelectric pickup gives good results; or, if the object is travelling faster than the speed of sound, a sonic pickup will work.

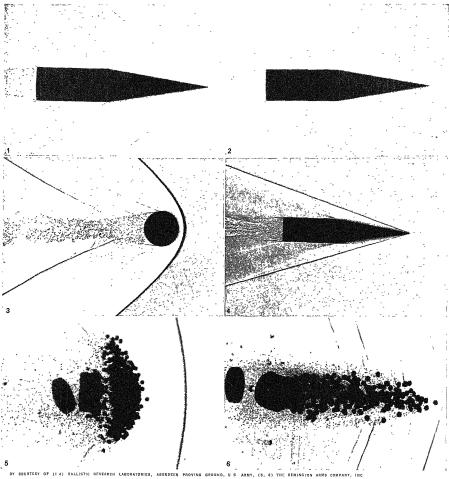
The over-all operation is conveniently illustrated by tracing through the sequence of events involved in taking the spark photograph of a bullet in flight by the apparatus shown in the diagram. The room is darkened, the photographic plate put in position, and the gun fired. Since a photoelectric pickup is used, the gun has been aimed so that the trajectory intersects the beam of light from the lamp to the phototube. As the bullet interrupts this beam, it changes the amount of light falling on the phototube and thereby generates a voltage pulse in the electronic circuit. This pulse is amplified and used to fire a gas discharge tube in the output of the amplifier. The discharge tube in turn sends a surge of current through the primary of an induction coil, and the high voltage surge resulting in the secondary is applied to the control element



# APPARATUS AND EXAMPLES OF SPARK PHOTOGRAPHY

- Complete spark photography equipment. Left to right: phototube lamp, phototube, amplifier, power supply and spark source
   Spark photographs of a ½-in-diameter model of a 155-mm. HE projectile travelling (a) far below, (b) near and (c) well above the
- velocity of sound

  3a. Diagram of optical system for multiple-spark apparatus; 3b. Penetration of armour plate by 13-mm. projectile



SPARK PHOTOGRAPHY OF BULLETS IN FLIGHT

- 1. Smooth cone-cylinder projectile (20 mm), at 1,850 ft. per second 2. Rough cone-cylinder projectile (20 mm), at 1,830 ft. per second 3. A 9/16-in diameter sphere (cannonball) at 2,050 ft. per second 4. Smooth cone-cylinder projectile (½-in. diameter) at 4,046 ft. per second

- A 12-gauge shot charge from cylinder-bored gun, photographed three feet from muzzle
   A 12-gauge shot charge fired from choke-bored gun, three feet from muzzle

of the trigger tube, the switch of the discharge circuit. Secondary emission ionizes this tube, thus effectively closing the switch, the condenser discharges through the spark gap, and the spark photograph is taken. The duration of the light is sufficiently short to arrest the motion of even the highest velocity projectiles.

Applications to Ballistics.—Spark photography is of great value to the ballistic engineer, enabling him to answer many questions on the flight of bullets and the flow of the air about them. Such questions as that of determining the distance from the muzle at which the velocity of the erupting gas becomes less than that of the bullet are readily answered. It is of particular interest in the case of shot shells where the disposition of the shot and wads may be easily observed. Work of this nature led to the commercial development of shot shells without the top card wad over the shot, for it was observed by spark photography that this wad interfered with the proper flight of the shot.

Aerodynamics Range.—As the projectile flies from gun to target, it experiences violent resistive forces because of its high velocity motion through the air, and, if the flight path is to be computed, these forces must be measured. Here, spark photography gives the ballistician a tool of great precision, in the so-called "aerodynamics range." The projectile is fired into a long, enclosed gallery containing from 10 to 25 spark photography stations spaced at intervals along its length. As the projectile passes each station in turn, two spark pictures are taken in perpendicular planes (one horizontal, say, and the other vertical) and the time of the event is recorded on a high-speed chronograph.

Thus, each pair of spark photographs records the position of the projectile at a measured time, and all of the records can be combined to determine the retardation of the projectile's motion and the aerodynamic drag. The inclination of the projectile's axis to its direction of motion can also be measured from each pair of pictures, and from these measurements the projectile's stability can be computed.

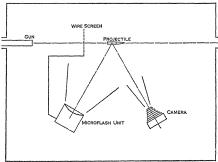


FIG. 2.—DIAGRAMMATIC DRAWING OF A TEST CHAMBER FOR TAKING A MICROFLASH PHOTOGRAPH OF A PROJECTILE IN FLIGHT

Multiple Spark Photography .- Many problems in ballistics require detailed knowledge of extremely high-speed action taking place in a relatively small space, such as the penetration of armour plate or the detonation and subsequent fragmentation of highexplosive shell. Again, spark photography furnishes the key to the instrumentation through the so-called "multiple spark apparatus." In this apparatus spark photography and optics are combined to give a rapid series of pictures of the action taking place within a confined space. It consists of a number of spark gaps mounted in a common plane, a large lens or mirror with its optical axis perpendicular to the plane of the spark gaps, and a corresponding number of cameras with their lenses placed (coplanar) at the conjugate focuses of the spark gaps. The elements are arranged so that the action takes place close to the lens (or mirror) in order to get the maximum field of view. The cameras are focused on the action. By the optical system the light from each gap is converged so that it enters only the particular camera located at the gap's conjugate focus. Hence, only the film in one camera is exposed by the light from one spark. The sparks are fired one after another at controlled intervals of time and the pictures resulting form a series of silhouettes each looking at the action from a slightly different point of view. The sparks can be operated at the almost unbelievable rate of 1,000,000 per second, and their terrific speed is sufficient to record the motion of such instantaneous phenomena as the detonation wave travelling along the length of an exploding projectile.

Shock Wave Phenomena.—One of the most spectacular characteristics of spark photographs is the shadows produced by compression waves in the air These are seen as lines, usually curved, with a dark front edge and a light rear edge. Strong compression waves, known as shock waves, have fronts that amount to surfaces of very small thickness through which the pressure, density, temperature, and, consequently, index of refraction change violently (roughly similar to the fronts of waves rolling up a shallow beach). The rays of light from the spark passing tangent to these wave surfaces are refracted to form lines of alternate dark and bright representing the projection of the wave surfaces on the photograph. The technique is very sensitive and wave patterns are recorded in fine detail.

Shock waves are produced in air by any disturbance that is sufficiently strong and abrupt. Electric sparks, explosives, projectiles and aircraft travelling at speeds close to or greater than the speed of sound, all generate shock waves. An example of pure wave photography is found in the study of the reflection of shock waves from solid surfaces. The wave pattern surrounding bodies at transonic and supersonic velocities are of particular interest since they tell much about the nature of the air flow over the body. Even the turbulent layer of air next to the projectile's surface and the wake following it are visible. (R. E. E.; A. C. Cs.)

SPARKS, JARED (1789-1866), U.S. historian and educator, was born in Willington, Conn., on May 10, 1789. He made a brilliant record in his studies and became a schoolteacher. In 1809-11 he attended Phillips Exeter academy, where he met John G. Palfrey and George Bancroft, two schoolmates, who became his lifelong friends. He graduated from Harvard (A.B., in 1815 and A M., in 1818); taught in a private school at Lancaster, Mass., in 1815-17; and studied theology and was college tutor in mathematics and natural philosophy at Harvard in 1817-19. He refused a professorship at Bowdoin college for the pastorate of a Unitarian church in Baltimore. In 1821 he founded The Unitarian Miscellany and was chosen chaplain of the national house of representatives, where he made many influential friends. Probably his natural bent toward writing as well as the state of his health was responsible for his leaving the ministry in 1823 and purchasing the North American Review, of which he had been acting editor in 1817-18 and which he edited until 1830. By good management he made this periodical a financial success and the arbiter of literature in New England. But although he founded The American Almanac and Repository of Useful Knowledge in 1830, the major portion of his energy after 1826 was devoted to historical scholar-

Born in the shadow of the great figures of the Revolution, he did his most important work in The Life and Writings of George Washington (12 vol., 1834-37) and The Works of Benjamin Pranklin; With Notes, and a Life of the Author (10 vol., 1836-40). Another valuable project was The Library of American Biography (first series, 10 vol., 1834-38; second series, 15 vol., 1844-47), which he edited and to which he contributed a number of articles. Of lesser value are The Life and Travels of John Ledyard (1828); The Diplomatic Correspondence of the American Revolution (12 vol., 1829-30); The Life of Gouverneur Morris (3 vol., 1832); and Correspondence of the American Revolution, Being Letters of Eminent Men to George Washington (1853).

Sparks had done some of the research for his book on Washington in Europe, and in 1840-41 he continued his studies abroad in the history of the American Revolution. In the course of his research he discovered in the French archives the red-line map, which, in 1842, came into international prominence in connection

with the dispute over the northeastern boundary of the United States In 1842 he delivered 12 lectures on American history before the Lowell institute in Boston. In 1839-49 he was McLean professor of ancient and modern history at Harvard. His appointment to this position, says his biographer, was "the first academic encouragement of American history, and of original historical research in the American field."

The esteem in which he was held in his day is shown not only by the large sale of his works but by his election to the presidency of Harvard in 1849. He retired in 1853 because of failing health, and devoted the rest of his life to his private studies. For several years he was a member of the Massachusetts board of education. He died on March 14, 1866.

His valuable collection of manuscripts and papers went to Harvard; and his private library and maps were bought by Cornell university, Ithaca, N.Y. He was a pioneer in collecting, on a large scale, documentary material on American history, and in this and other ways rendered valuable services to historical scholarship in the United States.

See H B. Adams, The Life and Writings of Jared Sparks (2 vol., 1893), and J. S. Bassett, The Middle Group of American Historians (1917).

SPARKS, a city of Washoe county, Nevada, U.S., east of Reno near the Truckee river. The population in 1950 was 8,203 by the federal census and in 1940, 5,318. It is served by the Southern Pacific railway, which established the city in 1905, and it is a railroad division point.

The city was named for John Sparks, governor of Nevada at the time of the city's founding Sparks is in an irrigated agricultural area where hay, potatoes and onions are raised. Near by are gold and silver mines.

**SPARROW**, a word originally meaning any small bird, now restricted to those of the types enumerated below.

- (1). The house sparrow (Passer domesticus) is "the sparrow" par excellence. Thriving best in the neighbourhood of man, this bird is common throughout the northern parts of Europe and Asia and has been introduced into North America (in 1851) and the British colonies.
- (2). The tree sparrow, or mountain sparrow (P. montanus), both sexes of which resemble the male house sparrow, but are distinguished by the rufous crown and doubly barred wings, is a local species in England. In China, it is abundant and replaces the house sparrow near houses and in towns.
- (3). The hedge sparrow or dunnock (Prunella modularis), belonging to the thrushes (q.w.), is a little brown-backed bird with an iron grey head and neck. It is widely distributed throughout Europe.
- (4). The reed-sparrow or reed-bunting is, as the second name implies, a bunting (q.v.).
- (5). The numerous American sparrows are also buntings (q, v). Among them may be mentioned the song sparrow (Melospiza melodio) of which about 20 sub-species are recognized. It has a fine song. The chipping sparrow (Spizella passerina) is a confiding, humble little bird, with no great attractions but his manners. The savannah sparrow (Passerculus sandwichensis) is abundant in the maritime provinces of Canada, but breeds south to Iowa. The grasshopper sparrow (Animodramus savannarum) is also a common form, but its skulking habits and insect-like notes cause it to be overlooked. The lark sparrow (Chondestes gramma-cus) is common in the Mississippi valley east of the great plains; it has a pleasant if hurried song. The fox sparrow (Passerella iliaca) has also a fine song; it breeds in north Canada and Alaska, wintering from Ohio southward.

SPARTA (Gr. Σπάρτη οτ Λακεδαίμων), an ancient city in Greece, the capital of Laconia and the most powerful state of the Peloponnese. The city lay at the N. end of the central Laconian plain, on the right bank of the Eurotas, S. of its junction with the Oenus (mod. Kelefina), commanding the only land-routes into Laconia, the Oenus and Eurotas valleys from Arcadia, and the Langáda Pass over Mt. Taygetus from Messenia. At the same time its distance (27 m. from its port, Gythium) made it invulnerable from the sea.

#### ARCHAEOLOGY

Until 1905 the visible ancient buildings at Sparta were the theatre, the "Tomb of Leonidas," a quadrangular building of immense blocks containing two chambers; the foundation of a bridge over the Eurotas; a curved structure since found to be a Hellenic retaining wall restored in Roman times, and some late Roman fortifications, buildings and mosaic pavements. Inscriptions, sculptures and other objects were collected in the museum, or built into houses or churches. Excavations were carried on near Sparta, on the site of the Amyclaeum (1890 Tsountas, 1904 Furtwängler) at the shrine of Menelaus in Therapne (1833, 1841, Ross; 1889, 1900, Kastriotis) and at the "round building" (1892 and 1893 American School at Athens). But no organized work was tried in Sparta itself.

Systematic exploration, however, began with the excavations of the British School at Athens, at Thalamae, Geronthrae, and Angelona near Monemvasia, in 1904, and at Sparta itself in 1906. A "small circus" described by Leake, was found to be a theatrelike building constructed soon after A.D. 200 round the altar and in front of the temple of Artemis Orthia. Here musical and gymnastic contests took place as well as the famous flogging-ordeal (diamastigosis). The temple, of the 2nd century B.C overlies an older temple of the 6th century, and close beside it were found remains of a yet earlier temple, dating from the 9th or even the 10th century. The votive offerings in clay, amber, bronze, ivory and lead found in profusion within the precinct range from the 9th to the 4th century B C.; they prove that Sparta reached her artistic zenith in the 7th century and declined in the 6th. In 1907 the sanctuary of Athena "of the Brazen House" (Χαλκίοικος) was found on the Acropolis immediately above the theatre, and though the temple is destroyed, fragments of capitals in Doric style remained; also the longest extant archaic inscription of Laconia, and numerous bronze nails, plates and votive offerings of great interest. The Greek city-wall, built in stages from the 4th to the and century, has a circuit of nearly 6 m. (Polyb. ix. 21). The late Roman wall enclosing the Acropolis, probably dates from the years following the Gothic raid of A.D. 262. A number of points of Spartan topography, have been fixed in accord with the description of Pausanias. In 1910 the town of the "Mycenean' period on the left bank of the Eurotas a little to the S.E. was found to be roughly triangular, with an area approximately equal to that of Sparta, but nothing is left but foundations and potsherds. More recently, excavation of the theatre has yielded, besides inscriptions and small objects, a remarkable fifth century statue of a warrior.

### HISTORY

Prehistoric Period .- Tradition relates that Sparta was founded by Lacedaemon, son of Zeus and Taygete. But Amyclae and Therapne (Therapnae) were in early times of greater importance than Sparta, the former a Minyan foundation a few miles to the south of Sparta, the latter the Achaean capital of Laconia and the seat of Menelaus. Eighty years after the Trojan War, according to the traditional chronology, the Dorian migration took place (see Greece; History [Ancient]). A band of Dorians (q.v.) united with a body of Aetolians to cross the Corinthian Gulf and invade the Peloponnese from the north-west. The Aetolians settled in Elis, the Dorians pushed up to the headwaters of the Alpheus, where they divided into two forces, one of which, under Cresphontes, subdued Messenia, while the other, led by Aristodemus, made its way down the Eurotas valley and gained Sparta, which became the Dorian capital of Laconia. In reality this Dorian immigration probably consisted of a series of inroads and settlements rather than a single expedition. The newly founded state did not at once become powerful; the turning-point is marked by the legislation of Lycurgus (q.v.), who instituted that training which was its distinguishing feature and the source of its greatness. Nowhere else was the individual so thoroughly subordinated to the interest of the state. The whole education of the Spartan was designed to make him an efficient soldier. Obedience, endurance, military success-these were the aims constantly kept in view, and all other ends took a secondary place.

The Expansion of Sparta.—The first step, in the reign of

SPARTA 171

Archelaus and Charillus, was to secure the upper Eurotas valley, conquering the border territory of Aegys. Archelaus's son Teleclus is said to have taken Amyclae, Pharis and Geronthrae, mastering the central Laconian plain and the eastern plateau between the Eurotas and Mt. Parnon; his son, Alcamenes, by the subjugation of Helos, brought the lower Eurotas plain under Spartan rule. About this time, the Argives, whose territory included the whole east coast of the Peloponnese and the island of Cythera (Herod. i. 82), were driven back, and the whole of Laconia was incorporated in the Spartan state. Under Alcamenes and Theopompus a war broke out between the Spartans and the Messenians, which, after 20 years, ended in the capture of Ithome and the subjection of the Messenians, who were forced to pay half the produce of the soil as tribute. An attempt to throw off the yoke resulted in a second war, conducted by the Messenian hero Aristomenes (q.v); but Spartan tenacity prevailed, and Messenia was made Spartan territory, its people being reduced to the status of helots (q v.).

This extension of Sparta's territory was viewed with apprehension by her neighbours in the Peloponnese. Arcadia and Argos had vigorously aided the Messenians in their two struggles; only the Corinthians supported the Spartans, doubtless through jealousy of their neighbours, the Argives. At the close of the second Messenian War (c. 631 B.C.) no power could hope to cope with that of Sparta save Arcadia and Argos. In the 6th century Sparta made a vigorous attack on Tegea, the most powerful of the Arcadian cities, but it was not until the middle of the century that Tegea was forced to acknowledge Spartan overlordship, though retaining its independence. The final struggle for Peloponnesian supremacy was with Argos; but Argos was now no longer at the height of its power; it could not count on the assistance of Arcadia and Messenia, since the latter had been crushed and the former had acknowledged Spartan supremacy. A victory, won about 546 B.C., made the Spartans masters of the Cynuria, the borderland between Laconia and Argolis. The final blow was struck by King Cleomenes I. (q.v.), and left Sparta without a rival in the Peloponnese. By the middle of the 6th century, Sparta had come to be acknowledged as the leading state of Hellas and the champion of Hellenism. Croesus of Lydia had formed an alliance with her; to her the Greeks of Asia Minor appealed to withstand the Persian advance and to aid the Ionian revolt; Plataea asked for her protection; and at the time of the Persian invasion under Xerxes (see Graeco-Persian Wars) no state questioned her right to lead the Greek forces on land and sea. Of such a position Sparta proved herself unworthy. She could never rid herself of her Peloponnesian outlook sufficiently to throw herself heartily into the affairs of the greater Hellas. She was not a colonizing State, and had no share in the expansion of Greek commerce and Greek culture. Her military greatness formed her sole claim to lead the Greek race; that she should truly represent it was impossible.

Constitution .- Of the internal development of Sparta down to this time but little is recorded. This was attributed to the stability of the Spartan constitution, but it is, in fact, due also to the absence of historical literature at Sparta, to the small part played by written laws, expressly prohibited by an ordinance of Lycurgus, and to the secrecy of oligarchical rule. At the head of the state stood two hereditary kings, of the Agiad and Eurypontid families, equal in authority, though the Agiad king received greater honour in virtue of the seniority of his family (Herod. vi. 51, 52). This dual kingship was explained by the tradition that on Aristodemus's death he had been succeeded by his twin sons. Aristotle describes the kingship at Sparta as "a kind of unlimited and perpetual generalship" (Pol. iii. 1285a). Here also, however, the royal prerogatives were curtailed; the king lost the right of declaring war, was accompanied to the field by two ephors, and was supplanted by the ephors in the control of foreign policy. The kings became mere figure-heads, and the real power was transferred to the ephors and to the gerousia (q.v.). In the powers exercised by the assembly of the citizens or apella (q.v.) we cannot trace any development, owing to the scantiness of our sources. The Spartan was essentially a soldier, trained to obedience and endurance, he became a politician only if chosen as ephor for a single year or elected a life member of

the council after his 60th year had brought freedom from military service

Social System.—Spartiates were debarred by law from trade or manufacture, which rested in the hands of the perioeci (q.v.), and were forbidden to possess either gold or silver, the currency consisting of bars of iron. Wealth was, in theory, derived entirely from landed property, and consisted in the annual return made by the helots, who cultivated the plots of ground allotted to the Spartiates. But this attempt to equalize property proved a failure; from early times there were marked differences of wealth within the state, and these became greater after the law of Epitadeus removed the legal prohibition of the gift or bequest of land. The number of full clitzens, 8,000 at the beginning of the 5th century, had sunk by Aristotle's day to less than 1,000, and had further decreased to 700 in 244 B.C.

The Persian Wars and After.-The beginning of the 5th century B C. saw Sparta at the height of her power; but after the Persian Wars the Spartan supremacy could no longer remain unchallenged. Sparta despatched an army in 490 BC. to aid Athens in repelling the armament sent against it by Darius. But it arrived after the conflict had been decided at the battle of Marathon. In the second campaign Sparta assumed the command of the combined Greek forces by sea and land. Yet, in spite of the heroic defence of Thermopylae by Leonidas (q.v.) the glory of the decisive victory at Salamis (q.v) fell in great measure to the Athenians, and their patriotism and energy contrasted strongly with the hesitation of the Spartans and their selfish policy of defending the Peloponnese only. By the battle of Plataea (479 B.C.), won by a Spartan general, the state partially recovered its prestige, but only so far as land operations were concerned; the victory of Mycale, won in the same year, was achieved by the united Greek fleet, and the capture of Sestos, which followed, was due to the Athenians. The perils and the glories of the Persian War were left to Athens, who, though at the outset merely the leading state in a confederacy of free allies, soon began to make herself the mistress of an empire. Sparta for a time took no steps to prevent this. Moreover, Sparta's attention was occupied by troubles nearer home-the plots of Pausanias not only with the Persian king but with the Laconian helots; the revolt of Tegea (c. 473-471); the earthquake which in 464 devastated Sparta; and the rising of the Messenian helots, which immediately followed. The insulting dismissal of Athenian troops which had come to aid the Spartans in the siege of the Messenian stronghold of Ithome, the consummation of the Attic democracy under Ephialtes and Pericles (q.v.), and the conclusion of an alliance between Athens and Argos united with other causes to bring about a rupture between the Athenians and the Peloponnesian League. In the so-called first Peloponnesian War Sparta herself took but a small share beyond helping to defeat the Athenians at Tanagra in 457 B.C.

Peloponnesian War.—A fresh struggle, the great Peloponnesian War (q.v.), broke out in 431 B.C. This may be to a certain extent regarded as a contest between Ionian and Dorian, or between the democratic and oligarchic principles of government; but at bottom its cause was neither racial nor constitutional, but economic. The maritime supremacy of Athens was used for comercial purposes, and important members of the Peloponnesian

confederacy, whose wealth depended largely on their commerce, notably Corinth and Megara, were being slowly but relentlessly crushed. Sparta remained unaffected, but she was forced to take action by the pressure of her allies. She did not prosecute the war with any vigour. her operations were almost confined to an annual inroad into Attica, and when in 425 B.C a body of Spartiates was captured by the Athenians at Pylos, she was anxious to terminate the war on any reasonable conditions. That the teims of the Peace of Nicias (421), were rather in favour of Sparta than of Athens was due almost entirely to an individual Spartan, Brasidas (q v.). The final success of Sparta and the capture of Athens in 405 were brought about partly by the treachery of Alcibiades. Funds were gained by subsidies from Persia, and Spatta found in Lysander (q.v.) an admiral of boundless vigour.

Spartan Empire.-The fall of Athens left Sparta once again supreme in the Greek world and demonstrated clearly her total unfitness for rule. Everywhere democracy was replaced by a philo-Laconian oligarchy, under a Spartan harmost or governor, and even in Laconia itself the narrow and selfish character of the Spartan rule led to a serious conspiracy. Under the energetic rule of Agesilaus, it seemed as if Sparta would pursue a Hellenic policy and carry on the war against Persia. But troubles soon broke out in Greece, Agesilaus was recalled from Asia Minor, and his schemes and successes were rendered fruitless Further, the naval activity displayed by Sparta during the closing years of the Peloponnesian War abated when Persian subsidies were withdrawn. İn 394 B.C. the Spartan navy under Peisander was defeated off Cnidus by the Persian fleet under Conon and Pharnabazus, and Sparta ceased to be a maritime power. In Greece itself, meanwhile, the opposition to Sparta was growing increasingly powerful, and the Spartans felt it necessary to rid themselves of Persian hostility. They therefore concluded with Artaxerxes II. the humiliating Peace of Antalcidas (387 B.C.), by which they surrendered to the Great King the Greek cities of the Asia Minor coast and of Cyprus After a desultory war with Thebes over the independence of the Boeotian towns, the citadel of Thebes was treacherously seized by Phoebidas in 382 and held by the Spartans until 379 B.C. In 371 a fresh peace congress was summoned at Sparta. Again the Thebans refused to renounce their Boeotian hegemony, and the Spartan attempt at coercion ended in the defeat of the Spartan army at the battle of Leuctra and the transfer of the Greek supremacy from Sparta to Thebes.

Decline of Sparta .- In the course of three expeditions to the Peloponnese, conducted by Epameinondas (q v), the greatest soldier and statesman Thebes ever produced, Sparta was weakened by the loss of Messenia and by the foundation of Megalopolis as the capital of Arcadia. On Epameinondas's fourth expedition Sparta was again within an ace of capture, but the danger was averted; and though at Mantineia (362 B.C.) the Thebans, together with the Arcadians, Messenians and Argives, gained a victory over the combined Mantinean, Athenian and Spartan forces, yet the death of Epameinondas in the battle more than counterbalanced the Theban victory. But Sparta had neither the men nor the money to recover her lost position, and the continued existence on her borders of an independent Messenia and Arcadia kept her in constant fear for her own safety. No Spartiate fought on the field of Chaeroneia (338 B.C.). After the battle, however, she refused to submit voluntarily to Philip of Macedon, and was forced to do so by the devastation of Laconia and the transference of certain border districts to the neighbouring states of Argos, Arcadia and Messenia. During the absence of Alexander the Great in the East, Agis III, revolted, but the rising was crushed by Antipater, and a similar attempt after Alexander's death was frustrated by Demetrius Poliorcetes in 294 B.C. Twenty-two years later the city was attacked by Pyrrhus (q.v.), but the formidable enemy was repulsed. About 244 BC. an Aétolian army overran Laconia, carrying off, it is said, 50,000 captives.

Attempts at Social Revolution.—This and other ignominious defeats of Sparta showed that she had shared, but in an unusual degree, in the general decay of Greece. On the accession of Agis IV. (q.v.) in 244 B.C. the citizen body had by the concentration of wealth in a few hands shrunk to a few hundred; the

rest of the inhabitants were in their debt and their power The Lycurgan constitution was ignored and Phylarchus (Plutarch's chief authority) gives us the usual picture of luxury and degeneracy. Agis by popular agitation was able to carry a resolution through the apella for a restoration of the Lycurgan discipline, together with a redivision of lands and a cancellation of debt. His fellow-king Leonidas opposed, but a section of the wealthy landowners, led by Agis's uncle Agesilaus, were in favour of a cancellation of debts, especially mortgages. With their assistance Agis was able to conciliate the ephors, remove Leonidas and replace him by his son-in-law Cleombrotus. The land was to be divided into "an inner ring about Sparta of 4,500 Spartan lots, and that in the outer ring into 15,000 lots for Perioeci; as there were nothing like 4,500 Spartans he proposed to fill up the number from Perioeci and selected metics in sympathy with Spartan institutions" (W W. Tarn in The Hellenistic Age, 1923, p. 134). Agesilaus persuaded him to divide his programme into two halves, the cancellation of debts being carried through first. Immediately after this measure had been passed, Agesilaus with the other ephors sent Agis north with an army to assist the Achaean league against the Actolian league During his absence the two sections of the wealthy class reunited and the division of lands was prevented Cleombrotus was expelled and Agesilaus brought back Leonidas. Agis on his return declined to use force to prevent the reaction directed by the Ephorate, took sanctuary and was killed by a trick To prevent a recurrence of a social revolution, Leonidas forcibly married Agis's widow to his son Cleomenes, who was, however, converted by his wife and the Stoic Sphaerus to Agis's views Thirteen years after Agis's death he came to the throne as Cleomenes III. (q v). He picked a quarrel with the Achaean league in order to be sent out in command of mercenaries, returned to Sparta, killed 14 of his opponents and exiled eighty. He carried through the division of land as contemplated by Agis (reserving 80 lots for the exiles), cancelled debts, and withdrew all the ephors' chairs except one, which he occupied himself His war with the Achaean league now became a series of sensational victories, but the league finally secured the aid of Antigonus of Macedonia who forced Cleomenes to flee to Egypt.

Sparta fell back into its previous abject condition, until the rise of the tyrant Nabis, of whom we have only extremely hostile accounts. He abolished debts, redistributed land, taxed the wealthy heavily for the expense of the Lycurgan common meals, and extended the scope of the revolution by liberating helots. His stern reign is marked by another sudden renaissance of Sparta's military power: Sparta was indeed the only Greek power which was able to resist the legions of Flamininus the conqueror of Macedon. Flamininus failed to capture Sparta and in his final settlement left Nabis undisturbed in Laconia, though not in Argos. The experiment was brought to an end by the assassination of Nabis by the Aetolians: in the ensuing confusion Philopoemen (q.v) the general of the Achaean league captured the city, destroyed the Lycurgan constitution of Nabis, and attached the state to the Achaean league. By his dexterity he was able to frustrate later attempts at revolution; and after the annexation of Greece by Rome Sparta has no history worth recording.

Mediaeval Sparta.—In A.D. 396 Alaric (q.v.) destroyed the city and at a later period Laconia was invaded and settled by Slavonic tribes. The Franks, on their arrival in the Morea, found a fortified city named Lacedaemonia occupying part of the site of ancient Sparta, and this continued to exist, though greatly depopulated, even after Guillaume de Villehardouin had in 1248-49 founded the fortress and city of Misithra, or Mistra, on a spur of Taygetus some three miles north-west of Sparta. This passed shortly afterwards into the hands of the Byzantines, who retained it until the Turks under Mohammed II. captured it in 1460. In 1687 it came into the possession of the Venetians, from whom it was wrested in 1715 by the Turks.

The Modern City.—In 1834, after the War of Independence, the modern town of Sparta was built on the ancient site from the designs of Baron Jochmus, and Mistra decayed until now it is almost deserted. Sparta is the capital of the prefecture (voués)

of Lacedaemon. Pop. (1951) 10,874.

BIBLIOGRAPHY -History: J. C. F. Manso, Sparta (3 vols, Leipzig,

of Lacedaemon. Pop. (1951) 10,874.
Billiodraphy — History: J. C. F. Manso, Sparta (3 vols, Leipzig, 1800-05); G. Gilbert, Studien zur altspartanischen Geschichte (Gottingen, 1872); G. Busolt, Die Lakedamonier und ihre Bundesgenossen (Leipzig, 1878); for the 6th century and the Persian wars, also the Greek histories of G. Grote, E. Meyer, G. Busolt, J. Beloch, A. Holm, B. Niese, E. Abbott and J. B. Bury.

Topography and Antiquities: W. M. Leake, Morea, chs. iv, v; E. Curtus, Peloponnesos, ii, 220 sqq.; C. Bursian, Geographie, ii, 119 sqq; Pausanias, iii, 122 sqq.; W. G. Clark, Peloponnesus, pp. 158 sqq.; E. P. Boblaye, Recherches, pp. 78 sqq.; W. Vischer, Erimerungen, pp. 371 sqq.; Bory de Saint-Vincent, Relation, pp. 418 sqq.; G. A. Blouet, Architecture, ii, 61 sqq. pl. 44-52; for full titles and dates of publication of these works, see Laconix; H. K. Stein, Topographie des alten Sparta (Glatz, 1890); K. Nestoiides, Toroyaepla viis Agxais Szaforne (Athens, 1892); N. E. Crosby, "The Topography of Sparta," in American Journal of Archaeology (Princeton, 1893), M. N. Todand A. J. B. Wace, Catalogue of the Sparta Museum (1966).

SPARTACUS, leader in the Gladiatorial War against Rome

SPARTACUS, leader in the Gladiatorial War against Rome (73-71 B.C.), a Thracian by birth. He served in the Roman army, but seems to have deserted and been sold as a slave. Destined for the arena, he, with some fellow gladiators, broke out of a training school at Capua and took refuge on Mt. Vesuvius (73 B.C.), where they were joined by other runaway slaves. They defeated two Roman forces in succession, overran most of southern Italy and ultimately were about 90,000 strong. Spartacus defeated both consuls of 72 and fought his way successfully toward the Alps. As the slaves refused to leave Italy, he returned to Lucania, hoping to cross to Sicily; but he was thwarted by the new Roman commander, M. Licinius Crassus, who had eight legions. His large army divided; the Gauls and Germans were defeated first, and Spartacus ultimately fell fighting in a pitched battle (71). Many slaves who escaped northward were cut to pieces by Pompey on his way home from Spain.

Spartacus was both competent and, apparently, humane. His reputation has suffered from the terror that his name inspired

throughout Italy.

BIBLIOGRAPHY.—The story has to be pieced together from the vague and somewhat discrepant accounts of Plutarch (Crassus, 8-11, Pompey, and somewhat discrepant accounts of Plutarch (Crassus, 8-11, 170mpey, 21), Appian (Bell. Civ.), 1, 116-120), Florus (ii, 8), Livy (Epit., 95-97) and the fragments of the Histories of Sallust, whose account seems to have been full and graphic. See T. Rice Holmes, The Roman Republic, i, pp. 135-161, 386-390 (Oxford, 1923); H. Last, in Cambridge Ancient History, ix, pp. 329-321 (1932).

SPARTANBURG, a city of South Carolina, U.S., the county

seat of Spartanburg county; in the northwestern part of the state,

on federal highways 29, 176 and 221.

It is served by the Charleston and Western Carolina, the Carolina, Clinchfield and Ohio, the Southern and the Piedmont and Northern (electric) railways, by air and bus lines. Pop. (1950) 36,795; (1940) 32,249 by the federal census, with an additional 20,000 in the immediate suburbs.

Spartanburg is 875 ft. above sea level, in the heart of the beautiful Piedmont section, a leading theatre of industrial development in the south, and is one of the large textile centres of the United

It is the seat of Wofford college for men (Methodist Episcopal; 1850), Converse college for women (1889) and the Spartanburg Junior college (1911), where students alternate weeks of classroom study with work in various stores and industries.

The city is a leading shipping centre of peaches, fresh tomatoes, pimiento peppers and grapes. Cotton is also produced in the

In 1947 the city adopted a commission-manager form of government. Spartanburg was founded in 1789 and incorporated as a city in 1831.

SPARTINA. A genus of grasses (Gramineae) belonging to the tribe Chlorideae. Of the seven or eight species, most are North American, where the Fox grass (S. patens) and Salt Thatch (S. alterniflora) are common on the salt marshes of New England. In Europe S. stricta occurs on the salt flats of southeast England, France, Portugal and the Adriatic. S. alterniflora has been known at Southampton from 1829, where it was probably introduced by shipping from America. The genus is remarkable for scribed as the woolsack, from the material with which it was

the sudden appearance of a new distinct form at Southampton in 1870, Spartina townsendii. This tall-growing and robust form has spread widely in recent times on the soft tidal muds of both sides of the English channel (Southampton water, Portsmouth, Poole harbour, etc., and in the Vire, Seine and other French rivers). Sparting townsendi is exceptional in colonizing soft mud previously bare, for the vigour of its spread and for its power of holding silt and raising the level of the mud. It is probably a hybrid between S. stricta and S. alterniflora. In 1924 it was introduced into the Netherlands and extensively planted on the bare mud of the Scheldt, in Zeeland and elsewhere, with a view to hastening the time when such ground could be banked (poldered) (F. W. O.) and used for agriculture.

SPASM: see CRAMP; MUSCLE AND MUSCULAR EXERCISE; NERVE

SPASMODICS, THE, a name given to a group of English poets in the '40s and '50s of the 19th century. It was first applied by W. E. Aytoun in Blackwood (May 1854) in a mock review of his own satire, Firmilian: a Spasmodic Tragedy (E. A. Poe had used the word "spasmodist" five years earlier). The writers usually classed as spasmodics are P. J. Bailey (Festus, 1839), Ernest Jones, the Chartist song-writer, Ebenezer Jones, also a Chartist (Songs of Sensation and Event, 1843), Sydney Dobell (The Roman, 1850; Balder, 1854) and Alexander Smith (A Life Drama, 1853; City Poems, 1857). But it would be difficult to exclude some of Mrs. Browning's early work (Seraphim, 1838; Drama of Exile, 1845), before she had assimilated her husband's influence, and Tennyson's Maud (1855) is in its violence, sentiment and frequent lapses of taste not far removed from the spasmodic manner. In the '40s the romantic impulse was exhausted and the Augustan notions of form discredited; but Tennyson and Browning had not risen to acknowledged ascendancy, and M. Arnold had not formulated the new canons of criticism. The interim was a time of false starts, of poets whose aspirations, excited by Byron and Shelley, were unrestrained by any tradition of style or any effectual contemporary criticism.

SPEAKER, the title given to the presiding officer in many of the legislatures which have taken their tradition from England. In the 13th century it became the practice to summon representatives of the counties and boroughs to attend the king "in his court in his council in his parliament." After the middle of the 14th century, if not before, the "commons" sat separately, and in 1377 we first learn of the existence of a "speaker" who presided over their deliberations and spoke for the commons when they were summoned to attend the king in parliament (i.e., in the house of lords). The speaker was appointed by the king, but on the nomination of the house of commons. From 1377 whenever there has been a parliament there has been a speaker. At the opening of parliament the king, or lords commissioners on his behalf, orders the commons "to repair to the place where you are to sit and there proceed to the choice of some proper person to be your speaker." The commons having done so, they attend upon the king or the lords commissioners, where the speaker-elect announces that the choice of "His majesty's most faithful commons" has fallen upon him and that he "submits himself with all humility for his majesty's gracious approbation." The king's approval having been expressed, the speaker not only "speaks" for the commons at the bar of the house of lords but also presides over their deliberations whenever he is present and they are not sitting in committee. When the house desires to discuss a matter privately. for instance the granting of supply to the king, the motion is made "that Mr. Speaker do now leave the chair." for the speaker is the king's representative. The term has, however, been generalized, and even the presiding officer of the house of lords, generally the lord chancellor, is often described, though inaccurately, as the speaker of that house.

In the house of lords the sovereign presides from the throne if present, but he is now never present except to read the king's speech at the beginning or the end of a session. In his absence the lord chancellor, or the lord keeper of the great seal if there is no lord chancellor, presides from a seat below the throne deformerly stuffed. The woolsack is technically outside the limits of the house, so that the lord chancellor or lord keeper need not be a peer In practice the lord chancellor is raised to the peerage, but it is not uncommon for him to preside before he receives his patent. The lord chancellor or lord keeper has none of the wide powers exercised by the speaker of the house of commons, for the house of lords decides its own procedure on a motion moved by a member of that house, and the lord chancellor's only function is to put the motion to the house and declare whether the house is content or not content. Also, he is an active member of the government and takes part in the proceedings of the house (if a peer) in that capacity He is invariably a lawyer and usually presides when the house is sitting for indicial business

Functions and Powers.-The speaker of the house of commons is not only the presiding officer but also the guardian of its powers, dignities, liberties and privileges. Immediately his election is confirmed by or on behalf of the king he lays claim, in the name and on behalf of the commons of the United Kingdom, "to all their ancient and undoubted rights and privileges, especially to freedom of speech in debate, to freedom from arrest, and to free access to his majesty whenever occasion shall require; and that the most favourable construction may be put upon all their proceedings." He has wide powers, not only by standing orders, but also by the practice of the house. His rulings on matters of procedure are accepted without question by the house and are recorded in the journals, where they become precedents for future decisions. Some decisions, such as those on the admissibility of questions, are taken outside the house and are recorded privately by the clerks at the table. On the basis of all these decisions, recorded for centuries, there has arisen a lex et consuetudo parliamenti described by Sir Erskine May, afterward clerk of the house of commons, in his Treatise on the Law, Privileges, Proceedings and Usage of Parliament (1st ed. 1844), which is kept up-to-date by successive clerks (14th ed. 1946, by Sir Gilbert Campion) and used as the standard work of reference.

Comparatively recent reforms in the procedure of the house, necessitated by the pressure of business, the development of a highly organized party system, the broadening of the electorate, and the growth of organized obstruction after the raising of the issue of home rule for Ireland, have added considerably to the speaker's powers. He may now accept a closure motion if he considers that it is not an abuse of the process of the house, select amendments from among those on the order paper (the "kangaroo"), and apply any "guillotine" motion that may be passed by the house for the closure of a series of debates by compartments. He also decides whether a motion for the adjournment of the house for the discussion of a "definite matter of urgent public importance" shall be put to the house. These are in addition to his ordinary power of deciding whether a bill, motion, question or observation is in order, whether a remark is "parliamentary," whether a discussion is relevant to the motion before the house, whether a question or a supplementary question shall be allowed, whether a financial resolution is necessary before or after a bill is introduced, etc. His influence is wider than even his wide powers would indicate, for a suggestion by the speaker as to the conduct of business is generally accepted by the house.

Modern Practice.—His enormous influence is due to the fact that the speaker makes every attempt to be completely impartial. In the 18th century the speaker was generally an active politician; and Henry Addington, for instance, moved from the chair to the treasury bench. Early in the 10th century, however, successive speakers made an attempt to reach impartiality, and the process was completed by Charles Shaw-Lefevre, who was speaker in the difficult period 1839-57, when party alignments were being drawn more strictly as the consequence of the first Reform act became clear. It is now the practice for the government of the day, after consulting the leaders of the opposition, to nominate a back-bencher who has taken no prominent part in political controversy and who is acceptable to all sections of the house. There was no opposition to any nomination between that of W. C. Gully in April 1895 and that of W. S. Morrison in Oct. 1951. The election is usually proposed by a back-bencher on the government

side and seconded by a back-bencher on the opposition side, the leader of the house and the leader of the opposition making the first congratulatory speeches after the election. It is also the practice in a new parliament for the late speaker to be re-elected if a member of the house and willing to serve, even if there has been a change of government in the meantime. It was formerly the practice for the late speaker not to be opposed in his constituency if he desired to stand again, but this practice was not followed by the Labour party in 1935 and 1945 on the ground that it prevented the constituency from expressing its views on the political questions of the day; and in 1950 Col D Clifton Brown was opposed by an Independent Liberal. The speaker has a salary of  $\frac{4}{5}$ ,000 a year, on his retirement he is offered a viscounty and provided with a pension by act of palliament

The speaker being thus as impartial as it is possible for a human being to be, he is able to guide the proceedings of the house even when controversy is at its height, and the prestige of the house depends in very large measure on the ability of its speaker not merely to control but also to lead. In particular, he is able to secure on the one hand that government shall not be obstructed and on the other hand that every point of view shall be adequately expressed. The small minority, such as the solitary Communist member in the parliament of 1935-45; is in fact given better opportunities than the back-benchers on the government side, simply because it represents an unpopular point of view. The speaker being impartial, he can also be used to preside over conferences of party representatives in which agreement between the parties is desirable, such as proposals for changes in the franchise or in the distribution of seats. Thus, the Representation of the People act, 1918, was the result of a conference over which J. W. Lowther (speaker 1995-21) presided, and the changes of 1945 were recommended by a conference of which Speaker Clifton Brown was the president

The house on its side does everything possible to exalt the office of speaker. No member may stand while the speaker is on his feet or pass between the speaker and the house. All observations must be addressed to the speaker and not to the house. The speaker's procession on its way to the house is a daily ceremony. Outside the house he speaker used to be the "first commoner," but since 1919 he has ranked after the prime minister and the lord president of the council, though before all peers of the realm except the two archbishops. His carriage is still entitled to drive down the centre of the Mall, passing all other carriages, because of the privilege of the house to "free access to his majesty whenever occasion shall require"

to his majesty whenever occasion shall require" BIBLIOGRAPHY.—J. A. Manning, Lives of the Speakers (London, 1850), E. and A. G. Porritt, The Unreformed House of Commons, 2 vol. (Cambridge 1903); Viscount Ullswater (Speaker J. W. Lowther), A Speaker's Commentaries, 2 vol. (London and New York, 1925); Sir William Anson, Law and Custom of the Constitution, new ed (Oxford, 1935); Sir Thomas Erskine May, Treatise on the Law, Privileges, Proceedings and Usage of Parliament, 14th ed. by Sir Gilbert Campion (London and Toronto, 1946); W. Ivor Jennings, Parliament (Cambridge, 1939, New York, 1940); (W. I. J.; X.)

## SPEAKER OF THE HOUSE OF REPRESENTATIVES

The United States constitution provides that "the House of Representatives shall choose their Speaker and other officers . . ." In creating this office its authors had in mind the speaker in the colonial assemblies who had been both a presiding officer and a political leader. Early expectations were later realized, for U.S. speakers after 1789 have been both parliamentary and political personalities.

The speaker of the house holds an office of dignity and honour, of great power and influence. Usage dictates that he shall always be a member of the house; and as such the constitution requires him to be seven years a citizen and at least 25 years of age. Candidates for the office are nominated by party caucuses prior to the convening of each congress and the speaker is customarily elected by the house on the opening day, barring a protracted contest. Competition for the place is keen and the final choice is influenced by knowledge of parliamentary procedure, previous legislative experience, sectional claims, private interests, personal qualities and political considerations.

History of Office.—During the first 83 congresses (1789–1953) the speakership was held by 47 men (including speakers bro tem), of whom 14 had previously been speakers of the state assemblies and 24 others had served in state legislatures. Only nine of the speakers were without any prior state legislature experience, and of these none held the office prior to at least his fourth term in the national legislature. Three speakers were elected to the office in their first term in the house of representatives: Frederick A. C. Muhlenberg, the first speaker, who had been speaker of the Pennsylvania house and a delegate to the constitutional convention; Henry Clay, who had served several terms in the Kentucky legislature as member and speaker and had been a U.S. senator; and William Pennington, who had once served in the New Jersey assembly. With the exception of these three, every speaker had had prior service in congress, ranging from 1 to 14 terms.

During the 19th century prior congressional service ranged from one to seven terms. Long experience in the house is a modern condition of election. Up to 1896, when Mary P. Follett published her pioneer study of the office, the average length of service of speakers as such had been three years; from 1896 to 1953 the average increased to five

vears

Many famous men have occupied the speakership after Muhlenberg, including Clay, Stevenson, Polk, Colfax, Blaine, Reed, Cannon, Clark, Gillett, Longworth and Rayburn. Henry Clay and Sam Rayburn hold the record for the longest service—six terms. Five of the six terms served by Clay, the only representative whose entire career in the house was spent in the chair, were consecutive Prior to the 83rd congress, Stevenson, Cannon and Clark had served four terms each, Macon, Colfax, Blaine, Randall, Carlisle, Reed, Gillett, Longworth and Bankhead each had three terms in the chair.

Of the first 47 speakers, 9 came from New England, 9 from middle Atlantic states, 70 from the middle west and 19 from the south. Southern influence predominates in the organization of the Democratic party, for "the soild south" has been prevailingly Democratic after the Civil War and repeatedly has re-elected the same congressmen. Southern members thus acquire seniority and power in party councils Every Democratic speaker (except Rainey of Illnois) after 1865 had been,

up to the soth congress, a southerner.

Powers and Duties.—The parliamentary powers and duties of the speaker stem from four sources: the constitution and laws of the United States, the rules of the house, previous decisions of the char, and general parliamentary law. He presides at sessions of the house and opens and closes its sittings, acts as its mouthpiece and representative and authenticates documents, announces the order of business, puts ougstions and announces the vote.

He also decides questions of order, can prevent obstruction of house business, refers bills and reports to the proper committees or calendars, chooses speakers pro tempore, and appoints the chairmen of committees of the whole. These duties he performs impartially like the speaker of the house of commons, as evidenced by the fact that his decisions are rarely appealed. He also enjoys the privileges of an ordinary member of the house of orthe house of the ho

Prior to 1910 the speaker also possessed important political powers. He appointed, deposed and demoted the chairmen and members of committees; he served as chairman of the committee on rules, which

Speakers of the U.S. House of Representatives

Name							
Colegate	_			speaker	served	Congresses served in	legislative
3   Jonathan Dayton   M.J.   4-5   6   7   3-6   5   5   5   5   5   5   5   5   5	r.	(delegate)	Pa.	1,3	-	1-4	Speaker
A	2	Jonathan Trumbull		2	1	1-3	Speaker
Separate			NJ.	4,5		2-5	Speaker
Galegate)   Gale				5 (pro tem)	3	3-6	Speaker
7. Joseph Varnum Mass. 10,11		(delegate)		,		1-4,6	Speaker
8. Henry Clay			N.C.		5	2-14	
Langdon Cheves   S.C.   15,16,18   18-10   1	7.	Joseph Varnum			0		Member
13	8.	rienry Clay	Ky.	12,13,14,	_	12-13,14-10,	
10. John W. Taylor   Va.   17   24   23   24   24   25   24   24   25   24   24	١.	Lanadan Chausa	9.0	15,10,18			Speaker
11. Philip P Barbour	1 -9.	John W Taylor	NV				Member
12.1 Andrew Stevenson   Va.   20,21,22,   3   17-24   Speaker	77	Philip P Barbour	Va.			13-22	
23   John Bell   Tenn.   23   Catal   3   20-36   Member   Member   24-35   5   20-35   Member   24-36   Member		Andrew Stevenson					
14   James K Polk   Va.   24-35   5   10-35   Member   15   Nobert M T. Hunter   Va.   26   1   24-35   1   24-35   Nember   15   Nobert C. Winthrop   Mass   30,31   40,37-34   Nobert C. Winthrop   Mass   30,31				23 (1st)			
15, Robert M. T. Hunter   Va.   26   x   25-27,29   Member   Mem	13.		1enn.		3		
15.   John White   K.y.   27   3   24-38   Member   34.00   Member   37.00   Member   38.00   Member   38.00   Member		James K. Polk			5		
17.   John W. Jones   Va.   28	15.	Kobert M 1. Hunter .				25-27,29	
18.   Ind.   20   3   3   3   3   3   3   3   3   3	10.	John White	Ly.	27		24-20	
20   Howell Cobb   Ga.   31   31   31   33   34   37   (6)   4   33   33   33   33   33   33   34   33   34   33   34   33   34   33   34   33   34   33   34   33   34   33   34   33   34   33   34	17.	John W. Jones	Trad		A (+)+	24-25	
20   Howell Cobb   Ga.   31   31   31   33   34   37   (6)   4   33   33   33   33   33   33   34   33   34   33   34   33   34   33   34   33   34   33   34   33   34   33   34   33   34   33   34	10,	Pohort C Winthrop			3 734	24,20,20-29	
1.	20.	Howell Cobb			4 (3/1	28-27-31	Speaker
22. Nathannel P. Banks   Mass.   34   x   33-35.59-62   X   X   X   X   X   X   X   X   X					7 (6) †		Member
23	22	Nathaniel P Ranks	Mass.				
23, James L, Orr   N.J.   35   4   31-75   Member   Mem				34	-		Speaker
25, Galusha A. Grow   Pa.   37, 3940   38 -37,3-37   38-40   38-40   38 -38-40   38-40   38 -38-40   38-40   38-40   38 -38-40   38-	23.	James L. Orr	S C.	35	4		Member
25, Galusha A. Grow   Pa.   37, 3940   38 -37,3-37   38-40   38-40   38 -38-40   38-40   38 -38-40   38-40   38-40   38 -38-40   38-		William Pennington	N.J.	36	-		Member
26. Schuyler Coffax 27. Theodora M. Pomeroy 28. Theodora M. Pomeroy 29. Theodora 29. Theod	25.	Galusha A. Grow	Pa.	37	5	32-37,53-57	1
27   Theodore M. Pomeroy   N.Y.   40 (1 day)   3   33-34   43-41   43-41   44   44   44   44   44   43-41   43   43   43   43   43   43   43				38,39,40	4		
20, Michael C. Kerr   Ind.   44 (protem)   7 (3)   30-24, 44   Member   30, Samuel S. Cox   N.Y.   44 (protem)   7 (3)   35-34, 4-96,   49-21   31, 32-34, 4-96,   49-21   32, 32, 32, 32, 32, 33, 4-96,   49-21   32, 32, 32, 32, 32, 32, 32, 32, 32, 32,	27	Theodore M. Pomeroy .	N.Y.	40 (I day)	3		
36. Samuel S, Cox   N.Y.   44 (protem)   7 (3)   135^-53.6495     37. Milton S, soyler   10 ho   44 (and)   1   49-21     38. Samuel J, Randall   Pa.   44 (and)   0   49-21     39. Samuel J, Randall   Pa.   44 (and)   0   49-21     30. Samuel J, Randall   Pa.   44 (and)   0   49-21     31. J, Warren Keifer   Ohio   47 (4.00   0   0   0     32. Samuel J, Randall   Pa.   44 (and)   0   49-21     33. J, Warren Keifer   Ohio   47 (4.00   0   0   0   0     47 (4.00   0   0   0   0   0   0     48 (4.00   0   0   0   0   0   0     49. Sam S, Soyler   S, Soyler   Member   Memb	28.	James G. Blaine					Speaker
37. Milton Saylor 3. Ohio 44 (1 day) 1 49-31 Member 32. Samuel J. Randull Pa. 44 (2 day) 1 43-45 Member 34. John G. Carlula 54. John G. Carlula 54. John G. Carlula 54. John G. Carlula 55. Charles F. Crisp 57. John G. B. Reed Maine 51,545 3 48-53 John G. B. Reed Maine 51,545 5 6 48-55 John G. Campa G. Campa G. Carlula 58. John G. Carlula 58. John G. Carlula 58. John G.		Michael C. Kerr	Ind.	44	4	39-42, 44	Member
31. Millton Saylor   2.   44 (1 day)   7   43-45   43-45   43-45   45-46   4	30.	Samuel S. Cox	N.Y.	44 (protem)	7 (3) T	35-38,41-49,	
33. Samuel J. Randall Pa. 44 (2nd.) 6 38-31 Member 33. J. Warm Káfir Ohio G. Catlala S. 1 Warm Káfir S. 1 Member 34. 1 Member 34. 1 Member 35. Thomas B. Reed Minio 51.45. 5 48-48-75. 3 Member 36. Charles F. Crisp Ga. 51.53 4 48-35. 3 Member 36. Charles F. Crisp Ga. 51.53 8 48-37. 3 Member 37. David B. Henderson III. 1 Mos. 54.55. 5 48-37. 5 3. 5 3. 5 3. 5 3. 5 3. 5 3. 5 3. 5		200 - 2 - 1	01.7-	(- 3)	_		35
33 J. Warren Keifer Ohio 454,650 2 45-48,59-67 Member 34,10hn G. Carlais Ky, 48,49.50 3 45-31 Member 35,1 Thomas B. Reed Asset S.		Milton Saylor		44 (I day)	I		
Warren Keifer   Ohio   47, 49, 50   24   48-48, 50   54   68   68   68   68   68   68   68   6	32.	oamuei j. Kandali	ra.	44 (200),	U	30-5x	Member
34. John G. Carlule Řy. 35. Thomas B. Reed Minis 35. Thomas B. Reed Minis 35. Thomas B. Reed Minis 36. Charles F. Criap 36. Charles F. Criap 37. David B. Henderson 38. Joseph G. Cannon 38. Joseph G.	.,	I Warren Keifer	Obio	43,40		45-48.50-61	Member
Maine   St.54.55   0   48-55   Member	33	John G Carlisle	Kv	48.40.50			
30. Charles F. Crisp   54.3   4 48-34     32. David B. Henderson   10mx   55.39.60,67   12 (3)   43-31.33-60     33. Joseph G. Cannon   10mx   55.39.60,67   12 (3)   43-31.33-60     34. Green   12 (3)   43-31.33-60     35. Green   12 (3)   43-31.33-60     36. Champ Clangworth   00m   00m   00m   00m     35. Green   00m   00m   00m   00m     40. Richard H. Gillett   00m   00m   00m     41. Wicholas Longworth   00m   00m   00m   00m     42. Wicholas Longworth   00m   00m   00m     43. Henry T. Rainey   10m   00m   00m     44. Joseph W. Byrns   10m   10m   10m     45. William B. Bankhead   Ala.   74,75,76   00m   00m   00m     46. Sam Rayburn   10mm   10mm   10mm   10mm     57. Speaker Member   10mm   10mm   10mm     58. Sam Rayburn   10mm   10mm   10mm   10mm     59. Speaker Member   10mm   10mm   10mm     59. Speaker Member   10mm   10mm   10mm     59. Speaker Member   10mm   10mm   10mm     50. Sam Rayburn   10mm   10mm   10mm     50. Sam Rayburn   10mm   10mm   10mm     50. Sam Rayburn	25	Thomas B Reed	Maine	51.54.55	6		
38. Joseph G. Cannon . III. \$8,85,96,671	26.	Charles F. Crisp			4	48-54	
38. Joseph G. Cannon . III. \$8,85,96,671	37.	David B. Henderson .		56.57	8	48-57	1 1
Mass	38.	Joseph G. Cannon		58,59,60,61	14 (5)†	43~51,53-62,	
Mass.   65,0768   13   53-68   Member		· ·	37.			04-07	1
41. Nicholas Longworth Ohio (5,70,71 to (5)1 \$8-62,04-71 Member 42. John N. Garner Texas 72 14 \$8-62,04-71 Member 43. Henry T. Rainey Ill. 73 14 (5)1 \$8-60,68-73 Member 44. Joseph W. Byrns Tenn. 74 15 (6)1 \$8-60,68-74 Member 45. William B. Bankhead Ala. 74,75,76 04 65-64 Member 45 Sam Rayburn . Texas 74,77,78,79, 14,34 \$3-83 Speaker Speaker	39-	Champ Clark		66 67 69		33,55-00	
42. John N. Garner 43. Henry T. Rainey III. 73 14 (5) 58-72 Member 44. Joseph W. Byrns 7 Tenn. 74. 75,76 0)4 65-76 Member 45. William B. Bankhead 46. Sam Rayburn 7 Texns 76,77,78,79, 14½ 63-83 Speaker 78,778,79, 14½ 63-					10 (t)+	E8-62 64-77	
43. Henry T. Rainey . Ill. 73	44.	John N Garner				58-72	
44. Joseph W. Byrns	42.	Henry T Rainey	ni		TA (5) †	58-66.68-73	
45. William B. Bankhead . Ala. 74,75,76 9½ 65-76 Member Speaker 8,88,89,14,24 63-83	43.	Joseph W Ryrns			13		Speaker
46. Sam Rayburn Texas 70,77,78,79, 142 03-83 Speaker	45	William B. Bankhead	Ala.	74.75.76	01/2	65-76	
81.82	46.	Sam Rayburn		70,77,78,79	14/2	63-83	
42 Toesph W Mortin Tr   Mass   80.82   12   60-83   Member	1 1			81,82			
	47.	Joseph W. Martin, Jr	Mass.	80,83	13	69-83	Member

<sup>\*&</sup>quot;Terms served prior" does not include the term elected speaker except for the ½ years as noted for 45 and 45.

Number in parentheses indicates the number of consecutive terms immediately preceding election as speaker. All are consecutive unless so indicated.

enabled him to control the business of the house; and he recognized or refused to recognize members claiming the floor. These powers, gradually evolved by strong speakers like Reed and Cannon, reached a peak of perfection and omnipotence during the latter's regime So dictatorial and despotic, indeed, did Speaker Cannon become that the house rebelled, and in March 1910 a coalition of Democrats and insurgent Republicans succeeded in drastically curtailing his powers. They removed the speaker from the rules committee, deprived him of the power to appoint the standing committees of the house and restricted his right of recognition. After the revolution of 1910-11 the speaker was more the servant than the master of the house.

These reforms, however, were less revolutionary than they then seemed. Prior to 1910 the speaker controlled the house in collaboration with a cotie of trusted party leutenants "Nowadays the leadership of the house is in commission, with the membership of the commission

more or less fluctuating and shadowy."

In 1910 the speaker was removed from the committee on rules, but he sits today on the unofficial steering committee which meets in his office and determines party strategy. In the March revolution he lost his power of appointing the standing committees, but he retained the power of appointing house conferees, the chairman of the committee of the whole and select committees. His power of recognition was reduced, but he still has a discretionary power of recognition over motions to suspend the rules and on days other than consent calendar days.

Place in Political System.—The Presidential Succession act of 1047 ranked the speakership next to the presidency and vice-presidency. Cannon considered the speakership a more important and powerful office than the presidency itself. Relations between speakers and presidents have fluctuated between rivalry and harmony through the years. Depending on the political complexion of the two offices, the speaker bas been leader either of the administration or opposition forces in the house. During periods of congressional supremacy the chair has overshadowed the White House, while popular-leader presidents from Thomas Jefferson to Franklin D. Roosevelt have dominated congress. Within their parties Reed and McKinley, Clark and Wilson, were bitter rivals who seldom came in contact. But relations between the second Roosevelt and his party speakers were cordial and frequent. Despite the reduction in his powers, the speaker continues to be at once the presiding officer and titular leader of his party in the lower chamber, a private member and the most influential man in the house of representatives.

BIRLIOGRAPHY.—Mary P. Follett, The Speaker of the House of Representatives (1896); George Rothwell Brown, The Leadership of Congress (1922); Paul DeWitt Hasbrouck, Party Government in the House of Representatives (1927); Chang-Wei Chiu, The Speaker the House of Representatives Since 1896 (1928). (G.B. Gy.; X.)

**SPEARMINT** (Mentha spicata), a species of mint (q.v.) used for culinary and other purposes, distinguished by its smooth sessile leaves and tapering flower spikes. The flowers are pale blue, and appear from July to September. Spearmint was introduced into the United States where it became widely naturalized in moist waste grounds. The volatile oil, from spearmint is also used as a medicine. (See MINT; PEPPERMINT.)

SPECIE POINT: see Exchange, Foreign: Gold Points.

SPECIES. The nature of species is a question of considerable importance in general biology and the species is regularly employed as a classificatory unit in systematic botany, zoology and mineralogy. The word "species" has, however, an important history outside those sciences. It was the Latin equivalent of the Greek This meant primarily shape or visible form, but was extended to cover the sensible character of things generally, and also the intelligible. For the former use compare the term "sensible species" or characters in things perceived, because reproduced in the organs of sense. To the supposition that we see these reproductions is partly due the doctrine that the mind perceives directly only its own ideas. So Locke says (Essay Concerning Human Understanding, Introduction, § 8) that he uses the word "idea" to express whatever is meant by phantasm, notion, "species." As intelligible character, eloos or species was the common essence of individuals or instances, as we say, of the same kind. As such it was an object of thought, not of sense; universal, not individual: and, unlike its instances, exempt from generation and decay. Its relation to its instances (which may be compared to that of a law to the events exemplifying it) was a subject of dispute both in Greek and scholastic philosophy. There were also disputes about the relation of species to their common genus, of which they are determinations (so that Aristotle compared the relation of genus to species with that of matter to form), and to the properties connected and accidents conjoined with their specific nature in instances of a species. Boetius' Latin translation 176 SPECIES

of the Isagoge (Introduction) written by Porphyry (born AD. 232) to the Categories of (or ascribed to) Aristotle made these questions familiar long before the revival of Aristotelian learning in the west. In particular it was disputed whether species and genera were anything real independently of our minds, or only common names, or else notions of ours, the products of our classifying activity. A settlement of these questions is not necessary to the work of the systematic biologist; but they must be faced if we are really to understand what we mean by the evolution of species; for this evolution is a process of which no persisting material thing is the subject.

#### BIOLOGICAL SPECIES

The concept of species as a kind of animal or plant is an old one in biological literature. Aristotle (384-322 B.C.) used the term for groups of organisms with common characters and these in turn he subdivided into more species. John Ray (1627-1705) is usually given the credit for using the term for groups with mutual fertility. C. Linné (see LINNAEUS) (1707-1778) established a system of binomial nomenclature universally used in the 20th century. Each organism was classified as a member of a species and each species was included in a higher taxonomic group, the genus. The genera were also classified in still higher taxonomic categories, but the binomial name consisted of the names of the genus and the species together. International congresses of botany and zoology respectively formulate, administer and interpret the international rules of botanical nomenclature and the international rules of zoological nomenclature. The basic principle used for natural classification is homology (q,v). In early modern times homology was a vague concept applied roughly to apparent similarities of structure. During the 20th century, however, genetics, embryology, ecology and evolutionary analysis came to place a firm scientific foundation under the concept of homology with consequent clarification, correction and verification of systematic

C. Linné first believed in the fixity of species but later in his life suggested that the genus constituted the ancestral species at the time of creation, and that derived species subsequently multiplied by means of hybrid generation or intercrossing between species. During the 19th century, particularly through the work of J. B. P. Lamarck (1744–1829) and Charles Darwin (1809–1882), the theory of the evolution of species was accepted by the large majority of biologists (1808 EVOLUTION, ORGANIC).

The importance of isolation in the origin of species was emphasized by M. Wagner (1813–1887) and J. T. Gulick (1823–1932). Modern genetic theory, initiated by Johann Gregor Mendel (1822–1884) by means of his investigations of domestic varieties of plants, was applied to both plants and animals in the early zoth century. Mendelian genetics of individuals led gradually to the establishment of the science of population genetics during the third and fourth decades of the zoth century. Population genetics substantiated the concept of the biological species and greatly improved the understanding of evolutionary processes.

proved the understanding of evolutionary processes.

The species is recognized as a prime biological unit with objective criteria. More than 1,000,000 species of plants and animals had been named by mid-20th century and probably at least twice this number would ultimately be recognized when the knowledge of the world faunas and floras approaches completion. The concept of the species is of great importance in both theoretical and applied biology and played a prime part in the development of evolutionary theory and principles. Much controversy arose concerning the basic characteristics of the biological species.

There are almost as many definitions of the species as there are biologists who have attempted to condense the major aspects of the concept. Some have thought that the species was wholly a subjective category and was merely a figment of the mind of the systematist. Others have emphasized the visible anatomical distinctions without searching for the basic principles underlying structural differences and similarities. Still others have confined the concept to the sexual interbreeding population. Slowly the operational factors producing the species under natural conditions were recognized and incorporated into the definition. It became known that numerous factors operate to produce species, and that these may vary in intensity and in time during the origin of the same or different species. The species shares the dynamic complexity of other basic biological units including the

gene, the cell and the individual organism, all of which present difficulties of precise definition.

A brief definition that includes the most generally recognized criteria of the biological species was given by A. E. Emerson in 1945. a species is an evolved or evolving, genetically distinctive, reproductively isolated, natural population. All of these attributes are necessary, and no others would seem to be essential. Each attribute is discussed separately in the following paragraphs.

Since the establishment of the principle of evolutionary change, species have been considered to be dynamic entities and not fixed or static. Evolutionary characterization is therefore necessary in the definition. Demancation sometimes is somewhat arbitrary when transitional stages are encountered, but true evolutionary gradations are not often found, so that ancient continuities are seldom observable between living species and the palaeantological record seldom bridges the gaps between species categories. Although nomenclature is easier when the ancient continuities are unknown, cases in which intergradations between species can be directly observed offer an opportunity for a more exacting study of the processes of speciation, and analytical biologists seek such material for investigation. Also the early stages in species divergence that have not progressed to the point of complete species division enable the scientists to analyze the dynamic factors more exactly and are consequently sought.

Genetic distinction seems to be the common denominator for all valid qualitative or quantitative species characters including cytological, physiological, embryological, ethological, ecological, and morphological characters. Taxonomists, of course, seldom can experimentally investigate the genetics of the species they study and must rely upon structural or colour indications of genetic relationship. Anatomy and pigmentation often are sensitive to small genetic influences that are not easily detected by other techniques of observation. Heredity may be inferred through demonstrated germinal continuity in populations and through the experimentally established basis of similar characters in investigated organisms. Hybrids and intergrading populations give some genetic information. If striking structural characters are not correlated with genetic distinctions of reproductively isolated natural populations, the taxonomist usually does not use them for species separation and will correct errors that have been committed in ignorance of the genetic implications For example, structural changes produced by various conditions at the time of growth, by differences in stages of development, by sexual dimorphism, by castes of social insects and by various types of polymorphism do not neet the criteria of genetic distinction and reproductive isolation. On the other hand, slight genetic distinction of natural populations that are reproductively isolated may be used for species separation, while gross genetic differences of individuals or of only partially isolated populations are not valid for species distinction.

Reproductive isolation (W. C. Allee et al, 1949) or lack of gene flow between populations, may result from chronological separation, spatial between populations, may result from chronological separation, spatial separation, topographical or geographical barriers to dispersal, abattat or ecological restrictions, cyclic differences in breeding periods, mechanical inability to crossbreed, psychological or ethological barriers to interbreeding, physiological barriers to fertilization, genetic unbalance preventing fusion, inviability of hybrids, hybrid sterility, and selective elimination of hybrids. Regardless of the exact type of isolation or the combination of isolating factors, anything that prevents genes from moring from one population to another has profound evolutionary con-sequences. Reproductive isolation is the dividing factor in the branching of the phylogenetic tree, and the two populations thus deprived of gene exchange will tend to drift apart through changes in gene incidence and gene or chromosome mutation. Because of its effect upon inbreeding, reproductive isolation also influences gene and character fixation. As most taxonomic characters are the result of complex genetic patterns rather than single genes or chromosomes, the consolidation of these patterns and their transmission as systems becomes a necessity for further adaptive evolution. Fixation of complex genetic patterns for intriner adaptive evolution. Fixation of complex genetic patterns is a primary consequence of reproductive isolation. Reproductive isolation may take place gradually and give rise to many subdivisions of the species population before speciation is completed. Theoretically the point of species origin is the moment that genetically distinctive natural populations cease gene exchange. Practically it may not be possible to recognize this point in instances of contemporary speciation. However, the large majority of valid species have been isolated for thousands or millions of years, so that it is a rare case that presents difficulties when an abundance of objective arctices has been one of the contemporary. difficulties when an abundance of objective evidence has been accumulated.

An important group of biologists including Theodosius Dobzhansky (1951) and E. Mayr (1942) excluded extrinsic barriers to gene finding (geographical or ecological) in their definitions of reproductive isolation as applied to species and confined the concept to examples separated by intrinsic barriers (psychological, genetic and physiological). They did not give full species rank to genetically divergent natural populations completely lacking gene exchange, but which have not lost their potential ability to interbreed if the extrinsic barriers are removed. Inasmuch as it is often impossible to judge the potentialities of interbreeding under natural conditions, these biologists had to rely upon a rough correlation between interbreeding potentialities and degrees of taxonomic divergence. When two related species occupy the same ter-

ritory (sympatric species) and no intergrades occur between them, biologists may assume an intrinsic barrier to gene flow Such an assumption is much less warranted in the cases of closely related but geographically separated distinctive populations (allopatric species), however, and there is a resulting confusion of taxonomic status of numerous groups One school of taxonomists may refer certain popula-tions to full species rank, while the other school will treat the same

populations as subspecies.

If reproductive isolation includes the extrinsic barriers to gene flow, it is possible that species that have not evolved intrinsic barriers may ultimately interbreed with the occasional breakdown of temporary extrinsic barriers. The hybrid origin of a species from two pre-existing species is thereby a possibility. The school of biologists that confine reproductive isolation between species to intrinsic prevention of gene flow only do not recognize full species status for the exof gene how only do not recognize in species saids for the possibility of hybrid origin of species except in special cases in which intrinsic barriers are also broken down (allopolyploidy in plants). In spite of these differences of opinion of the exact definition of reproductive these ametrices of opinion of the exact terminon of reproductive isolation with consequent confusion over the taxonomic status of some natural populations, the large majority of plant and animal species prove to be intrinsically isolated Therefore there is common agree-ment among biologists concerning most species limitations together with the criteria for the recognition of the species category

The final characterization of the species is that it constitutes a natural population. The population is integrated by means of genetic continuity through reproduction, and it may also be integrated through sexual reproduction and various other adaptations for attraction and interaction between individuals of the same species. The species population is often subdivided into many subpopulations, but the larger species population is a real entity with a definite boundary. Differences in fundamental biological interactions occur within the species population in contrast with the biological interactions between species populations. The species is generally conceived to result from natural evolution. Artificial populations compounded by man through domesevolution. Artificia populations compounded by man intologic norma-tication or for scientific investigation are not given species rank even when they are genetically distinctive and reproductively isolated popu-lations. Under natural conditions such man-produced populations would seldom maintain their genetic distinctiveness even if they were able to survive. The domestic dog is classified as a full species, but the separate breeds are not.

separate breeds are not.

Numerous infraspecies categories relate to variations in the qualitative or quantitative attributes of the species. Each term places emphasis upon particular aspects of the species concept (G. du Rietz, 1930)

Some of the terms are defined below and are useful in the

study of speciation mechanisms

Sexual Species .- This term is used for species that possess sexual adaptations and interfertility among the component individuals Sex-

adaptations and interfertility among the component individuals Sexual recombination of genetic elements greatly increases genetic variability. Many definitions of the species confine the concept to the sexually interbreeding population (Dobxhansky, 1951).

ASEXUAL Species.—These are species that have never evolved sexual fusion or have secondarily lost the ability to intercross. All reproduction is confined to division, parthenogenesis, apomixis, or vegetative reproduction. This species category would include the primary asexual bacteria and many single-celled organisms and would also include the secondarily asexual parthenogenetic animals and apomictic plants (G. L Stebbins, 1950). In asexual organisms, reproductive isolation between individuals of the same generation is absolute, and genetic continuity is only through descent. In some instances taxonomic distinction is maintained for periods comparable to the maintained of taxonomic pattern in sexual species (species of flagellate onomic distinction is maintained for periods comparable to the main-tenance of taxonomic pattern in sexual species (species of flagellate protozoans inhabiting the hind gut of termites). In other instances, taxonomic distinction may vary over short periods of time and the species category is difficult to apply (virulent and nonvirulent strains of viruses and nutritive strains of bacteria).

Subspecies.—This category is a subdivision of a sexual species with all the attributes of the species experient that reproductive schaltion is

all the attributes of the species except that reproductive isolation is partial rather than complete. Subspecies are given trinomial names by taxonomists and are recognized as constituting a valid category in the international rules of nomenclature. A species subdivided into subspecies or races is called a polytypic species.

Race.—This commonly used term is not separated by definition from

the subspecies. However, it is either used as a synonym for the subspecies category or is given a rank below that of the subspecies, presumably because the degree of reproductive isolation is smaller than

Sumany because the degree of reproductive isolation is smaller than that separating the subspecies.

Deme.—G. S. Carter (1951) defined a deme as a communal interbreeding population within a species either wholly or partially isolated from other demes.

Supraspecies.—This term was used by J. Huxley (1939) for a collection of groups or subspecies which replace each other geographically or physiologically and in which the extremities only have evolved intrinsic isolation. Comecting groups between the extremities interbreed and intergrade. There are several known cases among snakes, birds and mammals in which intersterility occurs among some of the subspecies within the species.

Coenospecies .- This term was first used by G. Turesson (1922) for the sum total of possible combinations of a genotype compound as seen particularly through cultivation under artificial conditions The term has also been used to include groups of species separated only by ex-

tinuc barriers to gene flow.

Ecospecies.—G Turesson (1022) used this term for the species as realized in nature under the limitations imposed by the natural environment. It emphasizes the limitations of potential variation produced

by natural selection

by hatural selection

Biotype.—This term is used for a population of individuals with
identical genotypical constitution under similar conditions. Biotypes
are usually limited to asexual species or to populations within a sexual
species that result from asexual reproduction from a single individual.

species that result from ascutal reproduction from a single individual. Parallel mutation may possibly account for some biotypes.

Clone.—A clone refers to a group descended from a single individual without sexual combination. The individuals are presumably genotypically identical or isogenic. The term overlaps somewhat with

the hintyne

-G C Robson and O W. Richards (1936) adopted this Lineage. term for a racial complex of several lines of descent forming a meshed

network of evolution within the species

Variety.—This term is used with somewhat different meanings by different authors J Bequaert (1919) used the category for individuals or small groups of individuals that varied in a describable way from or small groups of individuals that varied in a describable way from the typical individuals in the species. Varieties may be considered somewhat distinctive groups that fall within the range of species variation as a whole but do not necessarily have geographical or ecological correlations.

Cline.—J. Huxley (1939, 1942) introduced this term for a character gradient within a group—usually within a species

Numerous subdivisions of clines are named when there is a correlation with special factors. Ecoclines are correlated with ecological gradients. Geoclines are correlated with geographical gradients. Taxochnes are correlated are correlated with geographical gradients. Taxonomic gradations associated with hybridization. Chronoclines are correlated with time in palaeontological sequences. Ontoclines are gradations in the appearance of characters during the life cycle of individuals.

Ecotype.—G. Turesson (1922) introduced this term for the geno-typical response by portions of species populations to a given type of habitat. The ecotype is essentially an ecological subspecies and emphasizes the role of natural selection upon genetic constitution.

Ecophene.—This term was also used by Turesson (1922) reaction type to extreme environmental factors without genetic distinctions. Ecophenes are illustrated by climatic modifications at the tree line, by shade types of plants that normally range through a variety of light conditions, and by temperature influences on growth at different latitudes.

Physiological Species or Races.—These terms are used to dis-tinguish species or subdivisions of a species that are recognized by physiological characters rather than structural characters. Genetic distinction is usually manifest in structural or anatomical characters, but gene patterns may effect physiological characters without pro-ducing sufficient anatomical effects to be recognized. The term "bio-logical race" is essentially synonymous with "physiological race" Incipient Species.—This term is used for a diverging partially

isolated population that may become a species when isolation becomes

complete.

Complete.

B. BLOGRAPHY.—W. C. Allee, A. E. Emerson, O. Park, T. Park and R. P. Schmidt, Principles of Animal Ecology' (Philadelphia, 1949), J. Bequaert, "A Revision of the Vespidae of the Belgian Congo," Beltin of the American Museum of Natural History, 39 (1919); C. S. Carter, Animal Evolution (New York, 1951); Theodosius Dobzhansky, Genetics and the Origin of Species, 3rd ed. (New York, 1951); G. du Rietz, "The Fundamental Units of Biological Taxonomy, Svensk Bolanisk Tidskrift, 24 (1930); A. E. Emerson, "Taxonomic Categories and Population Genetics," Entomological News, 56 (1945); J. S. Huxley, "Clines: An Auxiliary Method in Taxonomy," Bydragen tol de Dierkunde, 27 (1930), Evolution, the Modern Synthesis (New York, 1942); E. Mayr, Systematics and the Origin of Species (New York, 1942); G. C. Robson and O. W. Richards, The Variation of Evolution in Plants (New York, and Toronto, 1950); G. Turesson, "The Genotypical Response of the Plant Species of the Habitat," Hereditas, 3 (1922).

SPECIFIC GRAVITY is the ratio between the density (mass per unit volume) of a body and the density of some substance assumed as a standard. For liquids and solids the standard is distilled water at 4° C. In the centimetre-gram-second system of units the numerical values for the density and the specific gravity of any substance are the same. In the English system the density of water is 62.4 lb. per cubic foot, while its specific gravity is still unity. (See Physics, Articles on.)

SPECIFIC PERFORMANCE, an equitable doctrine under which a court of equity, in certain exceptional cases where the normal legal remedy, ie., damages, would not be a sufficient compensation, orders by a defaulting party a specific or actual performance of the thing which he had contracted to do. The court as a general rule will refuse this relief where it would be unable to superintend or enforce the execution of its judgment. Specific performance is usually confined to executory agreements, ie., a conveyance or a lease of land, it is not usually enforced in the cases of personal acts or in those of contracts for personal service The doctrine of specific performance in the United States follows very largely that of England.

BIBLIOGRAPHY.—Ency Eng. Law, tit "Specific Performance"; J. Story, Equity Jurisprudence (1836); Sir Edward Fry, Treatise on Specific Performance of Contracts, 6th ed., ed by George Russell Northcote (Toronto, 1920).

SPECTACLES, a name given to a pair of focused corrective ophthalmic lenses supported on the nose by a frame or mounting and equipped with side pieces called bows or temples that are held in place by the ears. Spectacles differ from other forms of ophthalmic corrections by their construction. For instance, eyeglasses are a pair of corrective lenses supported on the nose by a mechanical bridge. The pince-nez falls into this classification. The oxford is a special eyeglass that is made in a folding and nonfolding form with a spring to make the bridge adhere to the nose. It is commonly carried on a light chain or ribbon which is worn around the neck and is used for an occasional or short interval of wear. A lorgnette is a pair of lenses held in a frame that is attached to a long handle. A lorgnon is similar to the lorgnette except it has a short handle which serves as a carrying case when the device is folded. To spectacles which are used primarily for ocular protection the term goggles is sometimes applied. However, goggles are an optical device which cover the eyes with an optical medium in front and with a shield on the sides and are attached to the head by bands, cap or hood. The tendency is to call all corrective ophthalmic lenses with their supporting equipment, eyeglasses.

The early history of spectacles is not clear (See Thomas Young Oration, Trans. Optical Soc., 1923-24, no. 2; also 1926-27, no. 3.) In 1266 Roger Bacon magnified writing by placing a segment of a sphere of glass on a book. The first reasonably dated evidence of spectacles is given in a portrait of Cardinal Ugone in a fresco painted in 1352 in a church at Treviso, showing two framed lenses with their handles liveted together and fixed over the eyes

The advent of the printed book created the need for spectacles. In north Italy and south Germany where the glass workers lived, the spectacle trade flourished during the 16th century. The optical trade spread rapidly through Europe and in 1629 Charles I granted a charter to the Spectacle Makers guild. About 1760 bifocals were devised by Benjamin Franklin. Not until 1900 were cylindrical lenses commonly used.

Short sight, called myopia, is generally caused by an abnormally long anteroposterior axis or a marked refractive power of the optical system of the eye. In the case of the short-sighted person, parallel rays of light come to a focus in front of the retina. A concave lens of proper curvature diverges the rays so that they meet at the retina. The optical correction gives good distant vision and the accommodative power of the crystalline lens adjusts for near vision. In high myopia the inconveniently heavy lens may be ground flat at the edge to reduce the weight.

Far sight, or hypermetropia, is generally caused by a short antero-posterior axis of the eye. It is a stage in the early normal development of the eye and is a common defect. Parallel rays of light come to a fo-cus behind the retina but a convex lens converges the rays so that they will focus on the retina. The far-sighted person always accommodates for distant vision. In rare congenitally defective eyes and in eyes after the removal of cataract, a high degree of hypermetropia occurs. Carefully adjusted heavy convex lenses are then necessary for good vision with the least amount of distortion. A lens of light weight made with a flat periphery and a convex centre is used occasionally. Contact glasses in place of a convex lens are suitable if they are tolerated. In astignatism the refractive power of the eye is more marked in one meridian than in the others. The correction is made with a convex

one meridian than in the others. The correction is made with a convex or concave cylindrical lens or with a similar cylindrical lens combined with a sphere.

Presbyopia is a condition occurring with normal eyes after the age of 40 to 45 years when the power of accommodation is sufficiently decreased to cause blurring of the near vision. It affects the reading range of vision with little or no change in the distant vision. Convex reading spectacles to correct for the loss of accommodation are prescribed, Blicoal spectacles are also a marked visual aid. The upper part of the lens is used for far vision and the lower part for near vision. The lens may be made of fused or cemented lenses. The fused bifocal lens is constructed in many forms so that advantage of various optical properties of glass are made manifest. In advanced presbyopia, trifocal lenses take care of the intermediate distance between the distant and near visual range. Tetrafocals are used by presbyopic draftsmen and artists requiring a fourth area of the lens which has a very short focus so that objects may be held close to the eye. Pulpit spectacles

have only half-moon shaped lenses as a visual aid in presbyopia.

Glass prisms or decentred lenses are employed if the visual axes of the eye are abnormal or if the external ocular muscles and accommodation are not in harmony Prisms are also used as a means of exercising the external ocular muscles Lenses with horizontal silvered prisms ar made for reading in bed

Spectacles are of service in filtering out the undesired part of the spectrum Dark or coloured lenses decrease the amount of glare and They also help diminish the photophobia of irritable or dises. With dark glasses the vision in cases with certain kilote eased eyes. of central cataracts may be increased by allowing the pupil to dilate. Lenses with different colours are necessary to see anaglyphs stereoscopically and are used in this manner as a device to exercise squinting eyes. Coloured lenses are used to detect camouflage, in cheating in card games, for testing malingerers and in ophthalmic tests such as for

diplopia Red lenses maintain dark adaptation of radiologists, roentgenologists, night aviators and photographers

Lenses absorbing ultra-violet light are made for skiers, aviators, polar explorers, mountain climbers, gas, electric and atomic welders, and persons who are exposed to ultra-violet light as a medual treatment. Lenses opaque to infra-red light prevent damage to the eyes of furnace workers and metal processors. Didymium glass increases the visual acuity of glass blowers by masking the sodium spectra. Lenses absorbing the visible light of short wave lengths are employed by aviators, sailors, sportsmen and gunners to overcome atmospheric haze Lead glass absorbs radiation from roentgen rays and radium.

Aniseikonia, the inequality of the size and shape of the two ocular Amberkonia, the inequality of the size and snape of the two comminges in binocular vision, may be a cause of visual discomfort. The specially designed corrective lens known as an iseikonic lens is a doublet with an air space between the two parts which may be adjusted to change the size of the image without changing the focus.

Telescopic spectacles with a pair of short-barrelled Galilean telescopes in place of the single lenses aid in low vision. The Galilean telescope is also modified by using a contact glass as the near lens and the lens in the spectacle as the far lens. Another kind of spectacle has longer, narrower barrelled telescopes placed in front of the lenses to serve as a loupe. The simple loupe has a pair of prismatic convex lenses placed before the spectacle frame as a visual aid in stereoscopic vision of near objects.

Spectacles are also devised to give ocular protection against me-chanical injury. The optical material may be surface-hardened glass, plastic, laminated glass and plastic, or made of metal or other material slotted or otherwise perforated for vision. Peripheral lateral shields of solid or perforated material may be employed to guard against ocular contact with solid, liquid or gas, or materials causing allergies.

Other types of spectacles are also devised for special purposes. frames may hold a prosthesis, or artificial part, of the eye, orbit or face. Crutch spectacles elevate a drooping paralytic upper lid. Pinhole spectacles tend to limit the voluntary movement of the eyes and in this way prevent mechanical injury after an operation. They also serve as a means to check the refractive correction of the eye Frosted lenses help in overcoming diplopia. Molecularly coated lenses decrease the annoying reflections of glass in myopia. Lenses covered with coloidal metal act as light shields against infra-red light. Polaroid lenses londar metal act as ingin sinedas against inner-tea fight. To allold charles hold a film of submicroscopic crystals of herapathite, all oriented in the same direction, which transmit plane polarized light and thus tent to eliminate reflections and scattered light. They are also used to discover malingerers Divers' spectacles are devised for seeing under water. The lenses consist of a pair of two meniscus lenses separated by a biconcave air space. Spectacles consisting of a flat metal frame holding a sheet of red plastic are spiked to the head of chickens with abnormal appetites to prevent them from seeing blood and egg yolk.

abnormal appetites to brevent unit from some second repetition of the Britiography.—H. H. Emsley, Visual Optics (London, 1936); L. Laurance and H. O. Wood, Visual Optics and Sight Testing, 4th ed. (Chicago and London, 1936), General and Practical Optics, 4th rev. ed. (Chicago, 1022). (A. C. Ke.) (Chicago, 1932).

SPECTROHELIOGRAPH, an instrument for photographing the sun with monochromatic light. In its simplest form it consists of a direct-vision spectroscope, having an adjustable slit (called "camera slit" or "second slit"), instead of an eyepiece, in the focal plane of the observing telescope. This slit is set in a position such that it transmits a single line of the spectrum; e.g., the K line of calcium. A fixed image of the sun is formed on the collimator slit of this spectroscope, and a photographic plate, with its plane parallel to the plane of the solar image, is mounted almost in contact with the camera slit. The spectroscope is then moved parallel to itself, admitting to the collimator slit light from all parts of the sun's disk. Thus a monochromatic image of the sun, formed of a great number of successive images of the spectral line employed, will be built up on the plate. As the only light permitted to reach the plate is that of the calcium line, the resulting image will represent the distribution of calcium vapour in the sun's atmosphere. The calcium clouds, or flocculi, thus recorded are invisible to the eye, and are not shown on direct solar photo-

BY COURTESY OF PROFESSOR G. E. HALE, MOUNT WILSON OBSERVATORY

# HYDROGEN WHIRLS IN THE SUN

These hydrogen whirls surrounding a large bipolar sun spot were photographed at the Mount Wilson Observatory of the Carnegle Institution of Washington, with the 13-ft, spectroheliograph, Aug. 30, 1924. Photographs of the hydrogen layers of the sun's atmosphere show that sun spots are vortical in nature and that their movement may be clockwise or anti-clockwise.

graphs taken in the ordinary way. These, on account of the brilliant reversals of the H and K lines to which they give rise, and the protection to the plate afforded by the diffuse dark bands in which these bright lines occur, are easily photographed with a spectroheliograph of low dispersion. In the case of narrower lines, however, higher dispersion is required to prevent the light of the continuous spectrum on either side of the dark line from blotting out the monochromatic image.

A five foot spectroheliograph which gives excellent results with the lines of calcium, hydrogen and iron has been used since 1905 in conjunction with the Snow (horizontal) and 6oft, tower telescopes of the Mt. Wilson Solar observatory. It was constructed in the observatory instrument shop in Pasadena. The instrument consists of a heavy cast-iron platform mounted on four steel balls which run in V guides of hardened steel. Most of the weight of the instrument is floated on mercury contained in three troughs which form part of the cast-iron base. The platform carries the two slits, the collimator and camera objectives and the prismtrain. An image of the sun, about 6-7in, in diameter, is formed by the telescope on the collimator slit. The collimator slit is long enough (81 in.) to extend entirely across the solar image and across such prominences of ordinary height as may happen to lie at the extremities of a vertical diameter. After passing through the slit the diverging rays fall upon the 8in, collimator objective which is constructed in the manner of a portrait lens in order to give a sharp field of sufficient diameter to include the entire solar image. The rays, rendered parallel by the collimator objective, meet a plane mirror made of silvered glass, which reflects them to the two prisms. These are of dense flint-glass (Schott 0-102), and each has a refracting angle of 63° 29'. Their width and height are sufficient to transmit (at the position of minimum deviation) the entire beam received from the collimator. A grating, ruled on speculum metal with about 15,000 lines per inch, is substituted for the mirror when higher dispersion is required. After being deviated 180° from the original direction, the dispersed rays fall on the camera objective, which is exactly similar to the collimator objective. This forms an image of the solar spectrum in its focal plane on the camera slit. Beyond the camera slit, and almost in contact with it, the photographic platecarrier is mounted on a fixed support. In order to bring a spectral line upon the camera slit, the slit is widely opened and the plane mirror is rotated until it is possible to see the line. A cross-hair, in the focal plane of an eyepiece, is then moved horizontally until it coincides with the line in question. The slit is narrowed down to the desired width, and moved as a whole by a micrometer screw until it coincides with the cross-hair. The eyepiece is removed and the photographic plate placed in position. An electric motor, belted to a screw connected with the spectroheliograph, is then started. (Two alternative screws, of different pitch, are provided to give different speeds.) The screw moves the spectroheliograph at a uniform rate across the fixed solar image. Thus a monochromatic image of the sun is built up on the fixed photographic plate.

The spectroheliograph, originally designed for photographing only the solar prominences, disclosed, in its first application by Hale at the Kenwood observatory (Chicago, 1891, 1892), a new and unexplored region of the sun's atmosphere. Photographs of the solar disk, taken with the H or K line, showed extensive luminous clouds (flocculi) of calcium vapour, vastly greater in area than the sunspots. About this time Deslandres introduced at the Paris observatory, the velocity spectrograph, which permits the motion in the line of sight of the calcium vapour at various levels to be measured on photographs of the H or K line in successive sections of the sun. By setting the camera slit of a spectroheliograph so as to admit to the photographic plate the light of the denser calcium vapour, which lies at low levels, or that of the rarer vapour at high levels, the forms of the flocculi corresponding to various superposed regions of the atmosphere can be recorded. The lower and denser vapour appears as bright clouds, but the cooler vapour, at higher levels, absorbs the light from below and thus gives rise to dark clouds.

The first photographs of the sun in hydrogen light were made

with the spectroheliograph at the Yerkes observatory in 1903. These reveal dark hydrogen flocculi, which, like the dark calcium flocculi, lie at a level above that of the bright calcium flocculi. They also show less extensive bright flocculi, usually in the immediate neighbourhood of sunspots, and frequently eruptive in character. These rise from a low level, and sometimes reach considerable elevations in the form of euuptive prominences.

In such an exploration of the sun's atmosphere it might be anticipated that definite currents, or some evidences of atmospheric circulation analogous to those familiar in terrestrial meteorology, would be discovered. In the early work neither the forms nor the motions of the calcium flocculi revealed the existence of such currents, but in the higher region shown by the hydrogen photographs the distribution of the dark flocculi suggested the operation of definite forces, though their full effect was not recognized until the spring of 1908. At that time monochromatic photographs of the sun were first made by Hale and Ellerman on Mt. Wilson with the red (Ha) line of hydrogen, previous hydrogen photographs having been taken with H\$, H\$\gamma\$ or Hδ in the blue or violet. On account of the relatively great strength of Ha at a considerable distance from the photosphere, the new photographs recorded flocculi at high levels previously unexplored. The forms and motions of these flocculi show that great vortices exist in the solar atmosphere above sunspots, which resemble terrestrial cyclones or tornadoes. About 75% of these high-level vortices indicate clockwise rotation in the southern hemisphere and counter-clockwise rotation in the northern, as in the case of terrestrial cyclones. The detection of these vortices led, in 1908, to the discovery of magnetic fields in sunspots, apparently due to electric convection in the primary vortices at lower levels which are the cause of the spots themselves. The long dark flocculi also shown on hydrogen spectroheliograms. identified as prominences projected against the surface of the sun, were subsequently called "filaments" by Deslandres, who has studied them extensively at Meudon. With a spectroheliograph of high dispersion the centre of the hydrogen line Ha shows the "alignments" discovered by Deslandres, which constitute a network of wide mesh associated with the filaments.

Spectrohelioscope.—The spectrohelioscope renders visible to the eye many of the phenomena of the solar atmosphere photographed with the spectroheliograph and also permits their velocities in the line of sight to be measured. It thus combines some of the functions of the spectroheliograph and the velocity spectrograph. Its principle was suggested by Young in 1870, and tried provisionally by him for the observation of prominences at the sun's limb. He discarded it, however, when the use of a wide slit was proposed for this purpose by Zollner and Huggins. Hale, who revived and developed the method (1924), succeeded with its aid in observing the bright and dark hydrogen flocculi on the sun's disk, and in analyzing and measuring the motions of the gas in eruntions and vortices.

Imagine a narrow slit, rapidly oscillating, between the eye and a telescopic image of the sun. Through persistence of vision, the image can be seen in white light. Introduce a spectroscope, which excludes from the slit before the eye all light except that of the red hydrogen line. We then have a spectrohelioscope. For satisfactory observations of the hydrogen atmosphere against the disk. fairly high dispersion is necessary. Hale uses a spectroscope of 13ft. focal length, having a plane grating ruled with about 15,000 lines to the inch, giving a first order spectrum which is very bright in the red. He has employed various means of moving the slits, one of which is a spinning disk pierced with 50 radial slits 0.004in. wide. A 2in. solar image is formed on one side of the disk and the observer sees the hydrogen image of a portion of the sun through a low-power eyepiece focussed on the diametrically opposite slits. J. A. Anderson and Sinclair Smith have suggested devices for producing an exactly similar monochromatic image with a spectroscope having fixed slits. These consist of a rotating prism of square section (Anderson) or an oscillating plane mirror (Smith) which cause a portion of the solar image to move rapidly across the fixed first slit of the spectroscope. The second slit is then viewed through another prism or mirror, moving at precisely the same rate and giving a fixed monochromatic image in the eyepiece.

The hydrogen lines on the sun's disk are frequently distorted by the rapid motion of the gas toward or from the observer. For example, a mass of hydrogen descending into a vortex above a sunspot is indicated by a local displacement of the lines, which frequently indicate a velocity of 60 km. sec. In such a case the distorted portion of the line would fall outside the narrow slit of the spectroheliograph, and the image of the rapidly moving gas would not be recorded. The spectrohelioscope not only brings these moving gases into view but also indicates their velocity. A "line shifter," consisting of a plane parallel-sided glass plate mounted behind the second slit, displaces the line toward red or violet when rotated. In all regions where he suspects motion, the observer frequently shifts the line on the slit, thus "tuningin" so as to pick up the wave lengths as altered by the motion of the luminous gases. In this way, for example, a rapidly ascending mass of hydrogen, near the middle of the sun (revealed by a line outside the  $H\alpha$  line on its violet side), may be watched as it shoots upward, curves over in a long arch nearly parallel for some distance with the surface (its line shown near the centre of the Ha line), and descends in a continuous arch toward the sun or is caught in a vortex and whirled downward (the line being seen outside the  $H\alpha$  line on its red side). A divided arc attached to the line shifter gives the velocity of the gas.

The spectrohelioscope affords a rapid means of detecting and analyzing eruptions or other important solar phenomena, as the entire limb and disk can be examined in a few minutes. Eight or more of these instruments will soon be used systematically at as many solar observatories, distributed around the world, thus permitting the sun's atmosphere to be kept under nearly constant observation. In this way it is hoped to increase our knowledge of the connection between solar cruptions and such geophysical phenomena as the aurora, the magnetic storm and certain interruptions in radio transmission, which probably depend upon the bombardment of the earth's atmosphere by electrified particles projected from the sun.

Descriptions of spectroheliographs and results by G. Hale, H. Deslandres, J. Evershed, Newall and others have appeared in various papers in Astronomy and Astrophysics, Astrophysical Journal, Competes Rendus, Bulletin Astronomical, Monthly Notices of the Royal Astronomical Society and the publications of the Yerkes, Meudon, Kodalkanal, Cambridge and Mt. Wilson observatories, Papers on the spectrohelioscope may be found in the Publications of the National Academy of Sciences, Nature, Astrophysical Journal and Publications of the Astronomical Society of the Pacific. (G. E. H.)

## SPECTROHELIOSCOPE: see Spectroheliograph.

SPECTROSCOPY (from Lat, spectrum, an appearance, and Gr. σκοπεῦν, to see), pertains to the investigation of spectra, the phenomena observed when the radiations from a luminous source are separated into their constituent colours or wave lengths. Such separation results from refraction (as in a prism) or from diffraction (as in a grating). Instruments designed for this purpose are called spectroscopes if used for visual observation, and spectrographs if photography or other methods of recording the spectra are employed. The rainbow, formed by refraction of sunlight in rain droplets, is the most beautiful and common spectrum in nature.

#### HISTORICAL SPECTROSCOPY

The composite nature of white light was first demonstrated by Isaac Newton (1664) when he allowed sunlight entering a round hole in a shutter to pass through a glass prism and fall on a screen. This elongated and coloured image of the sun he called a spectrum. In 1800 W. Herschel studied the spectral distribution of heat from the sun with the aid of thermometers and found the maximum temperature beyond the red end, thus discovering the infra-red spectrum. In 1801 J. W. Ritter, studying the effect of spectral light upon silver salts, found this action extending beyond the violet, thus discovering the ultra-violet spectrum. The first connection between spectral colour and wave length appeared in 1802 when Thomas Young substituted his wave theory of light for Newton's corpuscular theory, explained the

colours of thin films, and calculated the approximate wave lengths of the seven colours recognized by Newton. In 1814 Joseph von Fraunhofer modified Newton's solar-spectrum experiment by substituting a narrow slit for a hole and a telescope for a screen Under these conditions he observed the continuous spectrum of the sun irregularly interrupted by many hundreds of dark lines. still known as "Fraunhofer lines." These lines were the first fiducial marks in spectra, and were promptly exploited as wavelength standards for the comparison of spectral dispersion of various optical glasses. Fraunhofer constructed the first diffraction gratings by winding a fine silver wire upon two fine parallel screws, or by ruling a glass plate with a diamond point, and with these he made surprisingly accurate determinations of wave lengths corresponding to the Fraunhofer lines. Although Fraunhofer and others observed that certain bright lines in the spectra of flames seemed to coincide with dark lines in the solar spectrum it remained for G. R. Kirchhoff in 1859 to enunciate the general law connecting absorption and emission of light and to emphasize the fact that each species of atom has a uniquely characteristic spectrum. Kirchhoff and R. Bunsen (1861), by systematically comparing the solar spectrum with the flame or spark spectra of the purest elements available, made the first chemical analysis of the sun's atmosphere and thus laid the foundation for spectrochemical analysis and for astrophysics (q.v.) In the course of these investigations they discovered spectroscopically two new chemical elements, caesium and rubidium. These demonstrations greatly stimulated spectroscopic research and increased the need for accurate standards of wave length. The first useful standards were provided in 1868 by A. J. Angström who measured the wave lengths of about 1,000 Fraunhofer lines and expressed them in units of 10-10 metre-a unit now known as the angstrom, abbreviated A, and used for all spectroscopic measurements. Further refinements in standard wave lengths were made in 1887 by H. A Rowland who invented and applied the concave diffraction grating In 1892 A. A. Michelson invented the first interferometer. With this instrument he measured the wave lengths of cadmium lines relative to the standard metre and attained an accuracy far exceeding that of any previous work. The wave length of the red radiation from cadmium vapour was remeasured (1905) in terms of the standard metre by R. Benoit, C. Fabry and A. Perot, using the interferometer invented by Fabry and Perot, and since 1907 their value-6,438.4696 A-has been internationally accepted as the primary standard of wave length. Several thousand atomic radiations ranging in wave length between 2,100 and 10,200 A, have been measured relative to this primary standard by interference methods and many of these have been adopted internationally as secondary standards of wave lengths. wave lengths corresponding to lines characteristic of any spectrum whatsoever can be obtained by interpolation between secondary standards impressed on the same spectrogram. In this manner spectroscopists have accumulated wave-length data for several million lines observed in atomic and molecular spectra, extending from the extreme ultra-violet to the far infra-red and embracing nearly 30 octaves as compared with the single visible octave that was first recognized in 1802. These data have served, and will forever continue to serve, in making chemical identifications; since 1885 they have contributed mightily toward the analysis of spectral structures, interpretation of spectra in terms of quantum theory and development of fruitful hypotheses concerning atomic and nuclear structure.

These developments and applications of spectroscopy have unobtrusively but profoundly changed world civilization and have both figuratively and literally expanded the universe (see Light; RADIATION, RAYS).

## EXPERIMENTAL SPECTROSCOPY

Any experiment in spectroscopy involves (1) a source of light; (2) a spectroscope or spectrograph for forming the spectrum; (3) detectors for observing or recording details of the spectrum; (4) measurements of wave lengths and intensities; and (5) the interpretation of such measurements either as chemical identifications or as clues to the structure of atoms and molecules.

#### LIGHT SOURCES

The sun and lightning flashes are examples of bright sources of light occurring in nature. Artificial light sources studied spectroscopically may be divided into two groups according as they emit continuous or discontinuous spectra. A continuous spectrum is characterized by an uninterrupted gamut of wave lengths over a considerable range. Discontinuous spectra exhibit bright lines or bands of different colours or wave lengths on a dark background. Continuous spectra are emitted by incandescent solids and liquids (gas mantle, lamp filament, hot molten metal) or by certain electrical discharges (underwater sparks). These spectra are usually dependent only on temperature and are of no use for identifying the emitting substance; their principal use in experimental spectroscopy is to provide continuous backgrounds for the production of absorption spectra of gases, vapours, solutions, or solids. Discontinuous spectra are emitted by atoms, ions, or molecules in a gaseous or vaporous state in which the individual particles are excited to radiate uniquely characteristic spectra. The particles are excited by absorbing energy either from collisions with other atoms or electrical particles, or from incident radiation. Light sources producing discontinuous spectra are flames, furnaces, and electrical discharges in arcs and sparks at atmospheric pressure, or in lamps containing gases or metal vapours at reduced pressure. In the order named these sources form a rough sequence in which increasing temperatures or energies of excitation are responsible for producing different spectra.

Flames.-Since the days of Kirchhoff and Bunsen it has been customary in elementary chemistry courses to demonstrate spectrochemical identification by dipping a platinum wire into salt solutions, inserting it in a Bunsen burner and examining the spectrum of the coloured flame with a Bunsen spectroscope or Amici prism. Because the temperature of this flame hardly exceeds 2,000° C, the kinetic energy of atomic collisions is not sufficient to produce more than the strongest lines of easily excited atoms like alkalis and alkaline earths. These flames also emit band spectra of carbon compounds and of water vapour present in the gas and air and other bands due to oxides formed in the flame. Higher temperatures, about 2,500° C., are attained in an oxyacetylene flame and atomic spectra are more fully developed. H. Lundegårdh found that when solutions of materials to be investigated were sprayed into such flames 34 elements could be determined spectrographically.

Furnaces.—An evacuated furnace, in the form of a carbon tube heated by forcing large electric currents through it, provides a source of metallic spectra in which the excitation is pure thermal energy. The temperature may be controlled between 1,500° C, where spectra begin to appear, and 3,600° C. where the carbon tube tends to fail. Small samples are placed in a porcelain boat in the tube and the luminous vapour is imaged on the slit of a spectrograph. If a carbon plug is inserted in one end of the tube it provides a continuous spectrum for the observation of absorption spectra of metal vapours. Such furnace spectra have been extensively investigated by A. S. King at the Mt. Wilson laboratory, in Pasadena, Calif., and the results have greatly advanced the understanding of atomic radiation processes, and aided the structural analyses of atomic and molecular spectra.

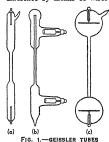
Electric Arcs.—Next to the Bunsen burner the simplest source of atomic spectra is the direct-current arc consisting of an insulated holder for electrodes, an applied potential of 100 or more volts and a resistance to limit the current to 5 or 10 amperes. The actual potential drop in such metallic arcs is 20 to 40 volts, most of which occurs immediately at the cathode. Atomic spectra are very fully developed in electric arcs because the temperatures range from 3,500° to 8,000° and all known substances are melted and vaporized. In addition to violent thermal agitation, many atoms collide, especially near the electrodes, with electrons or ions accelerated by the applied potential. For the study of metallic-arc spectra it is best to use solid rods of the pure metals themselves; other forms of material (powders, salts, precipitates, ashes, filings, foils, refractories, minerals, etc.) are readily volatilized by placing some of the substance on the lower (positive) pole of a pure carbon arc. The direct-current arc is characterized

by high intensity and effectiveness in generating the first spectra of atoms, but it is subject to erratic wandering and flickering which impair its usefulness for accurate spectrochemical analysis unless standardized conditions are imposed. A high voltage (2,200 volts) alternating-current arc, introduced in 1936 for quantitative analysis, reduces some of the irregularities of the direct-current arc at the expense of simplicity and sensitivity of spectral detection.

Electric Sparks .-- Compared with the electric arc the highvoltage condensed spark supplies higher excitation and is easier to control. Initially the high voltage was produced by a Rhumkorff induction coil, and a Leyden jar served as a condenser. In its modern forms the spark is animated by discharges from suitable condensers connected, in parallel with the spark gap, to the secondary terminals of a transformer giving from 10,000 to 50,000 volts. The condenser is charged on every half cycle to the voltage at which the gap breaks down. An oscillating current then flows in the spark circuit with an initial value of  $I = V\sqrt{C/L}$ where V is the condenser voltage, C the capacity in farads and L the circuit inductance in henrys. This initial current may be hundreds of amperes and the result is an energetic emission of excited or ionized atoms from the electrodes. Such sparks have higher effective temperatures than arcs. Indeed, in the highest attainable vacuum these sparks produce multiple ionization until atoms are stripped of all outer electrons and the corresponding temperature is estimated at several million degrees. The ordinary spark is somewhat variable owing to lack of constancy in breakdown potential or in the rate of decay of the oscillating discharges in each half cycle. Several devices have been introduced to control or stabilize sparks used for quantitative spectral analysis. Such devices are the synchronous auxiliary rotating spark gap and the air-blasted auxiliary gap. Any conducting solids may be used directly as spark or arc electrodes.

Other substances will serve as electrodes if they are packed in a hollow carbon rod or if they are pressed into solid form with some binder such as pure copper powder, but in such cases the spectrum of the substance is contaminated by that of the auxiliary electrode material.

Geissler Tubes.—An important type of light source is that produced by electrical discharges in gases at reduced pressures, first demonstrated and studied by J. Plücker in 1858 (fig. 1). It usually consists of a small-bore or capillary tube of glass (or silica) connecting two bulbs or larger bore tubes containing metal electrodes which can be attached to an electrical potential difference by means of wires leading through the glass. These



(a) original Geisster, (b) modern Geissier, (c) NBS Geisster

light sources are prepared by thoroughly exhausting the lamp, then admitting some pure gas (or vapour) through a side tube and sealing it off with a blowtorch when suitable conditions are established. The optimum pressure of gas is usually that equivalent to a few millimetres to a centimetre of mercury. When electrical potential is applied to such tubes a sheath of ions near the cathode marks the edge of the cathode fall within which electrons released from the cathode by ion bombardment attain sufficient speed to produce new ions by collisions with gas atoms. Outside this negative

glow is the Faraday dark space, and beyond it is the positive column extending nearly to the positive electrode. This positive column is responsible for most of the light emission, and being a region of relatively low potential gradient and electron speeds, it favours the first spectrum of the included gas. A glass blower named Heinrich Geissler, under Plücker's direction, prepared the first gaseous discharge tubes, and Plücker himself referred to them as "Geissler tubes"—a name that still clings to them. About 1930 a modified form of the Geissler tube became a spectacular type of light source for luminous coloured signs and shortly thereafter helium, neon and mercury lamps became commonplace. A more recent modification of the Geissler tube is the fluorescent lamp consisting essentially of a low-pressure mercury vapour tube whose discontinuous spectrum is partially converted to continuous bands characteristic of the fluorescent materials lining the inner walls of the tubes.

Hollow-cathode Discharge.—Another type of gas discharge of great utility for spectroscopic research is that devised by F Paschen. It consists of a hollow cylindrical cathode within a cylindrical anode, and a low pressure of pure noble gas. As the pressure is reduced the discharge retreats within the cathode until, at a pressure such that the mean free path of the electrons equals the cathode diameter, the negative glow fills the hollow cathode. The material of the cathode, or of any other metal within it, is vaporized by bombardment of the noble gas ions and excited by collisions with electrons whose maximum speeds are fixed by the ionizing potential of the sustaining gas. Since this source is operable at low pressures and low temperatures (the cathode may be cooled with liquid air) it yields atomic spectrum lines of extraordinary sharpness.

Electrodeless Discharges .- Gases or metal vapours may also be made luminous at low pressures in closed vessels without internal electrodes by placing the vessel inside a coil carrying a high frequency current generated by either a Tesla spark generator or a vacuum tube oscillator of ultra-high radio frequency. The oscillating high-frequency electric fields accelerate electrons sufficiently in rarefied gases and metal vapours to excite atomic and ionic spectra. These electrodeless discharges are especially convenient for minute quantities of pure materials (such as artificial elements), or for gases and vapours which attack electrodes or which may be contaminated by them.

Linelike Sources.-When viewed through a spectroscope any of the above mentioned light sources will be seen as a multitude of images, one for each monochromatic radiation characteristic of the excited atoms or ions in the source. Since all practical light sources are more or less wide these spectral images will overlap even if the spectroscope has enormous resolving power. In the case of electrical discharges in gases and metal vapours at reduced pressure, the light source is usually constructed with a long constriction to increase the intensity and this incidentally reduces the confusion of overlapping spectral images. However, in general, it is not possible to make all light sources linelike except by imaging the light source on a narrow slit with straight parallel jaws in which case the illuminated slit becomes the light source and the spectrum is a series of bright line images of the slit. The same effect may be obtained by substituting for the slit a cylinder of polished metal about one millimetre in diameter, and using the virtual image of any light source in this cylindrical mirror as a linelike light source. It is emphasized that spectral "lines" do not occur in nature but are consequences of using an artificial linear light source, because it gives the least confusion of overlapping images.

## SPECTROSCOPES AND SPECTROGRAPHS

Prism Instruments.-The production of a spectrum by the use of a prism of glass or any transparent material depends upon the fact that light rays of different colours, or wave lengths, are refracted differently on passing obliquely from one medium to another of different density. A composite ray of light is accordingly dispersed as well as refracted in passing through a prism, the amount of refraction being usually greater for shorter wave lengths. The first prism spectroscopes employed by Newton and by Fraunhofer exhibited astigmatism, a type of image defect in which a point source is seen as two perpendicular image lines at different distances from the optical system. This defect was effectively eliminated in Kirchhoff and Bunsen's first spectroscope by using a collimating lens to illuminate the prism with parallel rays. Astigmatism is least and definition best in a prism spectroscope if the prism is traversed by parallel light, the slit is parallel to the prism edge, the light rays are parallel to a section perpendicular to the edge, and the rays pass through the prism symmetrically at minimum deviation. The essential parts of a simple prism spectroscope are sketched in fig. 2. Light from a source under examination enters the spectroscope through a narrow slit S located at the principal focus of the collimator lens C. Parallel rays of complex light thus fall on the prism, and rays of each component colour continue parallel in their passage through the prism and on emerging from it. The colours are refracted differently, and after passing through the telescope lens T are focused to form a spectrum which may be observed with an eyepiece or recorded on a photographic film.

The brightness of the spectrum depends upon the wav in which the slit is illuminated by the light source, upon the focal lengths and apertures of the spectrograph lenses, and upon reflection and transmission losses within the instrument. The maximum illumination is attained if the light source is large enough or so close

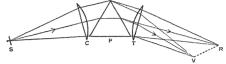


FIG. 2 .- PRISM SPECTROSCOPE OR SPECTROGRAPH Saslit, Cacollimator lens, Pa60° prism, Tatelescope lens, RVared to violet spectrum

to the slit that it subtends the same angle as the collimator lens. If the source is too small to fill the collimator with light the brightness of the spectrum may be increased by using a condensing lens of equal aperture ratio to form an image of the source on the slit. This type of slit illumination of a stigmatic spectrograph gives a point to point correspondence between a section of the source, the slit and the spectral images; it is preferred when the distribution of excitation in a source or of energy in an interference pattern is to be studied. When a perfectly uniform slit illumination is desired, as for the measurement of spectral-line intensity ratios by means of stepped filters, a condensing lens is placed just in front of the slit to form an image of the source on the collimator lens, in which case each point of the source sends light to every point of the slit and to every point of the spectral image. In either case a movable metal slide pierced with a series of openings (known as a Hartmann diaphragm) may be used to illuminate successive portions of a slit and thus record on a stationary photographic plate a number of spectra side by side for comparison and for measurement.

The light efficiency of a spectrograph, like that of a camera or telescope, depends chiefly on the ratio of the focal length, F, to the diameter, D, of the lenses, F/D. This ratio may be 100/1 or more in spectrographs employed for the study of bright sources like the sun, but extremely faint sources like phosphorescence or the night sky demand unit ratio or less. A ratio of about 15/1 represents a common compromise between desired speed and the necessity of using compound corrected lenses. In such spectrographs single plano-convex or meniscus collimator and camera lenses may be used if the curvatures are chosen so as to minimize spherical aberration and coma, and the plate is tilted and bent to fit the chromatic focus. The inclined plate obviously provides an increased spectral dispersion, and the use of single lenses ensures that light losses resulting from absorption and surface reflections are a minimum.

When all relevant factors are considered it appears that an isosceles prism with 60° angles is the best form for a spectro-graph. As to prism and lens materials there is a wide choice of optical glasses for the study of visible and near infra-red spectra but for spectral regions absorbed by glass it is necessary to use other materials such as crystalline quartz or fluorite in the ultraviolet, and rock salt or other alkali halides in the infra-red. Unfortunately, no crystals, natural or artificial, are transparent to all wave lengths; quartz is opaque below 1,800 A, and fluorite below 1,200 A, whereas rock salt is opaque above 17,000 A, and potassium iodide above 31,000 A. Furthermore they have limitations on account of size, homogeneity and cost. For ultra-violet spectrographs the most popular material is crystalline quartz But quartz polarizes the light it transmits and produces double images both on account of its birefringence and its property of rotating the plane of polarization. The birefringent effect is eliminated by cutting quartz lenses and prisms so that the light travels along the optical axis of the crystal, and the rotation doubling can be compensated by using equal parts of natural left-handed and right-handed quartz. A simple quartz spectrograph, therefore, has a collimator lens of one variety of quartz, a camera lens of the other variety, and the 60° prism is made by combining two 30° prisms of the opposite varieties of quartz. The same effect is obtained with economy of material in a Littrow-type spectrograph consisting of a single quartz lens and a 30° quartz prism backed by a mirror. (See fig. 3.) Obviously the rotation doubling



FIG. 3.-LITTROW QUARTZ SPECTROGRAPH

S-slit, P<sub>1</sub>-totally reflecting quartz prism, L-autocollimating quartz lens, P<sub>2</sub>-Littrow quartz prism, C-eamera, RV-red to violet spectrum

experienced by light in its forward passage through the lens and prism is cancelled by its return along the same path after reflection from the mirror or metallic coating on the back of the prism.

Received it this packability and possibly for visual bears,

Because of their portability and popularity for visual observations of spectra two types of compound prisms, the Amici and the Pellin-Broca, deserve brief descriptions. A form of "directvision spectroscope," invented in 1860 by G. B. Amici, consists of two prisms, ABC and CDE (fig. 4) of crown glass, having a low ratio of dispersion to index of refraction, cemented to a prism BCD of flint glass having a high ratio of dispersion to

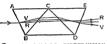


FIG. 4.—A MICI DIRECT-VISION SPECTROSCOPE
ABC=CDE=crown glass, BCD=fint glass, PV=red to violet spectrum

index. The prism angles are so chosen that the median spectral ray is undeviated upon emergence but all other rays are refracted and dispersed. Greater dispersion and resolving power are obtained by assembling trains of five or seven prisms.

five or seven prisms.

A type of "constant-deviation spectroscope," invented in 1899

by P. Pellin and A. Broca, has a four-sided prism ABCD (fig. 5) which is effectively a combination of two 30° refracting prisms ABE and DAC, and a totally reflecting right-angle prism BEC. Since the two refractions cancel and a right-angle deviation is introduced by the internal reflection the collimator and telescope axes are fixed 90° apart and different wave lengths are brought into the field of view by rotating the prism with a screw to which

SI LI ALE CO SE

E \$\displays\$

Fig. 5.—Pellin-broca constantdeviation spectroscope

Seilt, L\_scollimator lens, P-PellinBroca prism, L\_sctelescope lens, E-eye-

a wave length calibrated drum is attached.

Dispersing Power of Prisms. —The power of any spectroscope to separate different wave lengths emerging at different angles and focused at different points is called its dispersion; it is defined as the rate of change of the angle of deviation,  $\theta$ , with respect to a small change in wave length,  $\lambda$ , and represented mathematically by  $d\theta/d\lambda$ . Since  $\theta$  varies with the refractive index, n, of the prism, and the refractive index varies with the wave length,  $\lambda$ , we may write

Angular dispersion = 
$$\frac{d\theta}{d\lambda} = \frac{d\theta}{dn} \cdot \frac{dn}{d\lambda}$$
.

Dispersion thus depends upon two factors. The second factor,

 $dn/d\lambda$ , is determined solely by the optical properties of the prism material. Since the refractive indexes of a glass prism are approximately represented by an equation of the (Cauchy) form  $n=a+b/\lambda^2$ , where a and b are constants obtained from measured values of n for two different wave lengths,  $dn/d\lambda = -2b/\lambda^3$ . The negative sign merely indicates increase of n with decrease of  $\lambda$ . This formula shows that the dispersive power of a glass prism varies inversely as the cube of the wave length. For example, the dispersion at 4,000 A is about eight times that at 8,000 A. The other factor,  $d\theta/dn$ , depends upon the angle of the prism, and on the angle it presents to the incident light. If, as in fig. 6a, the angle of incidence and emergence be represented by i, and i<sub>n</sub> respectively, the internal angles of refraction by n, and n the angle of the prism by n, and the angle of deviation by n, it is readily deduced from Snell's law of refraction,  $n = \sin i / \sin n$ , that

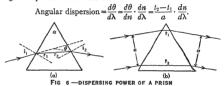
$$\frac{di_2}{dn} = \frac{\sin (r_1 + r_2)}{\cos r_1 \cos i_2}$$

or, since  $d\theta = di_2$ , and  $r_1 + r_2 = \alpha$   $\frac{d\theta}{dn} = \frac{\sin \alpha}{\cos r_1 \cos i_2}$ 

This expression clearly shows the dependence of the dispersion upon the prism angle and the angle of incidence. A convenient equivalent expression was first deduced by Lord Rayleigh; namely,

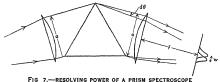
 $\frac{d\theta}{dn} = \frac{t_2 - t_1}{a}$ 

where  $t_2$  and  $t_1$ , in fig. 6b, are the lengths in the prism traversed by the extreme rays, and a is the breadth of the emergent beam. When the prism is at minimum deviation and completely covered by the beam,  $t_2-t_1$  is simply the base length of the prism. The original expression now becomes



When there is more than one prism  $t_2-t_1$  is summed for all prisms, and in Amici prisms the algebraic sum is taken, the lower dispersions being regarded as negative. The angular dispersion may be expressed in radians or degrees per angstrom, but it is usually more convenient to measure linear dustances, x, in the focal plane and express linear dispersion  $dx/d\lambda$  in millimetres per angstrom. In general, if f is the focal length of the image forming lens,  $dx/d\lambda = f/d\theta/d\lambda$ .

Resolving Power of Prisms .-- It would appear from this equation that, by choosing a large focal length, it would be possible to separate two close slit images due to light of two wave lengths, however little the wave lengths differed. Such, indeed, would be the case if an infinitely narrow slit were imaged as an infinitely narrow line. However, owing to the wave nature of light any optical image is a diffraction pattern of finite size which depends both on the wave length and on the dimensions of the optical system. An instrument is thus limited in its power to resolve images of slightly different wave length, or closely adjacent spectrum lines. This resolving power, R, is expressed numerically as the ratio of a mean wave length \( \lambda \) to the least difference  $d\lambda$  between two wave lengths that can be recognized as a double image, i.e.,  $R = \lambda/d\lambda$ . Each actual image of the slit is a diffraction pattern having most of the light concentrated in a central band of finite width flanked by secondary bands of negligible intensity. If f be the focal length of the camera lens, and a the effective breadth of the beam passing through a rectangular cross section, the half width, w, of the central diffraction band is given by the elementary theory of diffraction as  $w = f\lambda/a$ . This says that the image width increases with focal length and with wave length. but decreases with aperture increase. The condition for resolution is explained in fig. 7 where the spectrum is focused on a screen by a lens of focal length f. The beams of two equal-amplitude closely-adjacent wave lengths  $\lambda$  and  $\lambda+d\lambda$  are separated by the prism an increment of angle  $d\theta$ . Each slit image appears as a diffraction band, and, according to Rayleigh's criterion, resolution is just effected when the central maximum of one image coincides with the first minimum of the other, i.e., when the distance between centres of the two bands is w. Under these conditions the integration of the two bands gives a curve with two maxima, and if the intensity of these be rated as unity that of the minimum between is 0.81. Experience has shown that this intensity difference is sufficient to reveal duplicity of the image



and the condition for resolution is thus  $d\theta = w/f = \lambda/a$ ; or  $\lambda = a \cdot d\theta$ . By definition,  $R = \lambda/d\lambda$ , and therefore  $R = a \cdot d\theta/d\lambda$ , or in Rayleigh's form.

 $R = (t_2 - t_1) \cdot dn/d\lambda$ .

When there are several prisms, the algebraic sum is to be taken as in the case of dispersion. An ordinary flint glass prism of one centimetre base is found to have a resolving power for sodium-yellow light of about 1,000 but this number increases rapidly with decreasing wave length since  $ds/dh = -2b/\lambda^3$  approximately.

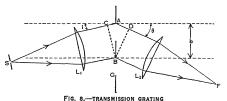
An infinitely narrow slit was assumed in the derivation of the theoretical resolving power but such a slit would transmit no appreciable light. In practice it is necessary to use a slit of finite width and sacrifice some of the resolving power for the sake of intensity in the spectral images. The actual separating power with finite slits was called "purity" by A. Schuster who defined a "normal slit" as the product of a quarter wave length by the aperture ratio,  $\frac{\lambda \cdot F}{4 \cdot D}$ , and calculated that nearly 99% of the

theoretical resolving power was conserved by using this normal slit. Thus, if F/D=20 the normal slit for 4,000 A would have a width of \$ Ao  $*_2$ . If double the normal slit is used the resolving power is reduced to 94% of maximum but the intensity is doubled. Increasing the slit width to about four times normal reduces the resolving power to 80% but trebles the intensity. Still wider slits rapidly reduce the resolving power or spectral purity without appreciably intensifying the spectra of monochromatic images except where they overlap. A wide slit greatly increases the intensity of continuous background relative to that of monochromatic lines. The above definitions of dispersing power, resolving power and spectral purity are valid also for diffraction gratings discussed below.

Grating Spectrographs.-The use of diffraction gratings instead of refraction prisms for the study of spectra brings advantages of constant and usually greater dispersion and resolution, as well as opportunity to observe extreme ultra-violet and infra-red spectra for which no transparent prisms can be found. Modern gratings are made by ruling with a diamond point equidistant parallel lines on a polished plate of glass, of speculum (copper+tin) metal, or of glass on which a film of aluminum has been deposited. Those in most general use for visible and ultra-violet spectra have either 15,000, 20,000, 24,000, or 30,000 lines per inch and effective ruled areas ranging from about 2 to 6 inches. A grating with 15,000 lines per inch permits measurements in infra-red spectra to 30,000 A, but for the investigation of longer waves coarser gratings must be used. In 1910 R. W. Wood first ruled 2,000 to 3,600 lines per inch on copper plates and by proper choice of groove form succeeded in concentrating much of the visible light into relatively high orders. Such "echellete" gratings concentrate the greater part of infra-red energy in a first-order spectrum and they

can be ruled to perform in this manner for almost any desired wave length. Thus, a grating with 900 lines per inch may be made to function well at about 300,000 A, 360 lines per inch around 900,000 Å and 80 lines per inch around 1,500,000 Å. These coarse echellete gratings have ruled surfaces up to 10x20 inches in area and are usually cut in a solder surface with a steel tool. A grating ruled on a sheet of transparent glass is called a "transmission grating," but it is impossible to rule large areas of glass without wearing down the diamond point. For shis and other good reasons most gratings are ruled on opaque soft metal surfaces, and are called "reflection gratings." The fundamental principle is the same in both cases.

The cory of Diffraction Gratings.—The simple theory of the plane diffraction grating gives the wave length of light as a function of the grating space and of the angles of incidence and diffraction of the light rays. Fig. 8 represents the cross section of a transmission grating in which transparent and opaque lines o spaces alternate and each pair, such as  $AB_i$  is called the grating space b. If light from an illuminated slit S falls as a parallel beam on the grating at an angle of incidence i with the normal, a portion of the light passes directly through the grating aperture to produce an undeviated image, but a part of it is diffracted in the direction AD making an angle  $\theta$  with the normal. After drawing the perpendiculars CB and DB it is seen that the difference in



S-slit, L<sub>1</sub>=collimator lens, G=Grating, L<sub>2</sub>=camera lens, b=grating space, i=angle

path travelled by corresponding rays from adjacent apertures, or the retardation as it is called, is given by the sum of the lengths CA and AD. When this retardation is equal to any integral number, u, of wave lengths,  $\lambda$ , bright images of S in colour corresponding to  $\lambda$  are produced where the diffracted rays are brought to a focus, F. This condition is simply expressed by the equation

$$CA + AD = n\lambda = b$$
 (sin  $i + \sin \theta_n$ )

in which n represents the order number of the spectrum.

of incidence, θ=angle of diffraction, F=focused spectrum

The law of reflection gratings is similar to that of transmission gratings. Thus in fig. 9 a beam of parallel rays falls on a plane reflection grating with grating space AB=b. The incident light makes an angle, i, with the normal, and part of the light is diffracted at an angle,  $\theta$ . The perpendiculars AC and BD show that BC and AD are the retardations. In this case the total retardation is AD-BC=b (sin i—sin  $\theta_n$ ). Whenever this equals one or  $\theta_n$  are the retardation where  $\theta_n$  is  $\theta_n$  and  $\theta_n$  are the retardation  $\theta_n$ .

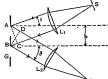


FIG. 9.—REFLECTION GRATING
S=slit, L<sub>z</sub>=collimator lens, G=grating,
L<sub>ω</sub>=camera lens, b=grating space, is
angle of incidence, θ=angle of diffraction, F=focused spectrum

bright image is seen in colour corresponding to  $\lambda$  and we have the law of the grating. If the diffracted rays are on the same side of the normal as the incident rays the two retardations are added, wherefore the general equation for all spectra must be written  $n\lambda = b$  (sin  $i\pm\sin\theta_n$ ), the positive or negative sign being used when the incident and diffracted rays are on the same or opposite sides of the normal,

respectively. If the grating space is not too small the groove form of the ruled lines can be controlled by shaping the diamond point in such a way that the diffracted light is largely concentrated in one general direction or spectral region. Such gratings may for example, give an intense visible spectrum and weak ultra-violet, or vice versa. If light is incident normally on any grating the angle i is zero and the grating formula reduces to  $\pm n\lambda = b \sin \theta$  which represents a central zero-order image flanked on either side by first, second, third, etc., order spectra according as  $n=\pm t, \pm 2, \pm 3$ , etc. It is obvious that the absolute values of wave lengths may be determined from the measurement of the grating space and of one (or two) angles. This was the method employed by Fraunhofer, and by Ångström to establish standards or fiducial points in spectra.

Concave Gratings .- All plane gratings, like prisms, require the use of lenses or mirrors to collimate and to focus the incident and emergent light. To eliminate lens aberrations and limitations of light absorption, Rowland in 1881 first ruled a grating on a spherical mirror which collected light from a slit, dispersed the diffracted light into spectra and focused them on a circle the diameter of which equalled the radius of curvature of the concave grating. All concave gratings mounted on the Rowlandcircle principle exhibit strong astigmatism, i.e., a point slit is imaged as a line with a length dependent on wave length and spectral order. This astigmatism reduces the brightness of the spectra and precludes the use of diaphragms or sectors at the slit, and other observations requiring a one to one correspondence in the slit and its spectral images. Fortunately this defect can be avoided either by placing horizontal lines to be focused on the circle at a greater distance from the grating than the slit, or by illuminating the concave grating with parallel light, in which case the astigmatism is practically eliminated and the brightness of spectra greatly increased.

With both plane and concave gratings a great advantage is obtained by forming and observing spectra on the normal to the reflecting surface, for this gives the "normal spectrum" in which angular or linear distances measured either way from the grating normal are, for a considerable distance, proportional to the change in wave length observed. Since the concave reflection grating is free from chromatic aberration and focuses all spectra on the same focal surface, Rowland took advantage of the normality of spectra and of the coincidence principle in overlapping orders of spectra to determine the relative values of the "Rowland system" of standard wave lengths.

**Dispersion.**—The explanation of dispersion by a grating is easily seen since the formula shows that the angle  $\theta$  increases or decreases with the wave length  $\lambda$ . When composite light falls on the grating it is obvious that the shorter violet waves will give an image closer to the central image than the longer red waves, and successive orders of spectra will increase in dispersion proportional to the order number.

If  $\theta$  be the angle of diffraction, dispersion is defined as before by  $d\theta/d\lambda$ , and since, for a given position of the grating, the angle of incidence, i, is constant, the grating formula gives  $d\theta/d\lambda = n/b \cos \theta$ . This equation shows clearly how the dispersion varies directly with the order of the spectrum, and inversely as the grating space; the closer the rulings the greater the dispersion, irrespective of the total number of grating spaces. Furthermore the dispersion is smallest when  $\cos \theta$  has its maximum value (which is unity for zero angle), i.e., when the spectrum is observed normal to the plane of the grating. In this position also the dispersion is most nearly uniform throughout the spectrum, since it varies with  $\cos \theta$ , and in the proximity of  $\theta = 0$ this trigonometric function changes very slowly. The spectrum given by a grating, unlike that given by a prism, is accordingly 'normal" in so far as  $\cos \theta$  can be considered constant. There is a certain amount of overlapping of successive orders since  $n\lambda$ may acquire the same value in different ways. For example,  $\lambda =$ 7.000 A in the first order will be coincident with  $\lambda = 3,500$  A in the second order, and  $\lambda = 4,000$  A in the third order will coincide with  $\lambda = 6,000$  A in the second. When observation of a particular spectrum is desired it is usually possible to remove the overlapping spectra by using suitable colour filters in front of the slit or selective detectors at the focus.

Resolving Power.-As in the case of the prism, the resolving

power of a grating is a theoretical quantity expressing the imageseparating power when the slit is indefinitely narrow; it is represented symbolically by  $R = \lambda/d\lambda$ , and is given in simple form by R = nN, where n is the order number of the spectrum and N is the total number of rulings. Thus the resolving power of a grating depends only on the total retardation in wave lengths from the first to the last line, and not on the grating space. For example, a five-inch grating with 20,000 lines per inch would have a theoretical resolving power of 200,000 in the second order, surpassing an imaginary glass prism of two metres base length At  $\lambda = 8,000$  A,  $d\lambda$  would be 0.04 A, while at  $\lambda = 4,000$  A it would be 0.02 A. This theoretical resolving power is attained only under ideal conditions since actual resolution depends on various factors such as the relative intensities of spectral lines, their form or structure, the width and manner of illuminating the slit, the perfection and adjustment of the optical parts, graininess or contrast of photographic emulsions, etc.

Interferometers.—Since the resolving power of a grating is proportional to the product (nN) of the order number and the total number of elements, it may be increased in two ways. To increase the number of elements the number of lines per inch may be increased or a greater number of inches ruled, but the total number of useful lines is usually limited to about 100,000 by the practical difficulties of making all grooves exactly alike and equally spaced. The alternative method of using higher orders is limited in highly dispersive gratings by the great reduction in aperture when the grating is viewed tangentially. These limitations in ruled gratings are circumvented more or less in certain interferometers, known as Michelson's echelon interferometer, the Fabry-Perot interferometer and the Lummer-Gehrcke interferometer, all of which employ a relatively small number of elements (10 to 30) but very large spectral orders (10,000 to 100,000 or more). Since such high orders are very close together confusion due to overlapping of many lines must be avoided by crossing these interferometers with any stigmatic spectrograph. The Michelson transmission echelon (fig. 10) consists of a number of glass plates of equal thickness, t (c. 1 cm.), and refractive index,  $\mu$ , but each shorter than its predecessor. These are wrung into optical contact with each other to form a series of steps, i.e., an echelon. Parallel light from a collimator, with the slit parallel to the edges of the steps, is then passed through the larger end.



Saslit, Lacollimator lens, lainterferometer, Lachromatic lens, Eacycpiece

In each step the light is retarded an equal amount  $(\mu-r)t/\lambda$  and diffraction spectra of very high order are formed when all the transmitted beams are collected and focused by a lens. This interferometer was later improved as a reflection echelon which is not limited by the absorption of glass and has nearly four times the resolving power since the retardation per step is  $2t/\lambda$ . An echelon of 30 plates each 1 cm. thick has a theoretical resolving power at 5,000 A of 30×2/.0005=1,200,000. This instrument has been employed for the examination of spectral line structure and for the precise measurement of relative wave lengths.

When a beam of light passes through a transparent film or plate multiple reflections occurring at the surfaces produce interference colour effects seen for example in soap bubbles or in oil films on a wet pavement. Such interference bands are relatively broad because the reflecting power is so low that only the first reflection at each surface is effective. When the reflecting surfaces are exactly parallel and the reflection coefficient is increased, the multiple reflections produce very narrow bright fringes on a broad dark background. These conditions are met in the Fabry-Perot and in the Lummer-Gehrcke interferometer. In the former a large coefficient of reflection is obtained by depositing bright partly-transparent metal films on two glass or quartz planes. These planes are mounted face to face, separated some milli-

metres or centimetres, and adjusted to exact parallelism. The most common type of Fabry-Perot interferometer (fig II) is the fixedetalon type in which the plates are maintained at a fixed distance by being pressed against a separating ring spacer or etalon. When illuminated with monochromatic light, and viewed axially, circular interference bands, known as Haidinger's fringes, are seen at infinity. When illuminated with complex light the overlapping of fringes belonging to neighbouring spectral lines is avoided by crossing the interferometer with a stigmatic spectrograph. The order of interference at the centre of the pattern for wave length  $\lambda$  is in general a whole number, n, plus a fraction,  $\epsilon$ , determinable from the diameters of successive rings. The double distance between the interferometer plates is  $2D=\lambda (n+\epsilon)$  for wave length  $\lambda$ , or  $2D = \lambda'(n' + \epsilon')$  for another wave length,  $\lambda'$ . Thus the simple proportion  $\lambda/\lambda' = (n' + \epsilon')/(n + \epsilon)$  offers an opportunity for the precise comparison of wave lengths, and this is in fact

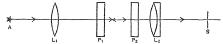


FIG. 11 ——FABRY-PEROT INTERFEROMETER

A=light source, L\_=coflimator lens, P. and P.=interferometer plates, L\_=achromatic projection lens, S=spectrograph silt

the method employed for the establishment of secondary standards of wave length measured relative to the primary standard (red radiation from cadmium) which was itself found to be 6,438.4696 A by comparison with the meter. (See Interferom-ETER.) This method of comparing wave lengths has been used extensively also for measuring the ratios of wave lengths in vacuo and in gases and thus determining the refractive indexes and dispersions of gases, notably air. In addition the Fabry-Perot etalon interferometer has proved the most effective instrument for the measurement of exceedingly small wave length differences which appear, for example, in hyperfine structure, isotope shifts, pressure shifts, etc. Besides simplicity, stability and freedom from defects this interferometer possesses a large advantage in the flexibility of its resolving power, since this is equal to the product of the spectral order, n, by the effective number of reflections, N. With a reflection coefficient of 0.75 the value of N is about 10, and with 0.90 the effective number of reflections is about 30. Thus a Fabry-Perot interferometer with silver mirrors reflecting 0.90 is equivalent to a reflection echelon of 30 plates having plate thickness equal to the etalon separator. The echelon plates have a fixed thickness whereas the Fabry-Perot plates may be separated as desired to increase resolving power.

In fact, the highest resolving powers on record have been attained with Fabry-Perot interferometers and the most detailed and reliable results on hyperfine structure must be credited to them.

The Lummer-Gehrcke interferometer consists of a long unsilvered plate with perfectly plane parallel surfaces in which a high reflection coefficient is obtained by directing the entering light beams so that they are reflected at nearly the critical angle (fig. 12). The greater part of the light is reflected at each internal reflection but the remaining fractions emerge with equal retardations as parallel refracted beams which may be collected and focused by a lens to form identical sets of interference patterns above and below the optic axis. The resolving power is



rig, 12.-LUMMER-GEHRCKE INTERFEROMETER

A=iight source, L:=collimator lens, i=interferometer, L:=achromatic projection lens, S=spectrograph slit

again n N where n is the order of interference (retardation) and N the effective number of reflections or emergent beams, which usually ranges from 10 to 20. The practical resolving power of

the Lummer-Gehrcke interferometer has been found to be about equal to the length of the plate measured in wave lengths. This instrument has been employed successfully for the observation of hyperfine structure, isotope shifts and Zeeman patterns.

The most famous of all interferometers is the very first one, invented by A. A. Michelson in 1892, and fully exploited by him in his classical investigations of "ether drift," sharpness of spectral lines, and evaluation of the international metre in wave lengths of cadmium radiations (see INTERFEROMETER).

#### METHODS OF OBSERVING OR RECORDING SPECTRA

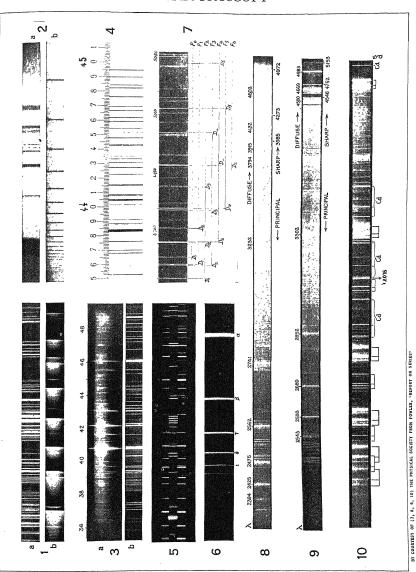
There are in general four ways of observing spectra: visually, photoelectrically, radiometrically, and photographically; each having certain advantages and limitations.

Visual.—Although the average human eye is extraordinarily sensitive for green light  $(5,500 \, \text{A})$ , its sensitivity declines rapidly to zero for infra-red ( $\lambda \geq 7,700 \, \text{A}$ ) and ultra-violet  $(\lambda < 3,800 \, \text{A})$ . Being highly selective, variable, localized and restricted to one octave, visual methods of observing are relatively unimportant in spectroscopy.

Photoelectric .-- As a substitute for the human eye the "electric eye" or photoelectric tube may be employed for the investigation of spectra in limited ranges. Briefly, the photoelectric tube consists of two metal electrodes in an evacuated glass tube. The anode is maintained at a positive potential with respect to the cathode. When radiation falls on the cathode the liberated electrons are drawn across the evacuated space to the anode. This flow of electrons constitutes a photoelectric current which is directly proportional to the incident energy. Since these photoelectric currents are usually very small they are magnified by the use of thermionic amplifiers, or in the case of feeble radiation, use is made of a Geiger-Müller tube in which each electron emitted gives rise to a pulse of current. Since 1940 multiplier phototubes, in which enormous amplification is obtained by a sort of chain reaction, have become popular as detectors and intensity recorders of spectral lines. All photoelectron emitters (e.g., Na, Zn, Cd, Mg) are highly selective and usually most efficient in the ultra-violet. By depositing thin films of heavy metals or compounds (e.g., CsO, PbS) photoelectric sensitivity may be extended to near infra-red, but not much beyond 40,000 A.

Radiometric .-- A unique and important class of radiation detectors, responding to the heating effect of the radiation, is found in blackened radiometers, radiomicrometers, thermopiles and bolometers. They are unique because they are nonselective, and important because their sensitivity extends from ultra-violet, through visible, to far infra-red spectra. The radiometer is a blackened vane supported some distance from the axis of rotation of a glass or quartz fibre in vacuo. When radiation is absorbed by the vane the supporting fibre is twisted through an angle proportional to the incident radiation. The radiomicrometer is essentially a moving coil galvanometer of the D'Arsonval type. A single thermocouple is suspended by a quartz fibre with the plane of the couple coil in the line joining the poles of a magnet. When radiation falls on the thermocouple junction the electric current generated causes the couple to turn in the magnetic field. The thermopile consists of one or more junctions of dissimilar metals, e.g., bismuth and antimony or silver, iron and constantan (alloy of nickel and copper). If radiation falls on alternate junctions a galvanometer in the circuit will give a deflection proportional to the heating effects. All radiation detecting and measuring devices depending upon the initial conversion of radiant energy into heat energy and finally into mechanical or electrical energy are extremely inefficient because all heat engines are naturally inefficient. The feeble final effects of radiation may be magnified up to about 200 times by suitable amplifiers but thermopile currents causing galvanometer deflections of the same magnitude as Brownian-motion effects obviously cannot be amplified to advantage.

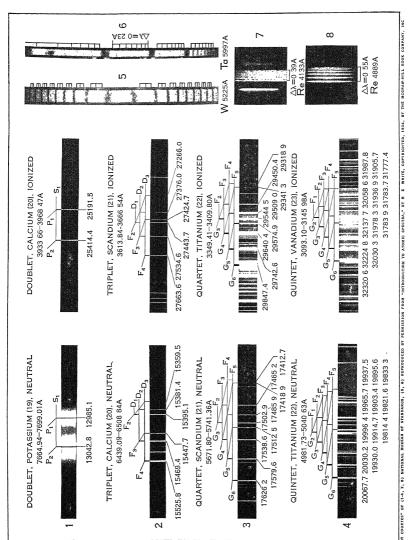
The bolometer, devised by S. P. Langley in 1880, consists of two similar very thin strips of metal, usually platinum, which form two arms of a Wheatstone bridge. The strips are blackened



SELECTED PORTIONS OF TYPICAL SPECTRA

1. Spectra of nitrogen; (a) line spectrum, (b) band spectrum. 2. Absorption spectra; (a) neadynim glass, (b) potassimy wapor. 3, Spectra of stroutum; (s) spectr, (b) ser. Flame innes are reduced in intensity in the spack spectrum, while "enhanced" or "spack" lines are intensified. 4. Portion of photographic map of renove spectrum, from which approximate wavenessed from the obtained. 5. Spectra of from and oxygen (middle), placed in juxtaposition for comparison and elemenmatons of wave-lengths. 6. "Red" spectra of lines.

series of lines peculiar to this element in the visible and near ultra-violet regions. 7, Aro spectrum of iron, under high dispersion showing a multiplet of 15 lines and pine of its structure. 8. Are septrum of Inthium, showing the constituent principal, sharp and driftes series. The lines, apparently unique, are vision of doublets, 9. Are spectrum of sodum, similar to that for Lithium. The terms principal, sharp, and diffuse refer to the appearance of the lines composing the respective series. 10. Are spectrum of race and cadmium, showing triplet systems



TYPICAL STRUCTURE OF ATOMIC SPECTRA

1. Doublet, 2. Triplet, 3. Quartet, 4. Quintet multiplet of neutral and of nonized atoms. (Reduce assistrate) of even-multipletity levels by \$\psi\$ to other intent inten J vidues.) This place numbers under each multiplet are wave numbers associated with the lines. The alternation has illustrated varietly, and the displacement has been contained.

tem of the turatise Inine, 22254. Abovenge components for three principal incipose, Wise, Wise, G. Farby-Perot pattern of tartition line, 55974, abovenge eight components of hyperfine structure. 7 and 8 Plane-parising mages of rhenium lines, 41,23 and 48894, along as to components of hyperfine structure.

on one side, one strip is shielded and the other is exposed to radiation. The absorption of radiation by one strip increases its temperature, thus changing its electrical resistivity and causing a deflection of the galvanometer. With his bolometer Langley, in 1888, mapped the solar spectrum to 55,000 A by using a spectrometer with rock salt lenses and prisms and passing the spectrum over the bolometer strip by rotating the prism. The galvanometer readings were recorded on photographic paper whose motion was co-ordinated with that of the prism. The same basic principles are today employed, with improved instrumentation, in all automatic recording of spectra scanned either by photoelectric or radiometric detectors.

Photographic.-The actinic action of radiation on silver salts is fairly effective throughout many octaves of spectra, from blue to extreme ultra-violet, but the maximum sensitivity is usually in the blue. Photographic image formation rests on a latent and lasting effect produced by light in microscopic silver halide crystals suspended in gelatin coated thinly on a glass, film, or paper base. The crystals affected by light are readily reduced to metallic silver by a suitable reducing agent or developer, and the unreduced silver halide is dissolved out with a fixer, usually "hypo," thus producing images composed of tiny silver grains, the density of which is a function of the intensity or total energy incident upon the emulsion. Although gelatin is highly transparent to waves longer than 3,000 A, it is strongly absorbent for shorter waves and practically opaque below 2,000 A. In order to record spectra below 2,000 A, in 1901 V. Schumann effectively eliminated the shielding effect of gelatin by depositing silver salts on glass plates with only enough gelatin to support them. Another way to circumvent the ultra-violet absorption of gelatin was discovered in 1921; it consists of coating an ordinary photographic plate or film with a thin film of oil or suitable organic substance that fluoresces in ultra-violet light and emits longer wave radiation not absorbed by the gelatin. (See Photography.)

In 1873 H. M. Vogel discovered that the light sensitiveness of silver salts could be extended to longer waves by bathing ordinary plates in certain dye solutions. By 1900 the incorporation of suitable photosensitizing dyes in emulsions produced panchromatic plates that were sensitive to the entire visible spectrum, and after 1930 the synthesis and application of an important series of polycarbocyanine dyes extended the sensitivity of photographic emulsions into the infra-red to about 13,000 A. Since large intervals of spectra and multitudes of spectral details could thus be recorded simultaneously it follows that more spectrographic observations have been made photographically than by all other methods. In addition to being applicable in an enormous range of wave lengths the photographic method provides a permanent, detailed record of a spectrum that can be conveniently examined or accurately measured by any number of persons as often as desired without repeating the experiment. Furthermore, photographic exposures are cumulative, and the photographic method thereby derives additional advantages in integrating the light from flickering or intermittent sources and in recording extremely faint images by giving long exposures. Although the absolute sensitivity of a photographic emulsion may vary considerably with wave length, it can often be regarded as constant over a limited range of spectrum, and in any case can be calibrated as a function both of wave length and intensity, thus providing a convenient method of measuring the relative intensities of spectral lines. This photographic-photometry method was developed' about 1925 for the purpose of testing quantum rules for the relative intensities of certain lines, and since 1930 it has become standard practice in quantitative spectrochemical analysis.

It should be emphasized that any selective receiver (eye, phototube or photographic plate) employed for measuring the relative intensities of spectral lines requires calibration by comparison with nonselective receivers (thermopiles, etc.).

## OBSERVATIONS AND MEASUREMENTS

Spectroscopic measurements are concerned essentially with energy distribution as a function of wave length. This function is characteristic primarily of the light source and secondarily of 21-G

on one side, one strip is shielded and the other is exposed to radiation. The absorption of radiation by one strip increases its temperature, thus changing its electrical resistivity and causing a deflection of the galvanometer. With his bolometer Langley, in 1888, mapped the solar spectrum to 55,000 A by using a spectrom
1888, mapped the solar spectrum to 55,000 A by using a spectrom
1888, mapped the solar spectrum to 55,000 A by using a spectrom
1888, mapped the solar spectrum to 55,000 A by using a spectrom
1888, mapped the solar spectrum to 55,000 A by using a spectrom-

If the spectral intensity changes rapidly from point to point and experiences sudden inflections the spectra are called "discontinuous." Such spectra also may be either emission spectra, or absorption spectra; they usually consist of hundreds or thousands of lines. The division of observable spectra into continuous and discontinuous, either in emission or in absorption is a broad but useful classification. Each class contains an enormous number of examples, some of which may be grouped according to certain criteria into smaller classes. The following examples will illustrate the principal classes of spectra that are subjected to observation and measurement.

Emission Spectra.—All self-luminous sources yield emission spectra, which are of different types according to the nature of the light source. Spectrally dispersed light from glowing gas mantles, electrically heated metallic filaments, or hot molten metals are continuous over great ranges of wave lengths, and for "black body" radiation the wave length of maximum intensity is an inverse function of absolute temperature. It follows that such substances cannot be distinguished by means of their spectra so long as they remain in the solid or liquid state.

The effects are quite different when the substances examined are in a state of luminous gas or vapour. They then emit characteristic discontinuous spectra by which they can be uniquely identified, whether they are excited in the laboratory or in a celestial body far away. These spectra consist of bright lines or bands variously spaced on a dark background.

Line spectra are characteristic of atoms or ions, while band spectra originate in molecules. The former consist of a certain distribution of slit images of different intensity and usually of various types such as partially self-reversed lines, sharp lines, diffuse lines, unsymmetrical lines and complex lines with two or more components. Partially reversed or easily absorbed lines always indicate that the normal state or some low energy state of the atom or ion is involved. The relative sharpness or diffuseness of lines is determined by such factors as pressure, temperature, mass and excitation. Complexity of spectral lines is referred either to different isotopes of the same element (isotope shift) or to interaction of valence electrons with a spinning isotopic nucleus (hyperfine structure).

In a band spectrum a great number of fine lines are closely and regularly placed in each band, becoming more and more crowded near the band head. The band heads are on the shortwave side of the line groups in some band systems, and on the long-wave side in others. The differences between line and band spectra are illustrated in Plate I where fig. 12 and fig. 1b are portions of the line and band spectra respectively of nitrogen. Some bands are less regular in appearance, and others do not appear to be resolvable into lines. In pure gases the commonly observed band spectra characterize molecules consisting of two similar atoms, such as H2, He2, N2, O2. The line spectra of metals excited in flames, arcs or sparks operated in the free atmosphere are usually accompanied by band spectra characteristic of monoxides such as CaO, BaO, ScO, LaO, formed by the oxidation of the metals. Arc spectra frequently show band spectra identified with NO and CN as well as line spectra of N, O, A and C, the principal constituents of the atmosphere. Many dipole molecules unknown to ordinary chemistry but recognized spectroscopically are apparently formed only under special conditions existing in the light sources.

No two substances yield the same spectrum and consequently the chemical nature of substances can be determined spectroscopically. Thus glowing atomic hydrogen is characterized by a bright line in the red, besides progressively weaker ones of shorter wave length (see Plate I, fig. 6), and since these are exhibited by nothing but hydrogen, they serve to disclose the presence of atomic hydrogen wherever it occurs in the luminous state. Each of the known chemical elements has its distinctive family of

spectral lines, differing in distribution, relative intensity and total number, but always the same under the same conditions of excitation. The same element, however, under radically different excitation conditions will emit entirely different spectra. The most easily excited spectrum is that of neutral atoms in possession of all their valence electrons, but if the excitation is violent enough to remove one electron from each atom the resulting ions when excited radiate another characteristic spectrum. A third type of spectrum is emitted when the atoms are doubly ionized by removal of two electrons, and so on until only one outer electron remains. Thus each element or atom has as many characteristic spectra as it has electrons. In most arc or spark sources generating atomic spectra of a pure element two or more spectra appear simultaneously with one usually predominating (see Plate I, fig. 3a and fig. 3b). When two or more elements with comparable excitation characteristics are abundant in a light source each element emits its own spectra essentially the same as if all other elements were absent. The spectra of complex substances such as ores, minerals, metal alloys and chemical mixtures thus reveal simultaneously all the types of atoms and ions that are excited in the light source. Such supernumerary line spectra often have superposed on them band spectra of molecules formed and excited in the same light source as well as lines and bands of atmospheric elements, and in addition, a more or less intense continuous background which may be traced either to unquantized radiation from the atoms, to continuous spectrum from incandescent oxides in the light source, or to stray reflected or scattered light in the spectrograph, sometimes to all three. In such complicated cases it is obvious that only experienced spectroscopists can interpret the spectrograms correctly. Familiarity with the spectra of various elements often enables an experienced observer to identify lines or bands at sight for the distribution and relative intensities in certain groups are memorized and recognized in the same way that constellations are recognized among stars. In theory any unknown spectrum or mixture of spectra can be identified by comparing it with all the spectra of known elements excited under similar conditions, but in practice the endless labour of repeatedly observing the comparison spectra is avoided by measuring wave lengths corresponding to the unknown lines and comparing these with wave-length tables of identified lines compiled for this purpose.

For purposes of chemical identification the wave lengths and the relative intensities of lines in spectra may be regarded as constants of nature, but closer examination shows that in any given spectrum certain variations are produced by different excitation conditions. Thus spectral wave lengths are generally slightly increased as the total pressure of gas or vapour surrounding the radiating particles is increased. Such pressure shifts are further correlated with atomic diameters and with atomic energy levels.

Also the wave lengths are either decreased or increased, according to Doppler's principle (see Doppler Effect) when the radiating source approaches or recedes from the observer. In astrophysics this principle has disclosed the sun's rotation, the radial velocities of stars, and an apparently expanding universe, whereas in the laboratory it explains, when combined with the kinetic theory of gases, the intrinsic natural width of spectral lines as a function of  $\sqrt{T/M}$  in which T represents absolute temperature and M molecular weight. When standard wave lengths in the solar spectrum are measured it is necessary to correct the observations for Doppler effect due to the relative motion of the sun and the spectrograph.

Again, with few exceptions, all atomic spectral lines are split into three or more components when the radiating particles are in strong magnetic fields (see Zeman Effect) and similarly many lines either shift or widen or divide into resolved components when the radiating particles are subjected to strong electric fields. (See Stark Effect.)

From the general theory of relativity (q.v.) A. Einstein in 1917 concluded that wave lengths characteristic of atoms should increase in strong gravitational fields. This effect is quite inappreciable in the laboratory but it appears to be present in the

solar spectrum, and especially in the spectra of very dense stars. The most striking changes in relative intensities of lines belonging to a particular spectrum occur when excitation conditions favour the partial self-reversal of selected lines. These variations of spectral characteristics are highly objectionable in standard wave lengths and in spectrochemical analysis, but they are of primary importance in spectroscopic research since they yield information about atomic structure and the mechanism of radiation. Consequently, when truly invariable spectra are desired they may be produced by carefully specifying and reproducing the light source in such a manner that spectral variations are eliminated or minimized, but if atomic structure is being investigated it is desirable to effect the largest practicable changes in spectra and relate these to variations in the light sources. In any case it is evident that some means of accurately expressing the positions of lines in a spectrum is of primary importance.

Wave Lengths.-Measurements of spectra become directly comparable with each other only when they have been converted to the scale of wave lengths (or frequencies) of the radiations which produce the spectral lines. The credit for introducing this scale into spectroscopy is due to A. J. Angstrom who described the spectrum of the sun in terms of wave lengths in 1868, and since that time the positions of practically all known spectral lines have been expressed in wave lengths. The unit of wave length in spectroscopy is a ten-millionth part of a millimetre or 10-10 m. It is called the "angstrom" and is symbolized by A. In these units, the visible spectrum ranges from about 3,800 A (violet limit) to about 7,700 A (red limit). Extremely short waves, in particular those observed in Roentgen or X-ray spectra which range from about 0.1 A to about 100 A, are more conveniently expressed in still smaller units, and for this purpose the X unit, approximately 1/1,000 A, is generally used Similarly, very long optical waves, in particular the far infra-red heat waves, are more conveniently expressed in larger units, and for this purpose the micron,  $\mu = 10,000$  A, is commonly used Summarizing:  $10^{-6}$ m. = 0.001 mm. =  $1\mu$ = 10.000 A = 10.000,000 X Wave lengths ranging from 6 A to 5,000,000 A have been measured in spectra associated with valence electrons but these limits will surely be extended in both directions. Absolute wave lengths cannot be determined directly from prisms but have been measured with gratings and interferometers by methods outlined in the discussion of these instruments. Because such measurements are relatively difficult and tedious they have been made only for the purpose of setting up standards of wave length, and in all other spectroscopic work, whether with prisms or gratings, wave lengths are deduced by interpolation between adopted standards

Wave Numbers .- In the interpretation of spectra as transitions between quantized energy states  $(E_2-E_1=h\nu)$ , it is necessary to express the positions of the spectral lines on a frequency, v, scale instead of a wave-length scale. Unfortunately, neither nature nor human ingenuity has disclosed a method of directly measuring the oscillation frequencies corresponding to light waves. These frequencies, defined as the number of waves that pass a given point in one second, must be derived from the relation  $\nu = c/\lambda$  in which c is the velocity of light and  $\lambda$  is the observed wave length. In order to make these frequencies independent of the medium through which the light passes both c and  $\lambda$  must be evaluated in vacuo. Since the velocity of light is very great (25,-977,600,000 cm. per second) and a light wave is very small (0.00000550 cm. for brightest visible light) the frequency is an extremely large and awkward number (545,000,000,000,000 in this example). In spectroscopy it has become common practice to replace the ungainly actual frequencies by "wave numbers." representing the number of waves in one centimetre of vacuum and symbolized by cm.-1. If the wave length has been measured in air it must be multiplied by the refractive index of air to change it to its value in vacuo. In 1926 H. Kayser prepared his Tabelle der Schwingungszahlen for the convenient conversion of wave lengths in standard air to wave numbers in vacuo. For example 5,500,000 A=18,176.781 cm.-1. Such wave numbers of observed spectral lines are strictly proportional to the natural frequencies and to the corresponding changes in atomic or molecular energy.

Standard Wave Lengths.—In modern spectroscopy the primary standard of wave lengths is that of the red radiation from cadmium vapour first measured relative to the international metre bar by interferometer methods in a classical experiment by Michelson in 1892. (See Interprementer) Benoit, Fabry and Perot, in 1905, found that 1 metre contained 1.553,164 13 of these waves and the reciprocal of this number has been internationally adopted as the definition of the primary standard: "the wave length of the red ray of light from cadmium is 6,438.4696 angstroms in dry air at 15° C. on the hydrogen thermometer, at a pressure of 760 mm. of mercury, the value of g being 980.67 (45°)." The probable error of this absolute value is of the order of 1 part in 16,000,000, i.e., somewhat less than the least error in the intercomparison of two metre bars.

A half century of intensive study of the spectra of natural elements proved that the red radiation from cadmium vapour is orobably the best primary standard that nature provides, but in 1940 W. Wiens and L. Alvarez demonstrated that a pure artificial isotope of mercury (Hg<sup>188</sup>) obtained by bombarding gold (Au<sup>197</sup>) with neutrons probably presents a superior primary standard. It is not unlikely that a progressive world will some day adopt the wave length of green radiation (5,461 A) from Hg<sup>188</sup> as its most convenient, constant, indestructible, accurately definable, and reproducible fundamental standard of length.

A method of measuring, with high accuracy, the ratio of two different wave lengths was outlined in principle in our brief discussion of the Fabry-Perot etalon interferometer. After 1907 this method was used in several laboratories to determine, relative to the primary standard, the wave lengths of selected lines which might serve as secondary standards. The wave lengths of several thousand atomic radiations characteristic of helium, neon, argon, krypton, xenon, iron, titanium in laboratory spectra, and well over 1,000 lines in the sun's spectrum, have thus been measured, but only such mean values are accepted as secondary standards by the International Astronomical union as have been independently and concordantly measured in at least three laboratories. For example, in the iron spectrum interferometric measurements have been made on thousands of lines with wave lengths ranging from 2,101 A to 10,216 A but only 306 secondary standards ranging from 2,447 A to 6,677 A have been adopted. These iron secondary standards are believed to be accurate within ±0.001 A but to insure their reproducibility the source is carefully specified as "the Pfund arc operated between 110 and 250 volts, with 5 amperes or less, at a length of 12-15 millimetres used over a central zone at right angles to the axis of the arc, not to exceed 1-1.5 millimetres in width, and with an iron rod 6-7 millimetres diameter as the upper pole and a bead of iron oxide as the lower pole." The International Astronomical union has also adopted as tertiary standards the wave lengths between 3,371 A and 6,750 A of 312 iron lines derived from secondary standards by grating or interferometer interpolation. In the absence of official standards in the extreme ultra-violet, spectroscopists have been forced to use preliminary values obtained by the coincidence method of overlapping orders in grating spectra or by direct calculation from spectral series formulae or from spectral terms accurately determined from longer waves.

Interpolation of Wave Lengths.—The wave lengths corresponding to lines in any spectrum whatsoever are readily determined by interpolation between standards, provided that the spectrum of the international iron arc is recorded with the same spectrograph. For this purpose the spectrum of the source under examination is photographed through one portion of the slit, and the arc spectrum of iron through one or both of the adjacent portions, so that two spectra in juxtaposition, or slightly overlapping, are obtained as illustrated in Plate I, fig. 5. For accurate determinations the relative positions of spectral lines and standards are measured with a micrometer or comparator consisting of an accurate screw designed to translate the spectrogram under a microscope so that the lines and standards are brought successively into coincidence with a reticle. The positions of the lines are then read from a scale which indicates complete turns of

the screw, and a divided drum head which registers fractions of a turn

In prismatic spectra the dispersion increases rapidly as the wave length diminishes, and linear interpolation will not give correct results. Approximate values of wave lengths may be obtained by interpolation on a graph of dispersion versus wave length constructed by plotting scale readings of standard lines as abscissae and wave lengths as ordinates. The most accurate method of determining wave lengths in prismatic spectra is by mathematical interpolation with the Hartmann dispersion formula which gives a simple relation between wave length,  $\lambda$ , and linear scale reading, r.

$$\lambda = \lambda_0 + \frac{c}{r - c_0}$$

where  $\lambda_0$ , c, and  $r_0$  are constants which can be evaluated from the solution of three simultaneous equations containing three known wave lengths or standard lines and their corresponding scale readings.

Relative wave lengths are most readily obtained from diffraction spectra since linear interpolation between standards is justified by the fact that the dispersion is constant or nearly so, in a given grating order or setting. If  $r_i$  and  $r_f$  are millimetre scale readings for initial and final standards,  $\lambda_i$  and  $\lambda_f$ , on a spectrogram, the dispersion  $d = (\lambda_f - \lambda_i)/(r_f - r_i)$  A per mm. The product of this dispersion constant and  $r_i$  subtracted from  $\lambda_i$ gives a constant \(\lambda\_0\) which, on any calculating machine, can be automatically added to any  $d \cdot r_x$  and the final result is  $\lambda_x = \lambda_0 +$  $d \cdot r_m$ . Both in prismatic and in grating spectrograms intermediate standards should be measured, in the former case to test the fit of the dispersion formula and in the latter to test the normality of the spectrum. If the calculated values deviate from the true standards a plot of such deviations will reveal the proper corrections to apply to the wave lengths calculated for the other measured lines. Under the most favourable conditions such interpolated wave lengths are probably correct within a few thousandths angstrom. All wave-length measurements relative to iron standards are obviously facilitated by reference to a good photographic map of the iron-arc spectrum permitting instant identification of the standards. A small portion of such a map is reproduced in Plate I, fig. 4.

Intensity Measurements.-The exact determination of relative intensities of the various parts or lines of a spectrum is in most cases as important as exact wave-length measurement but this phase of spectroscopy had a tardy development, partly because of experimental difficulties and partly because the important applications were mostly unrecognized before 1025. Only heat-absorbing detectors show a linear and nonselective response to spectral intensity and since they are naturally inefficient heat engines their use has been restricted mainly to infra-red spectra. All other detectors, being nonlinear and selective, require calibration but this is a complicated and difficult operation, especially in the extreme ultra-violet where heat detectors are relatively insensitive. Consequently, even the most modern tables of identified spectral lines contain only rough estimates of line intensities on arbitrary scales which differ from spectrum to spectrum and frequently from region to region in the same spectrum. These arbitrary intensity scales usually represent visual estimates of photographic blackening and they range from I to IO or I to 1,000 or 1 to 10,000. Such estimates have no definite meaning and no truly quantitative value.

After 1925 the need for accurate measurements of spectral line intensities was stressed by the new quantum theory of atomic spectra and by a rebirth of quantitative spectrochemical analysis. Mathematicians predicted important relationships between line intensities and multiplet structures or quantum numbers, and experimental spectroscopists promptly devised methods of testing the theory. Simultaneously in applied spectroscopy quick methods of accurate chemical analysis based on the measurement of spectral-line intensity ratios were empirically developed. Since almost all spectroscopic observing was done photographically the quantitative determination of intensities from spectrograms required

the construction and use of suitable microphotometers or microdensitometers to measure the photographic densities of spectral line images. By making a series of exposures of known ratio, either in intensity or in time, photographic density as a function of radiation intensity of a given wave length can be determined for the particular type of photographic emulsion employed, and from density measurements at different wave lengths in a comparison spectrum of known energy distribution true intensity ratios can be deduced. Standard sources of known energy distribution are found in the black body or in metal-filament lamps operated at specified colour temperatures. Photographic sensitivity and contrast may be regarded as constant in narrow spectral regions such as those encompassed by compact multiplets, hyperfine multiplets, Zeeman patterns or close line pairs, and in these cases relative intensities of component lines are determinable without spectral energy calibration.

minable without spectral energy calibration. Absorption Spectra .- In 1859 G. Kirchhoff gave mathematical and experimental proof of the following law: "The ratio between the powers of emission and the powers of absorption for rays of the same wave length is constant for all bodies at the same temperature." From this it follows that a transparent body cannot emit light, and one that radiates a continuous spectrum must be opaque. Further, a gas that radiates a line spectrum will absorb the lines which it radiates at the same temperature. For example, lines observed in laboratory arcs as emission spectra of 66 elements or compounds have been identified as absorption lines in the spectrum of the sun. As a consequence of Kirchhoff's law practically everything that has been said about emission spectra applies also to absorption spectra. There are, however, some experimental conditions that permit molecular identification and quantitative chemical analysis by means of absorption spectra that cannot be duplicated in emission spectra. Thus in the analysis of inorganic compounds (salts, minerals, etc.) by emission spectra the light sources (flames, arcs, sparks) commonly used for exciting the spectra completely dissociate the compounds revealing intense spectra of the metallic atoms and of unstable compounds formed in the light source, whereas the spectra of the halogens or radicals are either unobserved or masked. Thus, essentially the same atomic emission spectrum is observed with various metallic compounds (halides, oxides, carbonates, sulphates, etc.). Similarly organic molecules (tissues, dyes, etc.) are atomized by the heat and excitation of emission sources, revealing only spectra of metallic impurities that may be present, while the emission spectra of carbon, hydrogen and oxygen are indistinguishable from those emitted by atmospheric constituents, dissociated carbon dioxide and water vapour. In many cases, however, inorganic compounds in solution and organic compounds in general exhibit characteristic absorption spectra which distinguish them from each other. Since absorption spectra of compounds are observed at relatively low temperatures the molecules are stable and unimpaired, but since the substances are then usually in a liquid or solid state, rather than in a gaseous state, the absorption will depend on the energy content of the molecules and on the perturbing effects of surrounding molecules. These absorption spectra therefore usually consist of one or more broad bands in which the energy distribution is characteristic of the compound. If an unknown mixture contains two or more absorbing compounds their identity and relative amounts can be determined if the absorption bands are sufficiently different in wave length and accurately defined to permit an estimation of their relative intensities. Extraordinarily narrow absorption bands, almost linelike, are exhibited by solids, solutions and glasses containing atoms that possess one or more f-type electrons ("rare earths" with atomic numbers 58 to 71 and 91 to 96). This is illustrated in Plate I, fig. 2a, by glass coloured with salts of neodymium, atomic number 60. A typical example of true line absorption is shown in Plate I, fig. 2b, which represents the appearance of a continuous spectrum after passing through a column of atomic potassium vapour. Narrow lines belonging to molecular spectra of oxygen (O2) and water vapour (H2O) are readily observed in absorption but not in emission. Red and infra-red bands of these molecules invariably appear

on spectrograms made in the laboratory with long focus spectrographs provided that the light source emits a continuous background, and they are outstanding features of the solar spectrum especially when the sun is near the horizon and shines through the thickest layer of terrestrial gas and vapour. Similarly, because of the great depth of absorbing vapours in the solar atmosphere the atomic spectrum of iron is much more fully revealed in the Fraunhofer spectrum than has been observed in laboratory emission spectra.

#### APPLICATIONS

The principal applications of spectroscopy are to (1) chemical and physical analysis, (2) research on atomic structure and the mechanism of radiation and (3) investigations of some properties of atomic nuclei.

Spectrochemical Analysis.—That a system of qualitative chemical analysis could be based on spectroscopic observations was first convincingly demonstrated by Kirchhoff and Bunsen who (1860) applied spectroscopy to the discovery of two alkali metals (Rb and Cs) and to the identification of chemical elements in the sun. Save for chemical analysis of meteorites that fall to earth there is no way to lean anything concerning the chemical and physical conditions of celestial bodies except from an analysis and interpretation of the light those remote bodies emit. Consequently the challenge and urge to apply spectroscopy to astronomy was irresistible, and an amazing accumulation of information on the radial motions, chemical compositions, and physical conditions of planets, comets, stars and nebulae now constitutes the science of astrophysics (q,v.).

In terrestrial laboratories the application of spectroscopy to chemical analysis has always had to compete with conventional chemical methods and progress was slow until precise photographic photometry was introduced about 1925, whereupon quantitative spectrochemical analysis quickly became common practice throughout the world. It is readily observed that when one element is progressively diluted in another the spectra of the diluted element become progressively weaker and simpler until they finally vanish when the concentration is less than the limit of spectroscopic detection. Under specified conditions of observing, these partial or residual spectra may be correlated with the known composition of synthetic mixtures or standards and thus provide criteria for the quantitative estimation of comparable unknowns. This is essentially the principle of spectrochemical analysis as first applied to solutions by W. N. Hartley about 1880, to fused salts by A, de Gramont about 1900 and to metal alloys after about 1920. In 1925 W. Gerlach showed that unavoidable fluctuations in light sources and spectrum photography could be largely eliminated by referring the intensity of an impurity line to a neighbouring line of the major component as standard. In the spectrum of any alloy or mixture of known composition, one or more pairs of lines can usually be found in which a strong (analysis) line of a minor constituent has the same intensity as a weak (internal standard) line of the major constituent. When such homologous pairs are found in spectrograms of samples containing different but known amounts of the analysis element, the concentration of this element in other samples is found by intercomparing the line pairs and selecting the one in which the two lines are of equal intensity. A further improvement of this internal-standard method resulted from the use of only one pair of lines the relative intensities of which in known samples are determined by photometric tensities of which in known samples are determined by photometric measurements, and plotted as a function of concentration of the analysis element. If he two variables are plotted on logarithmic scales, the resulting analytical curve is usually a straight line with slope about 1. After preparing such a calibration graph for each analysis element any sample of comparable composition is easily analyzed by measuring line-intensity ratios and reading concentrations from the graphs. An meaninessly ratios and reating contentrations from the graphs. An excellent description of the preparation of samples and standards, spark excitation of spectra and analytical procedure can be found in Spark Spectrographic Analysis of Commercial Tin, published (1942) by B. F. Scribner as Research Paper 1,451 of the national bureau of standards, U.S. department of commerce. Similar procedures have been perfected for the analysis of iron alloys, aluminum alloys, magnesium alloys, brasses, bronzes, type metal, and practically all other types of metallic compounds. Careful chemical calibration and photographic photometry have reduced routine analytical errors to 1% or 2% of the amount present, and the time required for a complete analysis of a sample has been reduced to ten minutes or less. Since most of the time

required for such an analysis is consumed in procuring and measuring a photographic spectrogram, claborate spectrographs have been constructed with 12 photoelectron multiplier tubes to receive light from an intenal standard line and from 11 different analysis lines. Radiant energies received by these phototubes are amphified to actuate indicators calibrated in percentage composition thus permitting simultaneous and almost instantaneous determination of 11 elements. For composition control of metals and alloys in production, spectroscopy has suipassed chemistry in speed, sensitivity and accuracy of analysis. It must be remembered, however, that no satisfactory absolute method of spectrochemical analysis has been devised; all the practical methods by 1047 were relative to synthesized standards or chemically analyzed samples which serve for spectrographic calibration.

1947 were relative to synthesized standards or chemically analyzed samples which serve for spectrographic calibration.

Emission spectioscopy has also found extensive application to analytical problems in agricultural, biological and pathological chemistry, in mineralogy and geochemistry and in archaeology and climinology. In these problems the samples are often in highd or powder form which can be vaporized and excited to emit spectra either in hot flames or in electric arcs or sparks between electrodes of pure carbon. Usually a definite amount of some suitable element is added to supply internal standards and then the calibration and analytical procedures are essentially the same as for solid metal samples.

Empirically it is found that operating with beth sources at atmos-

Empirically it is found that operating with light sources at atmospheric pressure and with spectral detectors sensitive between 2,000 and 9,000 A at least 70 chemical elements can be readily determined by emission spectroscopy. This is related to the fact that these elements have ionization potentials less than ten volts and their strongest lines have wave lengths between the limits mentioned. Gaseous elements have higher ionization potentials; their strongest lines are in the far ultra-violet and their spectra are fully developed only at reduced pressure in Gessler tubes. In principle, everyone of the 50 chemical elements can be detected and determined by means of emission spectra, provided that proper sources and spectrographs are emission spectra, provided that proper sources and spectrographs are emission spectra, provided that proper sources and spectrographs are emission spectra.

son spectra, provided that proper sources man spectrage properties and of Atoms.—Because atomic spectra appear, generally, to consist of a random distribution of lines of different intensities, a century elapsed between the discovery of spectral lines by Fraunhofer and a fruitful clue to their physical interpretation by N Bohr (1913). Then in little more than a decade an amazing development in analysis and theory of spectral structure made all spectra interpretable in terms of atomic properties and, conversely, permitted the deduction of atomic structure from observations on spectra.

Hydrogen is the lightest atom and possesses the simplest spectrum; in the visible it consists of a regular succession of lines with ever closer spacing and decrement of intensity in the direction of shorter wave lengths (see Plate I, fig. 6). In 1885 J. J. Balmer discovered an extremely simple mathematical relationship between these 1H lines. Expressed in wave numbers the Balmer formula gives  $\nu=R/2^2-R/n^2$ , where the constant R=100,677,8 cm<sup>-1</sup>, and  $n_1$  represents the integers 3, 4, 5 . . . . . This Balmer series begins with 6,562 A and ends at 3,646 A. Similar 1H series were later found in the extreme ultraviolet,  $\nu=R/1^2-R/n^2$ , by T. Lyman, and in the infra-red,  $\nu=R/3^2-R/n^2$ , by F. Paschen, All possible H series can be accurately represented by one formula,  $\nu=R/n^2-R/n^2$ ; where  $n_2$  and  $n_1>n_2$  are integers and  $n_2$  is constant for a given series. Thus the wave number of any H line can be expressed as the difference of two quantities, the larger being a constant term called the limit of the series, whereas the other varies from line to line and is known as the running term.

other varies from line to line and is known as the running term. In 1889 J. R. Rydberg reported finding series in the spectra of alkali (Plate I, figs. 8, 9) and alkaliane earth elements (Plate I, figs. 70), and notwithstanding the imperfect data then at his disposal he discovered most of the important properties of spectral series. From certain characteristics of the lines he distinguished three species of series, principal, sharp and diffuse, superposed in the same spectrum, and he recognized that the members of each series were double for alkaline (7 Li, 1x Na, 19 K) and either single or triple for alkaline earths (12 Mg, 20 Ca, 30 Zn). Rydberg found that each series could be represented in wave numbers by a formula of the type  $v = L - \frac{R}{R}$ . In which L is the L-in the state of the series where L is the L-in the state of the series of the seri

 $\frac{n}{(m+\mu)^3}$ , in which L is the limit of the series, R the Rydberg constant (practically identical with R in the Balmer formula) and m has successive integral values to which a constant fractional part,  $\mu$ , is added. A fourth type of series was discovered in 1907 by A. Bergmann, and because it was more hydrogenlike ( $\mu \approx \infty$ ) than the others it came to be called fundamental. Rydberg also indicated that the difference between the limit of the P series and the common limit of the D and S series is equal to the wave number of the first line of the P series, and C. Runge in 1908 pointed out a similar relation between the D and F series, so that all the different series were interconnected. An abbreviated notation was then adopted for the four basic types of series:

Principal, v=n S-m P Sharp, v=n P-m S Diffuse, v=n P-m D Fundamental, v=n D-m F

where n stands for a simple integer, and m for appropriate integers

plus µ. In order to distinguish the components of doublets and triplets from each other it was necessary to add subscripts to these term symbols. In addition to the regular scenes others were detected when the limits were changed and still others between singlet and triplet terms (Ritz combination principle). Thus it appeared that any given term might combine with many others, and although two terms were necessary for each observed line the total number of terms required to represent any spectium completely might be much smaller than the total number of lines.

In 1944 A. Fowler found ionized belium atoms (2 He\*) characterized by a hydrogenlike series except that the Rydberg constant R required multiplication by 4 He also discovered, in the spark spectra of 12 Mg\*, 20 Ca', and 38 Sr\*, series of doublets resembling the P, S and D doublets of alkalis, but with 4 R in their formulas. By 1949 the regularities detected in vanous spectra sufficed to suggest two general laws: (1) the alternation law which states that even and odd multiplicities of terms alternate in successive columns of the periodic system (2) the displacement law which states that the spectrum of an ionized element resembles that of the neutral element preceding it in the periodic system (see Plate II). Term multiplicities of atoms or ions are thus determined solely by the number of electrons, whereas the atomic charge affects the position of the spectrum. These facts suggested a direct connection between spectral lines and the electrons and protons in atoms

suggested a direct connection between spectral lines and the electrons and protons in atoms.

In 1913 N. Bohr proposed two fundamental postulates, viz, that atomic stationary states exist, and that the radiation frequency is equal to the energy difference of two states divided by Planck's constant (h=6.64 x to-2" erg sec.) The empirically established spectral terms must therefore be interpreted as quantized stationary energy states characteristic of atoms and ions. The rapid development of the quantum theory of radiation constitutes one of the most thrilling chapters in the history of science (sec QUANTUM MECHANICS).

Quantum Numbers and Atomic Energies,—Omitting further review of historical and experimental details the following discussion is restricted to a vector model of the Rutherford-Bohr atom (see Atom) which is assumed to consist of a tiny but massive

Quantum Numbers and Atomic Energies.—Omitting flurther review of historical and experimental details the following discussion is restricted to a vector model of the Rutherford-Bohr atom (see Arom) which is assumed to consist of a tiny but massive nucleus (composed of protons and neutrons) around which circulate one or more electrons. The maximum number of electrons in any atom is expressed by its atomic number, Z (identical with the number of protons in its nucleus), and this number langes from 1 for H, the lightest, to 92 for U, the heaviest element in nature. These electrons move in imaginary orbits about the nucleus at average distances represented by a principal quantum number, n, which in turn numbers the successive shells of the periodic system and serves as a coefficient to the term symbol, S, P, D, F, etc. A sequence of n term values subtracted from a limiting term gives the wave numbers of lines in a spectral series. In most cases an electron jump from one shell or value of n to any other shell or value of n constitutes the largest change in energy that can occur in a given atom. If an electron is moved from its lowest value of n to n= 5 the atom is lonized, and the energy required to accomplish the removal of an electron is called the ionization potential. This energy is usually expressed either in wave numbers (cm.²) or in electron volts (ev.); in the case of 1H it is 109,677.58 cm.² (the Rydberg constant) or 1395 ev. (See Table VIII.) Hydrogen-lik (the Rydberg constant) or 1395 ev. (See Table VIII.) Hydrogen-lik the spectra are also emitted by ionized helium (21E°), by doubly ionized lithium (31E°), by terobly ionized benyllium (48e\*\*), etc., but the spectra are as shifted successively toward higher frequencies, because the energy of electron orbits as a function of n is proportional to 27/4°. It follows that for 24He' the separation energy of the remaining electron from the lowest level (the ionization potential) will be 4 times that for the 1H atom; for 3Li\*\* it will be 9 times as great and for 4B

3LN' it will be 9 times as great and for  $48e^{-1}$  to times. The next largest change in atomic energy (after that due to a change in n) is usually that associated with a constant orbital angular momentum of the optical electron. This momentum is pictured as a vector of magnitude 0, 1, 2, 3, ... in  $h/2\pi$  units; it is called the azimuthal quantum number and is symbolized by l. The numerical values of l=0, 1, 2, 3, ... correspond respectively to the empirical rem symbols, S, P, D, F, ... originally abbreviated from the different types of series first found in the spectra of alkali atoms. Electrons with l=0 are called s-electrons; those with l=1, P-electrons; those with l=1, P-electrons. It may be interjected here that these four l values and the first seven n values suffice to describe the normal electron configurations of all possible atoms and ions. When two or more optical electrons are present their individual orbital momenta, l,  $l_0$ , ... are added vectorially to form a resultant  $L_p$  but quantum theory dictates that such a resultant and l at the possible resultant L values are  $L = (l_1 + l_2)$ ,  $(l_1 + l_2 = 1)$ ,  $(l_1 + l_2 = 1)$ . The vector addition for this case, is shown graphically in fig. 13. If all but one of the l are zero, the resulting L values of two electrons and ther combining each of the resulting L values with the l of the third electron. The term types given by various simple electron configurations are shown in Table I.

Table I -L Values and Term Symbols Assing From Various Simble Electron Configurations

Electron Configurations	L	Term Symbols
ss sp pp pd dd dd df y ppp	O 1 2 1 2 3 4 5 6 O 1 1 1 2 2 3	SPP SPDF SPDFG SPDFGH PDFGHI SPPFDDF

Quantum theory and observation prove that an important selection rule controls atomic energy changes resulting in radiation—viz., the greatest intensity of emission results when  $\Delta L = \pm 1$ . In addition, when the interaction of the elections is small, only those quantum transitions take place for which only one of the electrons alters its I value in accordance with the selection rule.  $\Delta I = \pm 1$ . Notwithstanding these simple jules, many spectra exhibit lines corresponding to

ing these simple rules, many spectra exhibit lines corresponding to L=0,  $\pm z$ ,  $\pm z$ , as well as to double-electron jumps. A third contribution to the total energy of an electronic system comes from the rotation of each electron about its own axis. This axial angular momentum has the same magnitude for each electron  $s=\frac{1}{2}(h/2\pi)$ , it is usually called the electron spin. When two or more electrons are present, the individual spin vectors  $s_1$  combine with each other to yield a resultant S (just like the  $l_1$  combine to form L). Analogous to L, the resultant spin S can take only certain discrete values, the maximum being obtained when all the  $s_2$  are parallel, and the minimum being one-half or zero according as the number of the minimum being one-half or zero according as the number of

electrons is odd or even.

The spinning electrons, and their resultant spin vectors S, account The spinning electrons, and their resultant spin vectors S, account for the spinting of most spectral terms into two or more components, and piovide a physical meaning for the subscripts (linear quantum numbers) originally attached to components of polyfold terms. The total angular momentum J of an atom is the vector sum of the resultant orbital angular momentum L and the resultant axial angular momentum S. According to quantum theory, L and S can angular momentum s. According to quantum theory, 2 and 3 can be oriented to each other only in certain directions, and therefore only certain discrete values of the resultant J are possible. The largest and smallest values of J result from simple addition and subtraction of L and S, while all intermediate values of J that differ by integral amounts are allowed. That is:

$$J=(L+S), (L+S-1), (L+S-2), \ldots |L-S|.$$

This rule is illustrated graphically for simple cases in fig. 44. When L>S, it is obvious that the number of permitted I values for a given value of L is z3+x. On the other hand, if L<S, the number of permitted I values for a given L is L+x. Thus, for S terms (L=0, zL+1=1) there is only one value of I, viz., I=S. Similarly, for P terms (L=1, zL+1=3) the number of components can never exceed three. However, for a great majority of terms L>S and for all these the possible number of components or term multiplicity I is equal to 2S+1. The empirically indicated alternation law follows directly from this result is nee the maximum multiplicity will be even directly from this result since the maximum multiplicity will be even

or odd according as the number of electrons is odd or even. In general, atomic energy states with different S are not expected to combine with one another because of a selection rule  $\Delta S = 0$ , but intersystem combinations are found to be fairly abundant and intense, especially as the atomic number increases. Table II displays the resultant S values and possible multiplicities for different numbers of electrons, (See also Plate II, figs. 1, 2, 3, 4.)

TABLE II .- Resultant S Values and Possible Multiplicities

Number of Electrons	S	Possible Multiplicities, r.
1 3 4 50 7 8	1/2 0, 1, 1/2, 3/2 0, 1, 2 1/2, 3/2, 5/2 0, 1, 2, 3 1/2, 3/2, 5/2, 7/2 0, 1, 2, 3, 4	Doublets Singlets, triplets Doublets, quartets Doublets, quartets Doublets, quartets Singlets, triplets, quintets Doublets, quartets, sextets Singlets, triplets, quintets, seplets Doublets, quartets, sextets, octets Singlets, triplets, quintets, seplets, noneis

The total angular momentum of an atom can have integral or half integral  $J(h/2\pi)$  values because  $s=\frac{1}{2}(h/2\pi)$  for each electron. Furthermore, different sets of J values are associated with the same type of term (same L value) in systems of different multiplicity, because S is different, and finally, different sets of J values apply to different terms in the same multiplicity system because J=L+S. Since J represents the total angular momentum it is the most important quantum number for the fine-structure or multipliet analysis of atomic and ionic spectra. It has a perfectly definite physical meaning and quantitative value under all circumstances. Atomic energy changes are rigorously regulated by a simple selection rule, viz.,  $\Delta J = 0, \pm 1,$  recept that all 0 to 0 transitions are prohibited. Since the a priori probability that an atomic energy state exists is expressed by its statistical weight aJ+1, t its obvious that J is important for the relative intensities of spectral lines. The J values that belong to a few

different spectral terms in different multiplicity systems are shown in Table III

For any given spectrum in which energy levels have been established, relative values of J attached to the levels are readily determined from their combining properties and the selection rule.

$$\begin{vmatrix} I_{1-2} \\ I_{2-1} \\ I_{2-1} \end{vmatrix} = \begin{vmatrix} I_{2-1} \\ I_{2-1} \\ I_{2-1} \end{vmatrix} = \begin{vmatrix} I_$$

FIG. 13 --- VECTOR ADDITION OF OR-BITAL ANGULAR MOMENTA  $I_1=2$  and  $I_2=1$  to give resultants L=3,

L=3 o,±1. In spectra resulting from terms of odd multiplicity the absothe value of J is fixed by the absence of the transition J=0 to J=0 which is forbidden. In other cases, the absolute value of J can be deduced from the multiplicity and type of term if these are un-

2, 1 and type of term it these are un-ambiguous, as, for example, in mul-tiplets which are sufficiently law-abiding so that the terms can be identified from the sum rule (the sum of the intensities of all the lines of a multiplet which belong to the same initial or final state is proportional to the statistical weight 2J+1 of the initial or final state respectively), or from the interval rule (the interval between two successive components, J and J+1, of a polyfold term is proportional to J+1). Analysis of the more complex spectra is usually hopeless without the aid of Zeeman effect, i.e., the splitting of the lines into polarized components when the source of light is placed in a strong magnetic field. The total angular momentum J is space-quantized in a magnetic field and can assume 2J+1 discrete values which are differentiated by magnetic quantum numbers M. The magnitude of the level sphtting is the same for all singlet levels (normal Zeeman effect) but differs for all other terms according to the values of L and J (anomalous Zeeman effect). From any completely resolved Zeeman pattern the J values of the two combining levels are deduced at once from the number of components and the L values are simultaneously derived from the separations of the components since the splitting factors

FIG. 14.-VECTOR ADDITION OF ORBITAL MOMENTUM L AND AXIAL MO-MENTUM S FORMING RESULTANTS J FOR 8P, 3D, 4P AND 4D TERMS

4D7/2

have been accurately given empirically and by the quantum theory (see ZEEMAN EFFECT)

Summarizing the above discussion of quantum numbers we find that any atomic energy level (spectral term) is completely specified by four quantities: (1) its principal quantum number n which indicates the electron shell or period which the optical electron occupies; (2) its type—S, P, D, F, etc. where the capital letters stand for azimuthal quantum numbers or orbital angular momenta L=0, 1, 2, 3, etc., respectively; (3) its inner quantum number or total angular momentum I (written as a suffix or subscript to the term type symbol); and (4) its multiplicity number, r=2S+1, written as a superior prefix to the term type symbol. Thus  $4^3D_2$  represents the middle component (I=2) of a D term (L=2) in a triplet system (r=3) for which the principal quantum number n=4. Theoretically, the energy difference of two terms appears as intense radiation only when  $\Delta L=\pm x$ ,  $\Delta I=0$ ,  $\pm x$ ,  $\Delta I=0$ , and the two terms are of opposite parity, i.e., odd and even (Laporte rule). Typical energetic relationships of spectral terms and combining properties of the levels are shown graphically in fig. 15 which represents the spectrum of neutral mercury atoms. azimuthal quantum numbers or orbital angular momenta L=0, 1, 2, mercury atoms.

Table III -J Values for Terms of Odd and Even Multiplicity

	Odd Multiplicities							
Terms	Singlet	Triplet	Quintet	Septet				
S P D F G H	° 1 2 3 4 5	T 2 T 2 3 2 3 4 3 4 5 4 5 6	2	3 2 3 4 1 1 3 4 5 0 1 2 3 4 5 6 1 2 3 4 5 6 7 2 3 4 5 6 7 8				
		Ev	en Multiplicities					
Terms	Doublet	Quartet	Sextet	Octet				
S P D F G H	1/2 1/2 3/2 3/2 5/2 5/2 7/2 7/2 9/2 9/2 11/2	3/2 1/2 3/2 5/2 1/2 3/2 5/2 7/2 1/2 3/2 5/2 7/2 9/2 5/2 7/2 9/2 11/2 7/2 9/2 11/2 13/2	5/2 1/2 5/2 7/2 1/2 1/2 5/2 7/2 9/2 1/2 3/2 5/2 7/2 9/2 11/2 3/2 5/2 7/2 9/2 11/2 13/2 5/2 7/2 9/2 11/2 13/2 15/2	7/2 3/2 5/2 7/2 9/2 3/2 5/2 7/2 9/2 11/2 1/2 3/2 5/2 7/2 9/2 11/2 13/2 1/2 3/2 5/2 7/2 9/2 11/2 13/2 15/2 3/2 5/2 7/2 9/2 11/2 13/2 15/2 17/2				

TARTE	TV Pace	ible States	of an	Electron in	dtom

						-																								
	K		1							M											1	1								
n	I			2			3				4																			
ı	0	0		I b		0		ĭ b				2 d.			0		1				2						3 f			
				P				P							3		P				- 4	<u> </u>					,			
$m_l$	٥	0	- ı	٥	+1	٥	-r	0	+1	-2	- r	0	+1	+2	0	r	٥	+1	-2	- I	0		+2	-3	-2	- I	0	+1	+2	+3
$m_{\epsilon}$	11	1↓	11	11	1	11	11	11	11	⇅	11	1	11	îl	1	11	11	1	11	14	14	1	T.	1↓	îΙ	N	11	1	11	11

Pauli Exclusion Principle.-Having found an electronicquantum interpretation of spectral terms it is next in order to seek the connection between spectral terms and atomic structure. In order to understand the building-up of the periodic system (see Periodic Law, Tels, and account for stuking periodicities in atomic properties it is necessary to introduce a new assumption, known as the Pauli exclusion principle, which states that. "in one and the same atom, no two electrons can have the same set of values for the four quantum numers, n, l, m, and m, n." Table IV shows the electron shells and subgroups that are possible for atoms as a consequence of this exclusion of the properties of the second of the s to understand the building-up of the periodic system (see Periodic principle. The n cells are divided by l and the l cells are further divided by mi and by me, but instead of inserting the last quantum numbers

SINGLETS TRIPLETS cm.  $^3D_2$ D, 3D3 3F2 3 4 84.17 10 43 (EE 10<u>d</u> 施 80.00 70.00 916 60.00 ره. 50,000 40,000 30.000 849 20,000

-ENERGY-LEVEL DIAGRAM OF THE FIRST SPECTRUM OF MERCURY

the presence of an electron in a (n, l, m) cell is represented by arrows pointing up or down according as  $m: j \mapsto j$  or -j. Only two electrons can be meach such cell, and then only when they have antiparallel spin directions, since otherwise these two electrons would have the same four quantum numbers  $n, l, m_l, m_s$ . The maximum number of electrons that can have the same n and l is given by the number of arrows in the corresponding cells. This number is equal to 2(2l+1), since 24+1 is the number of possible  $m_1$  values for a gave 1/2+1/5 since 24+1 is the number of possible  $m_1$  values for a given 1/2+1/5 since 1/2+1/5 ties when arranged in atomic number sequence. Naturally the electron configurations of atoms in their lowest possible energy states, and the corresponding spectral terms, will show a periodicity, since, after a certain number of electrons of a given type have been added, the

outermost electron will be once more, for example, an s-electron. The spectral terms describing ground states of atoms may be deduced from assumed electron configurations by adding together the l and s moments of the individual electrons, but first it is necessary to make an assumption about the mutual coupling or interaction of the individual vectors. The coupling that seems to be most common is called LS coupling; it may be expressed symbolically:

$$(l_1, l_2, \ldots) (s_1, s_2, \ldots) = (L, S) = J.$$

(ii,  $t_2, \ldots$ ) (s<sub>1</sub>,  $s_2, \ldots$ ) = (L, S)=J. This means that the individual I, vectors are strongly coupled to produce resultant L values of different energies, and the individual s, vectors are also strongly coupled to produce resultant S values of different energies. The resultants L and S are then less strongly coupled with one another and their resultant is J. Other types of electron coupling, in particular ji coupling, cour relatively rarely, but coupling intermediate between LS and ji is found more frequently, especially among excited states of heavy elements. However, because LS coupling applies to all the lighter elements, predominates in many others, and is either accurately or very approximately valid for the ground states of all atoms and ions it forms the basis for the standardized notation for spectral terms. ardized notation for spectral terms.

The spectral terms arising from nonequivalent electrons (belonging to different n, l groups of Table IV) may be obtained, in simple cases, by adding the L values of Table II. For example, two nonequivalent p electrons, pp, yield (L=0, 1, 2) S, P,

TABLE V .- Terms of Nonequivalent Electrons

Electron Configurations	Terms (omitting J values)	
ss sp pp pp dd d ss ss ss ss sp sp sp etc.	S. 18 T. 19	

present) have L=0 and S=0, and therefore always present the S=0 state. Closed shells can therefore be ignored when deriving the terms given by any electron configuration Furthermore, 'So for a closed shell must result when the shell is divided into two parts, the term types for each part derived, and the resulting angular momentum vectors added together. For example, adding the angular momenta of  $p^2$  electrons to the corresponding quantities for  $p^4$  electrons will give

TABLE VI -Terms of Equivalent Electrons

Electron Configurations	Terms (omitting J values)
5 <sup>2</sup>	1S 1D, 4P
P2 P2	19, 10, 15 19, 10, 15
d <sup>2</sup>	*P, *D(2), *F, *G, *H, *P, *F
d <sup>a</sup>	<sup>1</sup> S(2), <sup>1</sup> D(2), <sup>1</sup> F, <sup>1</sup> G(2), <sup>1</sup> I, <sup>3</sup> P(2), <sup>3</sup> D, <sup>3</sup> F(2), <sup>3</sup> G, <sup>3</sup> H, <sup>5</sup> D <sup>2</sup> S, <sup>2</sup> P, <sup>3</sup> D(3), <sup>2</sup> G(2), <sup>2</sup> H, <sup>2</sup> I, <sup>4</sup> P, <sup>4</sup> D, <sup>4</sup> F, <sup>4</sup> G, <sup>4</sup> S
fi fi	1S, 1D, 1G, 1I, 3P, 3F, 3H 2P, 2D(2), 2F(2), 2G(2), 2H(2), 2I, 2K, 2L, 4S, 4D, 4F, 4G, 4I
etc.	

the resultant for  $p^6$  electrons, ie,  ${}^1S_0$ . From this it follows that L and S must be the same for these two electron configurations, and the terms arising from  $p^4$  are the same as those from  $p^2$ . Similarly,  $d^6$  gives the same terms  $as^2 d^4$ ,  $f^{12}$  the same as  $p^2$ , etc. In general, any subgroup lacking one or more electrons to fill the group behaves spectroscopically as if the lacking electrons alone were present, except that the terms are regular (smallest J level has least energy) when the group is less than half filled but inverted when more than half filled. Finally, of the terms given by equivalent electrons, those with greatest multiplicity generally lie lowest, and of these the lowest inta with the greatest L. In Table VI the last listed term is the lowest energy in each family.

Normal States and Electron Configurations of Atoms.—

Normal States and Electron Configurations of Atoms. Quantum principles having thus specified the types of spectral terms arising from certain electrons, it became theoretically possible in 1923 to determine from identified spectral terms the electron configurations of all atoms and their ions. By 1946 the ground states of 8a atom had been uniquely determined from spectral structure, and since had been uniquely determined from spectral structure, and since these data are of great importance in spectroscopy, atomic physics and chemistry, they are collected in Table VII. In addition Table VII lists all the spectral multiphicities experimentally detected, all the reported spectroscopic ionization potentials, and the wave lengths of the strongest spectral lines characteristic of neutral atoms. In general, the strongest lines result from s→p electron transitions.

Hyperfine Structure of Spectral Lines and Properties of Atomic Nuclei.—When examined with apparatus of adequate resolving power, many spectral lines have been found to consist of two or more components lying extremely close together. This hyperness the structure is caused by properties of the stowic nucleus with which

fine structure is caused by properties of the atomic nucleus with which me structure is caused by properties of the atomic nucleus with whene optical electrons interact more or less according to their orbits. The actual line-splitting is exceedingly small (usually a fraction of a wave number) but nevertheless of very great importance because it provides a means of obtaining quantitative information about certain properties of isotopic nuclei. The spectroscopic influence of a nucleus may be due either to its mass or to an intrinsic angular momentum or nuclear spin, analogous to electron spin. The former is called isotope effect and the latter nuclear-spin hyperfine structure, or his for short. (See Plate II, figs. 5, 6, 7, 8.)

Isotope Effect.-Many natural elements consist of a mixture of two or more isotopes, each of which has an approximately whole number atomic weight. Different isotopes of an element have the same number and arrangement of outer electrons, and consequently have the same multiplet structure for their spectra. They are, how-ever, distinguished from each other by their mass because an electron necessarily revolves about the common centre of gravity of itself and the nucleus, and the Rydberg constant therefore depends on the nuclear mass. Thus the Balmer lines of rH<sup>1</sup> atoms are accompanied on the short-wave side by very faint companions ascribed to 1H2 and the detection of these isotope-effect components in 1932 constituted the discovery of heavy hydrogen. Similar isotope effects have been observed in many other spectra, but as soon as several electrons are

Table VII -Atomic Properties From Spectroscopy

Period	Atom	Ground Level	Electron Configura- tion	Spectral Multi- plicities	Ionization Potential ev	Strongest Line, A
2	1 H 2 He 3 Li 4 Be 5 B 6 C 7 N 8 O 9 F 10 Ne	2504 150 2504 150 2P6 3P6 4574 3P6	151 152 251 252 252 252 252 252	2 1, 3 2 1, 3 2 1, 3 2, 4 1, 3, 5 2, 4	13.505 24.580 5.390 0.320 8.30 11.264 14.54 13.614	1,215 66 584 33 6,707 85 2,348 61 2,497 78 1,057 01 1,134 98 1,302 19 954 8
3	12 Mg 13 Al 14 Si 15 P	2P2 15 1S0 2S0 15 1S0 2P2 15 4S2 15 1P2 1P2 1P3 15	331 332 332 332 333 343 352 363 363 363 363 363 363 363 36	1, 3 2 1, 3 2 1, 3 2 1, 3 2, 4 3, 5 2, 4 1, 3	17 42 21 559 5 138 7 641 5 984 8 149 11 0 10 36	735 80 5,889 05 2,852 13 3,901 53 2,516 12 1,774 94 1,807 31 1,347 22 7,664 91 4,226 73 5,71 80 4,981 73 4,817 73
4	16 S 17 CA 18 K 20 CSc 21 TI 23 V Cr 25 Mr 26 CO 27 CN 28 CU 29 CU 30 Zn	25015 150 2D145 2F2 4F116 7S3 6S234 5D4 4F634 2F1	352 356 451 452 361 452 362 412 363 452 365 452 366 452 367 452 367 452 368 452	1, 3 2, 4 1, 3, 5 2, 4, 6 1, 3, 5, 7 4, 6, 8 1, 3, 5, 7 2, 4, 6	13 01 15 755 4 339 6 111 6 7 6 834 6 738 6 76 7 43 7 896 7 896 7 896 7 723 7 723 9 391 9 900	1,048 22 7,064 91 4,226 73 5,671 80 4,081 73 4,379 24 4,254.35 4,030 76 3,581 70 3,414 76 3,247 54 2,138 56
5	31 Ga 32 Ge 33 As 34 Se 35 Br 36 Kr 37 Rb 38 Sr 39 Zr 40 Cb	150 2P8 34 3P8 4 4S7 34 4S7 34 1S0 2S0 4 1S0 2D1 4 2F2 4D0 4 7S2	452 452 452 452 452 452 453 452 453 453 453 454 454 455 461 551 462 551 552 461 552 461 553 461 553 463 464 551 464 551 465 464 551 465 464 551 465 465 465 466 551 466 551 466 551 552 466 553 553 553 553 554 555 555 555	2, 4 1, 3 2, 4 1, 3 2, 4 1, 3 2, 4 1, 3, 5 2, 4 1, 3, 5 2, 4 1, 3, 5 3, 5, 7	9 391 6 00 8 13 9 750 11 84 13 996 4 176 5 692 6 6 6 95 6 77 7 38	2,135 50 4,172 50 2,651 18 1,890 5 1,960 9x 1,488 4 1,235 82 7,800 23 4,607 33 5,466 47 4,687 80 4,058 94 3,798 25
6	47 Ruhd & duning & Arculate & Arc	6F: 4F:14 150 150 150 150 150 150 150 150 150 150	4d <sup>2</sup> 5s <sup>1</sup> 4d <sup>8</sup> 5s <sup>1</sup> 4d <sup>8</sup> 5s <sup>1</sup> 5s <sup>2</sup> 5p <sup>2</sup> 4d <sup>2</sup> 6s <sup>2</sup> 4d <sup>2</sup> 6s <sup>2</sup> 4d <sup>2</sup> 6s <sup>2</sup> 4d <sup>2</sup> 6s <sup>2</sup>	3, 5, 7 2, 4 1, 3, 5 1, 3 2, 4 1, 3 2, 4 1, 3, 5 1, 3, 5 2, 4 1, 3	7 5 7 7 8 33 7 5785 8 991 5 785 7 332 8 64 9 01 10 44 12 127 3 5 210 5.61	3,498 94 3,434 80 3,404 58 3,280 68 2,288 02 4,511 32 3,175 04 2,068 38 2,142 75 1,459 62 8,521 10 5,533 55 6,249,93 5,699,23 4,951 36 4,924,53
	62 Sm 63 Eu 64 Gd 65 Tb 66 Dy 67 Ho	7F6 8S94 9D9	4fe 6s <sup>2</sup> 4f <sup>7</sup> 6s <sup>2</sup> 4f <sup>7</sup> 5d <sup>1</sup> 6s <sup>2</sup>	7, 9 6, 8, 10 7, 9, 11	5 6 5.67 6.16	4,296 75 4,594 02 4,225.85
	68 FT Y L L T T T T T T T T T T T T T T T T	*F:24 1C0 to 4 *F:2 *F:3 *F:4 *F:4 *F:4 *F:4 *F:4 *F:4 *F:4 *F:4	4511 652 4514 653 561 652 564 653 563 653 563 653 563 653 563 653 563 653 563 653 563 653	2 I, 3, 5 I, 3, 5 5, 7 4, 6, 5, 7 4, 6, 5, 7 4, 3, 5 5 2 I, 3 7 2, 4	6.2 5.0 7 08 7.87 8.7 9.2 8.96 9.223 10.434 6.106 7.415	5,675.83 3,987 99 4,518.57 3,082.24 2,647 47 4,008 75 3,460 47 2,909,06 2,543.97 2,659 44 2,427.95 1,849.68 5,330.46 4,057.82 3,067.72 2,449.99
7	86 Rn 87 Fa 88 Ra 89 Th 91 Pa 92 U Np 93 Pu 94 Am 96 Cm	1S <sub>0</sub> 1S <sub>0</sub> 2F <sub>2</sub> 5L <sub>0</sub>	6s <sup>2</sup> 6p <sup>8</sup> 7s <sup>2</sup> 6d <sup>2</sup> 7s <sup>2</sup> 5f <sup>2</sup> 6d <sup>1</sup> 7s <sup>2</sup>	1, 3 1, 3 3, 5 5, 7	±0.745 5.277 ≈4.	1,786.07 4,825.91 5,915.40

present the simple mass effect observed in the hydrogen spectra is complicated by other factors which were not completely understood

in 1947. Nuclear-spin Hyperfine Structure.—True hfs can be simply and quantitatively explained if it is assumed that the nucleus of the emiting atom possesses an angular momentum and an associated magnetic moment. According to quantum theory the nuclear spin can be only an integral or half-integral multiple of  $h/2\pi$ . It is written  $I(h/2\pi)$ , where I is the spin vector or quantum number of the nuclear angular magnetic spin of the spin vector or quantum number of the nuclear angular spin of the spin vector or quantum number of the nuclear angular spin of the spin vector or quantum number of the nuclear angular spin of the spin vector or quantum number of the nuclear angular spin of the spin vector or quantum number of the nuclear angular spin of the spin vector or quantum number of the nuclear angular spin of the spin vector or quantum number of the nuclear angular spin of the spin vector or quantum number of the nuclear angular spin of the spin of t

iar momentum. The spectrum of the  $H_2$  molecule shows that for the simplest atomic nucleus, the proton,  $I=\frac{1}{2}$ . The proton thus has the same mechanical moment as the electron, but various values may be expected for heavier nuclei since they contain more than one proton. As with electron spin, a magnetic moment is associated with the nuclear spin, since the nucleus is electrically charged and the rotation nuclear spiri, since the nucleas is electrically charged and ne foration of electrically charged particles gives rise to a magnetic moment. Because a proton is the same size as an electron but 1,840 times heavier, the magnetic moment of an atomic nucleus is always 1,000 to 2,000 times smaller than that of an electron For this reason the spectral term-splittings (energy differences) deduced from his are usually less

term-splittings (energy differences) deduced from his are usually less than 1/1,000 those in multiplet structure. L and S were combined to obtain the total angular momentum J of the optical electrons, it is necessary, for his, to combine J and I in order to obtain the total angular momentum J of the optical electrons, it is necessary, for his, to combine J and I in order to obtain the total angular momentum F of the whole atom, including nuclear spin. The hyperfine quantum number F can take the following values: F = J + I, J + I - 1, J + I - 2, ..., J - I - I. Thus gives, in all J + I or J + I - I different values, according as J < I or J > I. The vector-addition diagrams for J and I will be identical with those for L and S = I or 
have 2/+1 components.

The magnitude of hyperfine splitting depends on the nuclear magnetic moment but is also dependent on the type of electron. Thus, spectral terms arising from electron configurations containing one spectral terms arising from electron configurations containing one stype electron will be spht wider than those from a p electron with the same principal quantum number, because the s electron approaches closer to the nucleus and experiences a stronger interaction. The transitions between hfs states are regulated by the same selection rule for F that holds for J, i.e.,  $\Delta F = 0, \pm 1$ , but o to o transitions are forbidden. Furthermore, the same intensity rule and the same interval rule is valid for both hfs and ordinary multiplet structure, except F replaces J.

After deriving, from spectroscopic observations and quantum theory, a satisfactory explanation of hfs it became possible conversely to deduce, from the results of spectroscopic experiments, several properties duce, not take teams of spectroscopic expensions, several properties of atomic nuclei. In 13 years following 1927, the mechanical moments or spins of 90 atomic nuclei were determined, the magnetic moments for 70 and the quadrupole moments for 20. The results are compiled in the Journal of the Optical Society of America, No. 36, page 438 (1946). Typical data are shown in Table VIII in which the exponent on the chemical symbol represents the mass of the atomic nucleus. In general, nuclear mechanical moments are derived either from the number of observed his components, or from their relative intensities or from the intervals between his levels. Man witc moments are calculated from a theoretical formula containing the observed his intervals and other constants but the most precise values have been obtained from measured deviations of atomic or molecular beams in tained from measured deviations of aromaco's momenta indicates that the hfs terms are regular, i.e., the level with smallest F value has the lowest energy. Deviations of hfs levels from the interval rule are referred to a quadrupole moment arising from a nonspherical distribu-tion of protons in the nuclei. There are two possibilities: if the pos-litive charge is spread in the direction of the mechanical moment the nucleus is elongated and has a positive quadrupole moment; otherwise the nucleus is flattened and has a negative quadrupole moment.

Table VIII .- Mechanical, Magnetic and Quadrupole Moments of Atomic Nuclei

Mechanical Moment I(h/2π)	Magnetic Moment in Nuclear Magnetons μ(he/.4πMpc)	Quadrupole Moment q(10-24 cm.2)
1/2 1/2 1 1 3/2	-1.035 2.7896 0.855 0.820 3.2532	0.00273
3/2 I 3/2 I	-1.176 0.597 2.682 0.402	
1/2 1/2 3/2 5/2 2/2	2.625 2 215 3.628	
3/2 3/2 3/2 3/2	-1 290 0.217 2 11 2.69	0.20 0.13 -0.4
	Moment $I(h/2\pi)$ 1/2  1/2  1/2  1  3/2  3/2  1	Moment   In Nuclear Magnetons   In Nuclear

The only regularity apparent in Table VIII is that the nuclear mechanical moment is a half-integer if the mass of the nucleus is odd, and a full integer if the mass is even. It is also seen that the algebraic and a ful integer if the mass is even. It is also seen that the algebraic sums of the mechanical moments and of the magnetic moments of the neutron (on!) and proton (IH!) are exactly equal to the respective quantities for the deuteron (1D!). The manner in which the moments of the elementary particles must be combined to yield the observed values for the other atomic nuclei was in 1947 the out-

observed values of the other atomic factor was in 1947 the outstanding and most tantalizing question in nuclear physics.

BIBLIOGRAPHY.—H. Kayser, Handbuch der Spectroscopie (Leipzig, 1900–34). The standard work in eight large volumes, containing all BIBLIOGRAPHY.—H. Kayser, Handbuch aer Spectroscopie (Ledpus) 1900—34). The standard work in eight large volumes, containing all spectroscopic information to 1912 in the first six volumes, and further data on about half the elements, Ag to Nb (Cb) in the last two volumes; E C. C Baly, Spectroscopy, 3 vol. (London, 1924—27); F. Hund, Linienspektren und Periodisches System der Elemente (Berlin, 1927); A. Sommerfeld, Atombou und Spektrallinien, 5th ed (1931); Complation of spectral terms reported in 231 spectra of 52 elements; H. E. White, Introduction to Atomoc Spectra (1932). Complation of spectral terms reported in 231 spectra of 52 elements; 1935); H. Kaysei and R. Ritschl, Tabelle der Haupklinien der Linienspektren aller Elemente (Berlin, 1930) Contains 27,000 wave lengths, 10,850 A to 33 A, in spectra of 88 elements; G. R. Harrison (ed.), M.I.T. Wavelength Tables (1939) Contains 190,275 wave lengths, 10,404; W. F. Meggers, "Spectroscopy, Past, Present Spectroscopy, (1944); W. F. Meggers, "Spectroscopy, Past, Present and Future," Journal of the Optical Society of America, 36, pp. 431–448 (1946).

SPECTROSCOPY, ASTRONOMICAL. Astronomical

SPECTROSCOPY, ASTRONOMICAL. Astronomical spectroscopy is that branch of the science of astrophysics which is built around information obtained by means of a prism, a diffraction grating or some other dispersing device. (See Light; OPTICS.) When a ray of light from the sun is transmitted through a prism it is broken up into its component shades of colour and we observe a continuous spectrum. Closer examination shows that not all shades of colour are represented in the spectrum of sunlight. If the incident light beam is made very narrow by means of a slit which runs parallel to the refracting edge of the prism and if an image of the slit is formed on a screen by means of two lenses; one-the collimator-just in front of the prism, and the other-the camera lens-just behind it, the resulting band of the rainbow colours separates out the radiations so that the missing ones appear as black gaps or absorption lines. The spectra of most stars resemble that of the sun in that they show continuous spectra-some with an excessive intensity in blue light, others with more of the red light-upon which are superposed numerous absorption lines.

Rarely do we observe stellar spectral lines in the form of brilliant emission lines on top of the continuous spectra. The absorption and emission lines are produced by absorbing and radiating atoms in the atmospheres of the stars. Each chemical element or chemical compound has several characteristic sets of spectral lines, and each set is indicative of definite conditions of excitation, such as pressure and temperature. Hence, it is possible not only to identify the chemical elements in the atmospheres of the stars but to draw conclusions concerning the temperature and pressure in these atmospheres,

Some astronomical objects, such as the Orion nebula, produce only emission lines without a continuous spectrum or with one that is abnormally weak. Such spectra resemble those produced by the commercial neon signs used in advertising. Astronomical spectra are of great variety. They represent conditions which range in temperature from a few degrees above the absolute zero for interstellar particles to 100,000° K. (absolute temperature), or even more, in the atmospheres of the hottest star, and 1,000,-000° in the solar corona. In density the range is from that of interstellar space, which contains about 10 atoms per c.c., to that of the atmosphere of a white dwarf (see Stellar Constitution AND EVOLUTION), which exceeds the density of air at the surface of the earth.

Of all the results of stellar spectroscopy the most interesting is the uniformity of distribution of the chemical elements throughout the universe. It must have been a revelation to the earlier spectroscopists when they discovered in the sun the same familiar substances-hydrogen, iron, calcium and the rest-which they knew on the earth. Their belief in the principle of the uniformity of the chemical elements must have been strengthened when several mysterious spectral lines, observed by Norman Lockyer in 1869 at the rim of the sun, turned out, in 1895, to be produced by the newly discovered gas, helium. As recently as in 1941 the last great enigma of line-identification was solved when B. Edlén in Sweden announced that the previously unidentified lines of the solar corona originate in the atoms of the common elements, iron, calceum, nickel and argon, excited to a degree of ionization not even dreamed of previously. Henry Norris Russell had remarked some years earlier, when Ira S. Bowen in a similar manner disposed of the so-called "nebulium" lines in certain nebulae, that the mysterious substances of the astrophysicists one after another literally disappeared in "thin air." As a matter of fact. Bowen found that the nebulae consist of oxygen, nitrogen, hydrogen and a few other gases, in other words, they are not very different in composition from air The principle of the uniformity of chemical elements has now been extended to include even the distant galaxies whose light travels hundreds of millions of years at the rate of 186,000 mi. per sec before it reaches the eye of the observer. The principle of uniformity of chemical elements means that the atomic building blocks of the universe are the same throughout space. It does not mean that the proportions of these elements are the same in all astronomical objects.

### HISTORICAL DEVELOPMENT

Astronomical spectroscopy had its beginning in 1666 when Isaac Newton observed the separation of the colours of the rainbow in a prism. In 1802 William H. Wollaston placed a narrow slit in a window blind and with a prism of better quality than the one used by Newton, but without a collimator or a camera. noticed several dark lines in the spectrum of sunlight. Real progress in astronomical spectroscopy became possible when Joseph von Fraunhofer in 1814 made use of a telescope, in addition to the prism and a distant slit, and thereby constructed the first modern spectroscope. A collimator lens was first used by W. H. Simms in 1840. With his instrument Fraunhofer observed and mapped 754 dark lines in the spectrum of the sun. He also observed the spectra of several bright stars and found that although they all had dark lines upon a coloured continuum, the lines were not the same as those of sunlight. Fraunhofer noticed that the vellow emission line from a flame fed with table salt, which had already been observed by John Herschel, coincides in position with a conspicuous black line in the solar spectrum, which he had designated by the letter D. But he did not follow up this result.

It was only after Gustav R. Kirchhoff had advanced his famous three laws of spectroscopy that the connection between absorption and emission became obvious. Thereafter William Huggins (1824-1910) in England undertook a systematic survey of the spectra of all stars and nebulae within the reach of his instruments at Tulse Hill in London. This period was the richest in the number and importance of astrophysical discoveries. Many different types of stellar spectra were found; the Orion nebula was found to be gaseous, contrary to the opinion of other astronomers, while the Andromeda nebula showed a continuous spectrum similar to that of normal stars like the sun. Huggins concluded independently of Johann K. F. Zöllner that the solar prominences could be observed without an eclipse by means of a spectroscope, and that the planets shine by reflected sunlight. He was the first to try to measure the radial motions of stars from the Doppler displacements of their lines. The work of Huggins was of a pioneering character, and it was he who laid the foundations for all further investigations. His tradition in England was carried on by Norman Lockyer and F. E. Baxandall at the Solar Physics observatory in South Kensington, which was transferred to Cambridge after Lockyer's retirement in 1913, and was directed first by H. F. Newall and later by F. J. M.

The problem of spectral classification was undertaken in the middle of the 19th century b, Angelo Secchi in Italy and was later continued by H. C. Vogel in Germany who was the first to introduce the photographic method into spectroscopy and who succeeded in determining accurate radial velocities of many stars. Vogel's work, especially his measurements of radial velocities, stimulated several other observatories, near the turn of the century, to undertake systematic studies in this field. W. W. Campbell at the Lick observatory undertook the determination

of the motions of all stars brighter than magnitude 5.5 in both hemispheres of the sky. E. B. Frost at the Yerkes observatory concentrated upon the motions of hot stars. J. S. Plaskett at Victoria, British Columbia, discovered many spectroscopic double stars and determined their orbits; he also extended to fainter stars the work of other observatories. W. S. Adams and his associates at Mount Wilson observatory, Calif., determined the velocities of hundreds of faint stars. A. A. Belopolsky at Pulkovo, Russia, and, more recently, G. A. Shajn at Simeis, in the Crimea, also made important contributions in this field. H. Spencer Jones, then at the Cape observatory, published numerous measures of stellar motions in the southern sky.

The work on spectral classification received a new impetus when E. C. Pickering at Harvard, assisted by Miss A. J. Cannon, Miss A. C. Maury and Mrs W. P. Fleming, undertook the classification of several hundred thousand stars over the entire sky. This work, which culminated in the Henry Draper Catalogue by Miss Cannon, published 1918-24, provides the basis for all modern astrophysical work. The spectroscopic study of the sun was advanced by J. C. Janssen, of the Meudon observatory in Paris, who followed Huggins' suggestion and succceded, in 1868, in observing the prominences of the sun in full daylight. Further advances were made by N. C. Dunér in Sweden, who determined the rotation of the sun from the Doppler effect (q.v.) and found it to be different in different latitudes of the sun, and by H. A. Rowland at Johns Hopkins university, who prepared a catalogue of solar wave lengths. At the turn of the century great progress in this field was made by G. E. Hale, who successively founded and directed the Kenwood observatory in Chicago, the Yerkes observatory in Williams Bay, Wis., and the Mount Wilson observatory at Pasadena, Calif. The spectroheliograph was invented independently by Hale and Deslandres of the Paris observatory. Hale discovered the magnetic fields in sunspots and announced the existence of a 22-year period in the polarity of sunspots. One of his most striking discoveries was that of invisible sunspots, made in 1922; he pointed out that sunspots usually appear in pairs of opposite magnetic polarity. He concluded that single spots are single only in appearance, and that in all probability they are associated with invisible spots "in which the cooling due to expansion is insufficient to cause perceptible darkening of the sun's surface." He was able to confirm this hypothesis by means of the Zeeman effect (q.v.)which clearly demonstrated the existence of the invisible spots of opposite polarity to that of the visible single spots.

The connection between the temperature of the stars and their colours was recognized as soon as differences in colour were observed, but the reddening effect of interstellar dust was for many years a subject of controversy and was settled only through the work of R. Trumpler at the Lick observatory. The recognition of spectroscopic differences between stars of high and oi low luminosity goes back to the work of E. Hertzsprung, around 1905, but the systematic utilization of the method of spectroscopic parallaxes—the most powerful means of penetrating distance within our galaxy—was developed by W. S. Adams and A. Kohlschütter at the beginning of World War I.

## INSTRUMENTS

Silt Spectrograph.—The stellar spectrograph is an instrument constructed like an ordinary laboratory spectrograph (see Spectroscoper: Spectroscopes and Spectrograph(see Spectroscoper). Spectroscopes and Spectrograph(see Department) all astronomical light sources are exceedingly faint, special precautions must be observed that all the available light of the object be utilized in forming the spectrum The instrument most commonly used is a slit spectrograph attached at the focus of an astronomical telescope. It is essential that the angular aperture of the collimator be the same as that of the telescope. Otherwise, light is spilled over the edges of the collimator (collimator of greater focal ratio than telescope) or the optical parts of the spectrograph are unnecessarily large and wasteful (collimator of smaller focal ratio than telescope). If the instrument is used in good seeing for the observation of stars, which appear nearly as points on the slit of the spectrograph, then the efficiency is pro-

proportional to the length of the collimator. But if the instrument is used for the observation of luminous surfaces, such as nebulae, the moon, the planets, etc , the efficiency is independent of the linear or angular apertures of the telescope and depends only upon the aperture of the collimator.

In practice the astronomer is usually concerned with intermediate conditions; the stars have tremor disks caused by irregularities in the air, and while their images have a pronounced, sharp peak of light intensity in their contours, they cannot be regarded as mathematical points. Hence, it is advantageous to use a telescope of large aperture to gather in a large amount of light, and a long collimator to secure the maximum possible purity. In very "poor seeing," when the star images may be as large as 1 minute of arc in diameter (this would project as a disk of 4 mm in diameter on the slit of the spectrograph of the 82-inch reflector of the McDonald observatory) the advantages of the large aperture are largely lost, while in good seeing, when the diameter of the image is less than one second of arc, the efficiency is almost exactly proportional to the linear

The length of the camera and the dispersion of the prism or grating are chosen to give the desired scale of the spectrum. For very bright objects long cameras and powerful dispersing units may be used. For example, the spectrum of the sun has been completely photographed for photometric purposes in the first and second orders of a diffraction grating having 600 lines per millimetre and installed in a 75-foot spectrograph of a 150 ft. tower telescope at the Mount Wilson observatory. The linear dispersions of these plates were 0.33 Å/mm. and 0.67 Å/mm. For special purposes even higher dispersions can be used to advantage. For the brightest of the fixed stars, linear dispersions of one A/mm, have been used at Mount Wilson. Naked-eve stars have been photographed with 2 to 3 Å, mm. The ordinary stellar spectrograph used for radial velocity work (see later) has a dispersion of the order of 10 to 75 A/mm. Finally, for the faintest objects, such as stars of apparent magnitude 16, or fainter for galactic nebulae, external galaxies, etc., dispersions of 500 to 1,000 A/mm. are frequently used.

The design and construction of spectrograph camera systems constitutes one of the most difficult tasks in optics. For the greatest efficiency it is desirable to make the ratio of collimator to camera lengths as large as possible, so that the slit can be opened without increasing the width of the projected image of the slit on the plate to more than the size of the plate-grain clusters. Thus, short-focus cameras are favoured, which require dispersing units of great power in order to secure the desired scale of the spectrum. For ordinary work with cameras of the order of f/3 to f/5, four-component lenses designed by F. E. Ross or three-component Cooke-type lenses give excellent results. For instruments of very short focus, Schmidt cameras of conventional design can be used down to about f/1; modified Schmidt cameras made from a solid block of glass, one side of which is figured to approximate a sphere and silvered on the outside while the other side is figured in such a way as to remove the spherical aberration, can be used at a speed of f/0.35. Schmidt cameras of improved design have been proposed by James Baker at Harvard. Microscope objectives for use as camera lenses were proposed by W. B. Rayton and by R. J. Bracey. A lens designed by the latter at f/0.35 has been used successfully at the Mount Wilson observatory for work on external galaxies.

Slit spectrographs are usually attached at the focus of a moving telescope and must meet two important requirements: they must be sufficiently rigid to show no perceptible change in flexure during a long exposure and they must be accurately controlled for temperature to prevent changes in excess of about o.r° in the spectrograph throughout the night. Permanent stationary spectrographs of high dispersion are used for solar work where vertical towers with mirror systems (coelostats) are used for forming the solar image on the slit, and a vertical underground shaft serves to house the spectrograph. Installations of this type are used at the Mount Wilson observatory, Pasadena,

portional to the area of the telescope objective while the purity is Calif., at the McMath observatory of the University of Michigan at Pontiac, Mich, at the Potsdam observatory in Germany, at the Arcetri observatory near Florence, Italy, and elsewhere For stellar work stationary spectrographs are used at the Coude focus of very large reflecting telescopes. The Mount Wilson observatory and the McDonald observatory of the University of Texas, Fort Davis, Tex, have made excellent use of such installations.

The principal advantages of sht spectrographs consist of (1) greater purity than is possible with slitless instruments, (2) a comparison spectrum that can be photographed alongside the astronomical spectrum to serve in radial-velocity determinations and (3) the elimination of the background of the night sky, which places a definite limit to the efficiency of slitless instruments. The spectral region covered with modern instruments ranges from \$\lambda\$ 2900 \, A, where the terrestrial atmosphere becomes opaque, to about \(\lambda\) r3.500 \(\lambda\), where even the special infra-red photographic emulsions cease to be effective. In fact, for stellar work the practical photographic limit in 1945 was about λ 10,000. Beyond this limit special methods may be used, such as employing thin layers of a substance which vaporizes easily and is removed from regions exposed to infra-red radiation, being deposited on the cooler, unexposed regions. In 1946, two sensational advances were made in extending the observable spectral region; physicists of the U.S. Naval Research laboratory at Washington, DC., announced that with a spectrograph in a German V-2 rocket at White Sands, N.M., they had photographed the sun's radiation to about \( \lambda \) 2,100 at a height of 33.5 mi. In the infra-red region the construction of special PbS photoelectric cells by R. J. Cashman permitted G. P. Kuiper and W. Wilson to observe the spectra of stars and planets to about 3 µ, with sufficient dispersion to record a mass of new absorption features.

The dispersing units of astronomical spectrographs are made in the form of prisms (glass, quartz, rock salt) or of diffraction gratings. The latter are particularly useful in the red and infrared regions, where the dispersion of glass is so low that a prohibitive thickness of the substance is required to obtain the same dispersion that a grating with 600 lines per mm. gives in the second order. The grating is also efficient in the ultra-violet region, where ordinary glass is opaque and where quartz prisms are difficult to obtain in sufficiently large sizes for high-dispersion instruments. Large quartz prisms of the Cornu type are used at the McDonald observatory. R. W. Wood at the Johns Hopkins university ruled gratings on a thin aluminum film deposited on glass, using diamonds specially shaped to give the highest possible concentration of light in the desired region of the spectrum. Other fine gratings have been ruled at the Mount Wilson observatory. Unusual freedom from "ghosts" has been achieved in the ruling engine at the University of Chicago.

Under ordinary observing conditions a large amount of light is lost on the slit jaws of the spectrograph (where it is used for guiding the telescope on the star image). It is not possible to filter this light into the spectrograph in such a way that it will reinforce the spectrum of the central portions of the star image. But an ingenious device has been constructed by Ira S. Bowenan instrument called the image slicer-in which small plane mirrors are used to place the originally wasted light in the slit, alongside the main spectrum.

In this manner a widened spectrum is obtained without letting the star trail on the slit, and this results in a substantial reduction of the observing time.

Very large luminous areas, such as diffuse gaseous nebulac, the zodiacal light, etc., can be observed without a telescope if the collimator is sufficiently long so that its angular aperture is smaller than the diameter of the object. A powerful spectrograph employing a slit of 2 to 3 cm. in width and 1 m. in length, at a distance of 46 m. from two quartz prisms, and a f/1 Schmidt camera of 94 mm. aperture, was used at the McDonald observatory for recording the spectra of exceedingly faint nebulous regions in the Milky Way. This instrument has no collimator lens because the rays are sufficiently nearly parallel when they enter the prism.

Slitless Spectrographs.—The image of a star is approxi-

mately a point. Hence, if a prism is placed in front of the lens or mirror of a telescope, the spectrum is recorded as a narrow continuous band with interruptions in place of spectral lines. If during the exposure the star is permitted to trail slightly in a direction parallel to the refracting edge of the prism, a widened spectrum is obtained in which the star serves as its own slit. The great advantage of slitless spectrographs consists in the fact that they record a large field of stars in a single exposure instead of being limited to a single star on the slit of the instrument. The principal disadvantage lies in the fact that in a large telescope, such as would be required to record the spectra of very faint stars, the images of the stars are tremor disks of appreciable diameter, the latter being very sensitive to the conditions of seeing in the atmosphere.

Hence, spectra obtained in this way are not as pure as are spectra obtained with slit spectrographs. Another difficulty consists in the absence of a comparison spectrum for determining the radial motions of the stars. This can be circumvented by placing a glass container of a solution of neodymium chloride in the path of the rays. This substance produces one sharp absorption band in the photographic region, which can serve as a reference point for measuring the displacements of the stellar lines. Nearly all work on the spectral classification of faint stars is being carried on with objective prisms.

Various modifications of the objective prism have been invented for special purposes. The light rays can be made parallel by means of a negative lens just before they reach the focus of the telescope and a prism or grating can be used to produce slitless spectra of stars and small nebulae, which are then brought to a focus by means of a positive lens. Instruments of this kind are being used in several observatories, one of the most successful being the slitless spectrograph of the 36-inch Crossley reflector of the Lick observatory, with which W. H. Wright obtained some of the finest spectra of small planetary nebulae.

The wide field and the critical definition of star-images at relatively short focal lengths, obtained with large Schmidt cameras, render these instruments especially suitable for objective-prism work Among the best instruments of this type are the 24-inch Schmidt reflector of the Case School of Applied Science in Cleveland, O., and the 18-inch telescope on Mount Palomar in California

Among the many slitless spectrographs one designed by E. L. McCarthy for the McDonald observatory deserves special menton. A prism with a small silvered spot on one face is placed near the principal focus of the large reflector. The rays reflected from the spot are collimated by a small parabolic mirror whose coma cancels that of the large telescope. The collimated beam passes through the prism and is focused by means of an f/2 Schmidt camera. The entire instrument works at f/2 and the star images are made reasonably small by the reduction from f/4 of the large telescope. Another interesting arrangement was used by W. M. H. Greaves and others at the Greenwich observatory. In this instrument the beam is collimated by the secondary Cassegrain mirror before it enters the prism.

Spectrophotometric Instruments.—For the measurement of the light intensities in continuous spectra and in spectral lines microphotometers of various designs are used. Usually the instrument is employed to measure the photographic density on a plate, but occasionally direct measures of the light at the telescope are preferable. Instruments for measuring photographs usually consist of a light-source and a narrow slit; the latter—or its image—is placed in contact with the plate, parallel to the spectral lines, so that only a narrow band of light passes through the plate. This band falls upon a photoelectric cell which activates a galvanometer whose mirror produces a displaced light signal upon a sheet of photographic paper. As the plate is slowly moved across the slit, the drum carrying the paper is turned and the signal produces a continuous record of the galvanometer deflection of the original beam as modified by the continuous spectrum and by the lines on the plate. Tracings of spectra obtained in this manner must be calibrated by means of

marks produced on the original plate by a step wedge, a tube sensitometer or some similar device which changes intensities by known amounts. This is required in order to express the displacements of the signal on the tracings in terms of relative intensities.

Since this conversion is often laborious, a number of devices have been perfected for reading directly the intensities on the tracing, or for converting the original tracing automatically into one giving relative intensities. Instruments of this type have been used by R. C. Williams and W. A. Hiltner at the University of Michigan, by M. Minnaert and his associates at Utrecht, by Theodore Dunham, Jr. at Mount Wilson and elsewhere. Dispersing systems have been used by J Stebbins and A. E. Whitford at Mount Wilson and by J. Hall at Amherst to serve for the photoelectric measurement of approximately monochromatic star images.

The Spectroheliograph was invented almost simultaneously. in 1890 by G. E. Hale in Chicago and by H. Deslandres in Paris. This is a large spectrograph into which a narrow slit has been built in front of the focal plane of the camera so that only the light of a narrow range of wave lengths falls upon the plate. This slit is so adjusted that the light of a particular absorption line in the sun's spectrum is transmitted. It must be remembered that the lines originate in the uppermost regions of the sun's atmosphere and are not completely dark but contain light of smaller intensity than that of the continuous spectrum. The continuous spectrum is formed by light which is produced, on the average, at a depth of several hundred kilometres in the atmosphere. The image of the sun is projected upon the first, the ordinary, slit of the spectrograph and the entire telescope is slowly moved by means of an electric motor at right angles to the slit. Simultaneously the plateholder carrying the sensitive emulsion is moved past the second slit. In this manner an image of the sun is obtained on the plate which is produced by the residual light of a particular spectral line. Since not all regions on the surface of the sun are equally bright in such monochromatic light, it is possible to study features like calcium eruptions (or flocculi), hydrogen tornados (or vortices) and other structures which cannot be seen in the brilliant light of the continuous spectrum which alone is strong enough to register in the extremely short exposures required for obtaining a direct photograph.

A modification of the spectroheliograph, the spectrohelioscope, was invented by Hale for visual observation. Some phenomena, such as brilliant eruptions in hydrogen light (bombs), last only a few minutes and can best be detected and followed by means of prolonged visual observation.

R. R. McMath of the University of Michigan has improved the spectroheliograph by combining it with a moving picture machine so that a continuous record of a solar phenomenon may be obtained. Since radial motions in the solar atmosphere sometimes shift a spectral line outside the limits of the second slit, a picture obtained in two dimensions is necessarily distorted and is inadequate for many purposes. To correct this feature, McMath has built an instrument referred to as a radial-velocity-spectroheliograph, which resembles an earlier instrument by Deslandres. By its means it is possible to study the radial motions, as well as the tangential motions, of such features as prominences, eruptions, etc.

Coronal Spectrographs.—B. Lyot built on the Pic du Midi in France an instrument with which he succeeded in photographing the spectrum of the solar corona on any clear day. The principal new feature of this instrument consisted of devices for the elimination of scattered light in the optical parts. All glass parts were chosen for freedom from bubbles and striae and the surfaces were made and are kept free from scratches, minor irregularities and dust. In addition, the direct image of the sun was eliminated by an occulting disk, and special precautions were taken to eliminate diffracted light from the image forming lens. Other coronal spectrographs are used at Arosa in Switzerland by M. Waldmeier and at the Climax station of the Harvard observatory by D. H. Menzel and W. O. Roberts.

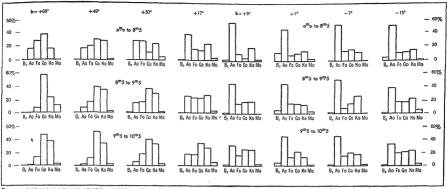


FIG 1 -THE DISTRIBUTION OF THE RELATIVE NUMBERS OF STARS OF DIFFERENT SPECTRAL CLASSES. THE SYMBOL & INDICATES THE GALACTIC LATITUDE

# CLASSIFICATION OF STELLAR SPECTRA

Methods.—Nearly all of the 500,000, or more, stellar spectra which have been examined at several observatories can be arranged empirically in a two-dimensional sequence in which the intensities of selected absorption lines or bands change gradually. The system of classification of stellar spectra is based principally upon the Henry Draper Catalogue of the Harvard observatory where spectral types of nearly 300,000 stars are given. This work recognizes only one dimension or parameter in the classification, which has since been identified as the temperature of the atmosphere of the star. In this one-dimensional system two stars may have identical intensities of some lines, and slightly different intensities of others. Most of these discrepancies were removed when it was recognized that stars of different luminosity, but of similar temperature, show slightly different spectra.

The temperature co-ordinate can be empirically divided into a number of steps which are designated, following Miss Cannon's procedure, by the letters O, B, A, F, G, K, M, R, N and S, or by actual temperatures, which for the sequence named decrease steadily from about 30,000° K. for type O, to about 3,000° K. for types M, R, N and S. Since the exact correspondence between temperature and empirical spectral class is not known, the empirical scheme is used for most purposes. The second co-ordinate can also be expressed by arbitrary designations such as I, II, III, IV and V, used by Morgan and Keenan at the Yerkes observatory, or by actual luminosities expressed in the form of absolute stellar magnitudes, which the stars would have if they were brought to a distance of 10 parsecs, or 3 x 1014 km. Stars of luminosity class I have absolute magnitudes of the order of -5, those of class V of the order of +5. The latter value corresponds to about the intrinsic brightness of the sun, while the former would be 10,000 times brighter. In this case, again, the use of arbitrary designations is preferable as long as we do not have an accurate calibration in terms of absolute magnitudes.

The hottest stars, class O, have spectra dominated by the lines of ionized helium; those of class B have hydrogen and neutral helium. In class A hydrogen is very strong, helium is weak or absent, and ionized metals, such as Fe II, Ti II, Mg II, are prominent. In types F, G and K the lines of neutral metals, Fe I, Ti I, etc., become gradually stronger, and the lines of Ca II, Ca I and Na I are conspicuous. Near type G we first observe bands of certain diatomic molecules, CH and CN, which also increase in strength as we pass toward the cooler stars. Types M, R, N and S are characterized by very strong molecular bands of TiO in class M, C2 and CN in classes R and N and ZrO in class S. These four types do not form a well-defined

temperature sequence, and the exact interpretation of the empirical classes in terms of physical parameters is incomplete.

The luminosity criteria which are used within each spectral class differ greatly. In the hottest stars, classes O, B and A, the hydrogen lines are much narrower in the more luminous stars (supergiants). In the intermediate and cool stars, lines of relatively high ionization potential, such as Sr II in classes G and K, are enhanced in the more luminous stars. The molecular bands of CN, and others, can also be used as luminosity criteria.

An accurate classification of stellar spectra is important for three widely different problems: (1) the study of the physical properties of stellar atmospheres, (2) the statistical study of stars according to their principal characteristics and (3) the study of the spatial arrangement of the stars in our galaxy by means of their luminosities. It is important to have a clear understanding of the purpose of an investigation before the methods and the criteria are chosen. Thus, certain spectral features may be useful in empirical determinations of luminosities, but may be almost useless in studies of physical characteristics because they consist of unresolved lines or bands of different sources.

The principal catalogues of stellar spectra are those of the Harvard observatory—the Henry Draper Catalogue, which covers the entire sky and is complete to about apparent magnitude 8.5, and its extensions, which carry the work to much fainter stars in selected regions of the sky. Approximately 100,000 faint stars located in the selected areas of the southern sky, chosen by J. C. Kapteyn, were classified by F. Becker and H. Brück at the Potsdam observatory from photographs taken at La Paz, Bolivia. A similar study for some of the northern selected areas, containing approximately 68,000 stars to apparent magnitude 13, was made by A. Schwassmann at the Bergedorf observatory near Hamburg. Spectral types of several thousand other stars located in regions of special interest, such as star clusters, nebulae, Milky Way clouds, etc., have been determined by A. A. Wachmann at Bergedorf, by numerous observers at the observatories of Upsala and Stockholm in Sweden and elsewhere.

In most of these studies only the temperature parameter of the classification has been recognized. At the Dearborn observatory O. J. Lee has made a search for stars of very low temperature over the northern sky. At the McCormick observatory of the University of Virginia, Charlottesville, Va., A. N. Vyssotsky was engaged in 1945 in a systematic classification of about 500,000 stars in 1,200 areas of the sky to magnitude 12. Classifications of several hundred faint stars have been obtained with slit spectrographs by M. H. Humason at Mount Wilson and by W. W. Morgan at the Yerkes observatory.

The percentage distribution of the stars according to spectral type is shown in fig. x taken from the Bergedorf catalogue. The stars are divided into several groups according to their galactic

latitude (angular distance from the central line of the Milky Way) and apparent magnitude. The hotter stars have a pronounced tendency to concentrate near the Milky Way, while the

cooler stars are more evenly distributed.

Interpretation of Spectral Classification.-The theoretical interpretation of the two-dimensional classification of stellar spectra rests upon the theory of thermal ionization proposed by M. N. Saha in 1920 and developed in later years by H. N. Russell, E. A. Milne, R. H. Fowler and others. Some of the ideas underlying this theory were already present in the pioneering work of Norman Lockyer, but the exact mathematical formulation was first given by Saha. In a gas submitted to high-temperature radiation neutral atoms are constantly being ionized by quanta of light, and free electrons are being captured by ions. An equilibrium is set up by which the number of ionization processes is exactly balanced by an equal number of recombinations. The relative numbers of ions (n') and neutral atoms (n)depend upon the temperature of the radiation (T), the ionization potential of the atoms (I), and the partial pressure  $(p_e)$  of the free electrons, many of which may result from the ionization of some other element than the one we are considering:

$$\log_{10} \frac{n'}{n} = -I \frac{5040}{T} + \frac{5}{2} \log_{10} T - 0.48 - \log p_e$$

The observed intensity of a neutral line is directly dependent upon  $n_t$ , that of an ionized line upon n'. As the temperature increases,  $n_t$  decreases while n' increases, by virtue of the first factor containing  $T_t$ , which is more important than the second factor. The ionization is smaller when I is large. But the ratio n'/n also depends upon  $p_0$  and increases as the pressure decreases.

Consider two stars of the same temperature but of different pressures and suppose that we observe in their spectra lines of two elements having different ionization potentials. In the dense star the ionization is less than in the more tenuous star. Moreover, the element of higher potential will be less ionized than the one of lower potential. In practice we do not choose the stars according to temperature but according to spectral class. The latter rests upon a compromise of several slightly conflicting criteria, corresponding to different ionization potentials; for example, two stars classified as F do not have exactly the same temperature if their pressures are not alike; the more tenuous star has the lower temperature. It must also be remembered that many elements can be ionized more than once, so that as T increases or pe decreases, n' at first increases at the expense of n, reaching a maximum at definite pairs of values of T and pe, after which it again decreases, while n', representing the next stage of ionization, begins to increase. Ionization temperatures are determined for a sequence of stars for which it may be assumed that  $p_0$  is constant, by observing at which spectral class lines of different ionization potential reach their greatest intensity. The condition for maximum intensity is obtained by differentiating the ionization formula with respect to T.

The theory of ionization suffices to explain many of the observed absolute magnitude effects in stellar spectra, remembering that for a given temperature high luminosity is equivalent to large size (giants) and therefore to small surface gravity and, in turn, small surface gravity indicates low pressure. The tendency of ionized lines to become stronger in giants is explained by the fundamental formula. But other effects require a more complete theory which has been developed by Milne and which involves the interplay of two tendencies: (a) the increased effective mass of the atmospheres of giants as compared with dwarfs, and (b) the effect of altered pressure, consequent on change in surface gravity, on ionization.

change in surface gravity, on ionization.

Continuous Spectra.—The continuous spectra of the stars show conspicuous differences in the distribution of energy as a function of wave length. The latter are closely related to the observed colours of the stars. The O and B stars are bluish, while the M, N, R and S stars are red. Observations of the absolute energy distributions of selected stars have been made by Vogel, G. Müller and others at Potsdam, by Greaves and his associates at Greenwich, by R. C. Williams at the University of Michigan,

by D. Chalonge and D. Barbier in France, and by others. From these observations the absolute colour-temperatures are derived by adjusting T in the Planck function (see Hear) to give the best possible fit with the observed distribution. These absolute determinations have yielded a number of standards with which it is possible to compare other stars. Differences in the energy distributions of two stars are usually given in the form of "relative gradients":

$$\Delta \phi = \frac{c_2}{T_1} - \frac{c_2}{T_2},$$

where  $c_7$  is the constant of the Planck function. These considerations rest upon the empirical fact that the energy distributions of many stars, in regions not affected by absorption lines, resemble fairly closely the black-body curves. However, accurate observations have shown a number of important departures:

(1) At the limit of the Balmer series the spectra of moderately hot stars (class A) show a discontinuity, usually described as the "Balmer jump": the continuous spectrum is abnormally weak on the violet side of \(\lambda\) 3647. (2) In the spaces between the strong hydrogen absorption lines on the violet side of H y of many A-type stars the continuous spectrum is depressed because of the enormous extent of the wings of these lines, this phenomenon being especially conspicuous in white dwarfs, like O2 Eridani B. (3) In some stars the hydrogen lines are complicated by emission, and the "Balmer jump" appears as an abnormal strengthening of the spectrum on the violet side of \( \lambda \) 3647 (4) In a few unusual stars the colour temperature is different for In a few unusual stars the spectrum: for example, in P Cygni, J. Dufay found colour temperatures of the order of  $6,000^{\circ}$  to  $7,000^{\circ}$  in the region of  $\lambda$  5,000 Å, with a tendency to increase in the shorter wave lengths. The spectral type suggests that the temperature is about  $18,000^{\circ}$  in the region  $\lambda$  500 to  $\lambda$  1000 Å, but this depends upon an indirect conclusion. (5) Many distant stars appear greatly reddened by selective absorption in interstellar clouds. This type of reddening is not in accordance with Rayleigh's  $\lambda^{-1}$  law but is more nearly proportional to  $\lambda^{1}$ . (6) In stars which have heavy absorption lines and molecular bands, there must be a pronounced distortion of the continuous spectrum because of the "blanketing effect" of the absorption features. This phenomenon has been predicted theoretically by S. Chandrasekhar and observed indirectly in the central intensities of He absorption lines by A. Unsöld. (7) The continuous spectrum of the sun is weaker and redder at the edge than in the centre, and the combined light is therefore a mixture of different energy distributions. This phenomenon of limb darkening is present also in a number of eclipsing variables. (8) A strange inconsistency between spectral class inferred from the absorption lines and colour temperature inferred from the surface brightness is observed in several close double stars. This effect is attributed to the "reflection effect" which causes lines of relatively high excitation to be produced in the atmosphere of a cool binary component by the radiation of a hot component.

All of these phenomena are reasonably well understood. The theory of the continuous spectrum, and especially of the effect of limb darkening, is closely related to the problem of the physical mechanism which causes the gases in the outer layers of stars to be more or less opaque to continuous radiation. Continuous absorption at the series limits of H and He, and to a lesser extent of other elements, scattering of light by free electrons, and, in the cooler stars, continuous absorption from negative ions of hydrogen and probably of other elements are known to contribute to the continuous absorption coefficient (as distinct from the absorption coefficient within a spectral line). The energy distributions of the stars in the extreme ultra-violet region are not observed because of the oxygen and ozone bands in the upper air. Considering the very high absorption of H at the Lyman limit and the probable strength of the Lyman absorption lines, this energy curve must depart greatly from that of a black body. There is some evidence that there may even be a tre-mendous excess of ultra-violet light in the sun, which would

account for the presence of He II in the chromosphere, but this is not certain.

### RADIAL VELOCITIES

The Doppler principle gives the displacement of a spectral line  $(\Delta\lambda)$  as a function of the wave length  $(\lambda)$  and the relative radial velocity of the source and the observer (v):

$$\Delta \lambda = \frac{\lambda \cdot v}{c}$$
,

where c is the velocity of light. The displacement can be measured on plates furnished with a comparison spectrum and, accordingly, v can be determined. The quantity thus obtained must be corrected for the components of the earth's motion around the sun and the earth's rotation around its axis. The precision of the determination depends upon the dispersion of the spectfogram, the precision of the laboratory wave lengths used for star and comparison lines, the sharpness of the star lines, the quality of the optical parts used, the uniformity of the illumination of the slat and the collimator by the star image and a number of other factors. W. W. Campbell and J. H. Moore at the Lick observatory obtained a precision of about o.t km/sec. for the best stars photographed on many nights. They investigated all systematic errors and established an accurate system of radial velocities free of any appreciable systematic errors.

With the highest attainable dispersion of the Mount Wilson Coudé spectrograph, Adams obtained the velocity of  $\alpha$  Bootis with a probable error of  $\pm$ 0  $\pm$ 0  $\pm$ 0 km/sec. The largest velocity of a single star in our galaxy is more than 500 km/sec. The average velocity of the stars is of the order of 10 to 15 km/sec. It varies with spectral class; the B stars have smaller individual motions than the stars of lower temperature. The most complete catalogue of radial velocities is by Moore and was published in 1932 as volume 18 of the Publications of the Lick Observatory. It contains 6,739 stars, 133 gaseous nebulae, 18 globular clusters and 90 extragalactic nebulae. However, many new velocities have been obtained since 1932, especially by M. H. Humason for extragalactic nebulae and by N. U. Mayall for globular clusters.

Among the results obtained with the aid of radial velocities are the following: (1) The determination of the velocity (about 20 km./sec.) and the direction in space of the motion of the solar system, with respect to the nearer stars. (2) The recognition that the entire galaxy rotates around a distant centre located in the direction of the constellation Sagittarius, with a velocity of between 200 and 300 km./sec. in the region where the sun is located. (3) A method for determining the distances of groups of stars from the effect of galactic rotation, because the differential motion is directly proportional to the distance. (4) The discovery of the so-called K-effect, which can be described as a slow expansion (about 4 km./sec.) of the system of relatively near stars of spectral class B but which has not been adequately explained; it may be caused by the accidental distribution of the motions of only a small fraction of the stars. (5) The discovery that all rapid stars tend to be moving in the same direction with respect to the sun; this phenomenon can be satisfactorily explained in terms of the theory of galactic rotation if it is remembered that the orbits of individual stars may be highly eccentric, instead of circular. (6) The measurement of red shifts (inferred from the existence of otherwise unaccountably large recessional velocities) amounting to about 20 km./sec. in very dense and massive stars, such as the white-dwarf companion of Sirius, the hot Trumpler stars in clusters and the group of O stars in the Orion nebula; it is possible that these red shifts are caused by the Einstein effect (see GRAVITATION). (7) The existence of a peculiar connection between the average speed of a group of stars and certain peculiarities in their spectra; for example, all so-called sub-dwarf stars (less luminous than real dwarfs) have fast motions. (8) The law of linear increase in the velocity of recession of external galaxies with distance; the largest velocity known in 1945 was about 20,000 km./sec. (9) The determination of the distance of the sun from measurements, throughout the entire year, of the relative velocity, with respect

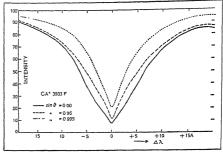


FIG. 2.—PROFILES OF THE STRONG LINE CA II K IN THE SPECTRUM OF THE SUN:

(----) near the centre of the sun's disk; (---) at a point intermediate between centre and limb, (...) near the extreme edge of the sun. These profiles are breadened by the effects of radiation damping and collisional damping. The general weakening of the line from centre to limb is explained by the theory of transfer of radiation through a stellar atmosphere

to the earth, of a star of constant radial velocity; in this problem, worked out by H. Spencer Jones at the Cape of Good Hopeobservatory and by W. S. Adams at Mount Wilson, the variable correction of the star's velocity to the sun is regarded as the unknown, and the distance appears through its connection with the orbital velocity of the earth. (10) The discovery of numerous stars showing periodic variations in radial velocity—close double stars, pulsating stars, etc. (11) The study of eruptions in novae and in other expanding shells of gas which surround such stars as P Cygni and others. (12) The discovery of stationary lines in spectroscopic binaries and their interpretation as absorption produced by interstellar gas.

# ASTROPHYSICAL RESULTS OF ASTRONOMICAL SPECTROSCOPY

Although the great majority of the stars can be arranged within the two-dimensional framework of the temperature-luminosity classification there are some important exceptions

The Wolf-Rayet Stars, numbering less than 100 out of about 500,000 well-observed stars, show continuous spectra upon which are superposed broad emission bands of atoms of a high degree of ionization, such as He II, C III, C IV, N III, N IV, N V, etc. These bands are often flanked on their violet sides by more or less diffuse absorption lines-a phenomenon which is believed to indicate that the lines and bands originate in shells expanding in all directions with velocities of several hundreds or even several thousands of km./sec. No forbidden lines have been found among the various features, which suggests that the shells cannot be very great in extent. A large fraction of the known Wolf-Rayet stars are close binaries, and in some the spectra of the companions turn out to be normal stars of class B. In these cases the Wolf-Rayet stars invariably have much smaller masses. O. C. Wilson, working at Mount Wilson, called attention to the absence of a lag between the observed light minimum of a Wolf-Rayet star which happens to be also an eclipsing binary, and the computed time of conjunction as inferred from the velocities of the emission lines produced by atoms which must have required some time to reach that portion of the shell where conditions are suitable for their radiation. C. S. Beals, at Victoria, discovered that there are two kinds of Wolf-Rayet stars-one group in which carbon is abundant and another in which nitrogen predominates.

Stars with Bright Lines.—Some stars that are otherwise normal in spectrum, have bright lines of hydrogen and of other elements, in addition to the usual absorption lines. Sometimes these lines are broad, or even double; in other stars they are sharp and narrow. The broadening appears to be caused by Doppler effect but the nature of the motions involved is not the

same in all cases. In a large group of bright-line stars of classes B and A the motions are rotational in character, a tenuous shell of gas revolving around a normal star which itself has such a rapid axial rotation that it approaches (or perhaps even reaches) the condition of rotational instability. Several stars of this kind happen to be members of close eclipsing double stars. The occulting star in its path eclipses first the approaching lobe of the rotating shell, then the star itself and, finally, the receding lobe of the shell. In other stars the motions are those of expansion, as in Wolf-Rayet stars and in novae, and in still others they are of an irregular or turbulent character. In many stars the bright lines vary in the course of years.

Å separate group is formed of various stars of the cooler classes which also show bright lines of H, Ca II, Fe I, Mg I, Si I, etc. Even the sun has weak central emissions in the lines designated as H and K of Ca II and in other stars, like Arcturus, they are fairly strong. The origin of these emission lines is somewhat obscure. It is probable that they come from the outer regions of the atmospheres of the stars; but in a large subgroup of these stars, the long-period variables, several hydrogen emission lines are weakened by absorption lines in gases which lie at still higher levels. This is especially striking in the case of He in Mira Ceti, where this particular hydrogen line is greatly

weakened by overlying vapour of Ca II.

An interesting but small group of stars have spectra containing forbidden emission lines, i.e., lines which are not produced in the laboratory because the corresponding transitions are not permitted by the rules of the quantum theory. Some of these stars have weak continuous spectra upon whose background are seen numerous bright lines of H, Fe II, [Fe III], Fe III, [Fe III], [Fe V], [Fe VI], [Fe VII], and probably even [Fe X] and other elements. The bracketed designations of elements stand for forbidden lines, and the Roman numerals designate the state of ionization. Since the ionization potentials of these substances differ widely, by Saha's formula of ionization they could not all be observed in a gas of uniform temperature and pressure. The conclusion is that they come from different regions of a highly complex nebulous structure. P. W. Merrill found that most of these stars also show absorption bands of TiO. It is believed that they consist of three sources: a cool star, a hot companion and a gaseous mass in which the radiation of the hot star causes ionization and excitation. In some cases, like the star Antares, the binary can be observed directly. Its bright component is a cool giant, but it also has a faint, hot companion whose spectrum reveals for-bidden [Fe II]. Swings and Struve have found that in these stars the forbidden lines of [Fe II] and those permitted lines of Fe II whose energy levels are low are abnormally strong, so strong, in fact, that an impossibly low excitation temperature results when the intensities are interpreted by means of the Boltzmann exponential relation. The conclusion is that the mechanism of excitation consists in collisions between atoms and electrons, and not in the process of line absorption or ionization. Most of these spectra undergo rapid variations, sometimes in the course of a few days.

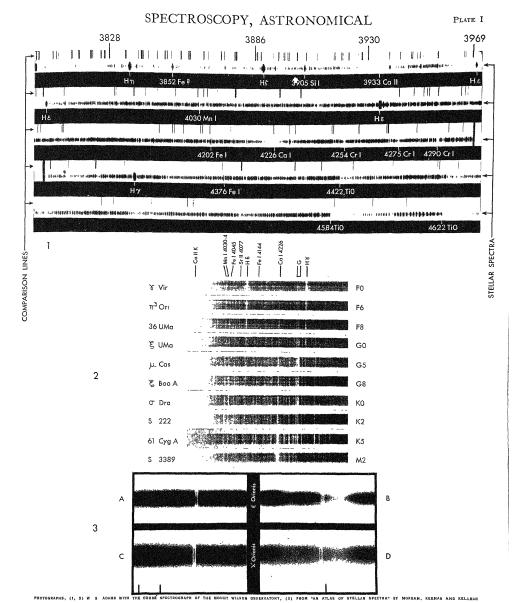
Spectra of Shells .- In 1938 the spectrum of the star Pleione, one of the brighter members of the cluster of the Pleiades, underwent a sudden change. For about 30 years the spectrum had been that of a normal B star with very diffuse absorption lines of H and He. It now developed emission lines of H and a set of sharp absorption lines of H, Fe II, Ti II, Ca II and other ionized elements. In the course of several years these sharp lines became very strong and indicated a tendency toward lowered ionization. A number of other stars which possess similar spectra are known, though they have not often been observed in the process of formation. The source of these spectra is designated as shells because it is inferred from the reduced intensities of a few characteristic lines that the gases in which they are formed are not at the surface of the star but are removed above it to several times its radius. The phenomenon producing these lowered intensities is designated as "dilution of radiation." To obtain normal intensities the populations of the different atomic levels must correspond to Boltzmann's relation. If the mechanism of excitation is the absorption of radiation this happens only when the radiation corresponds to conditions of thermodynamic equilibrium. When a gas is illuminated by a distant star the radiation is "diluted" and those excited energy levels which possess transitions to lower terms are depopulated in the same ratio that the apparent area of the star as seen from the gas bears to the complete sphere. The phenomenon of dilution causes the lines of Mg II 4481 and Si II 4128, 4131 to appear abnormally weak. It also produces remarkable changes in the relative intensities of the He I lines. The formation of shells seems to be related to the process of axial rotation of the stars. In some shells (f Tauri and  $\phi$  Persei) the shell is stratified and different layers of it revolve at different speeds around the main body.

Novae.—Few astronomical phenomena can compare in spectacular interest with the outburst of a bright nova. The spectra of these stars show very rapid changes. Prior to its outburst the spectrum is as inconspicuous as the star itself. But in a few hours, when the light suddenly increases several thousandfold, the spectrum becomes that of a rapidly expanding shell.

At first the shell shows mostly absorption lines which are greatly displaced toward the violet, because in the early stages the exploding gases are still largely projected upon the disc of the star, and we observe only the absorbing action of those regions which are being ejected in our direction. Gradually numerous broad undisplaced emission lines appear in the spectrum and rapidly increase in intensity. Usually several distant expanding shells are formed, each having its own velocity of expansion. The bright lines of the metals which appear early in the history of a nova gradually give place to those of the lighter elements. like H, O and N. The forbidden lines of [O III] become particularly strong and often cause the star to appear conspicuously green when observed through the telescope. D. B. McLaughlin has shown that all normal novae follow a definite pattern of spectral evolution, the character of which depends upon the duration and the violence of the outburst. The amount of matter lost by a nova during its outburst is a very small fraction of the total mass of the star.

A totally different series of changes is presented by the supernovae, whose visual brightnesses may suddenly increase by a factor of 100,000,000 times, while ordinary novae vary about 100,000 times. R. Minkowski has investigated the spectra of several of these objects, many of which have been discovered by F. Zwicky on photographs of remote galaxies. Statistical considerations show that the outburst of a supernova in our galaxy may be expected once every 600 years. The spectra of the most luminous supernovae show unresolved features which may be emissions or absorptions, or both. No satisfactory identifications of these features have been made. In the less luminous supernovae, F. L. Whipple and Mrs. C. H. Payne-Gaposchkin have found evidence of some of the same bands which are present in ordinary novae but which are broadened by expansion to a much greater extent than in the latter (about 5,000 km./ sec., as against about 1,000 km./sec.). There are many unexplained features, such as a variable red shift discovered by Minkowski, but it is difficult to study these stars because of their small apparent brightnesses. It is possible that the so-called Crab nebula has resulted from a supernova in our galaxy.

Pulsating Stars.—Among the stars whose radial velocities undergo periodic changes are the variables of the Cepheid and the long-period groups. The former have velocity curves which may be described as the mirror-images of their respective light curves. The variations in velocity are not caused by orbital motion, as in ordinary binaries, but are believed to be produced by periodic pulsations. The periods vary from a small fraction of a day to about 50 days. The spectral classes also undergo periodic variations, being hottest near maximum light, or near minimum radial velocity. There is conflicting evidence from the luminosity criteria but the hydrogen lines give maximum luminosity near maximum light; this correspondence is not physically obvious because the observed change in brightness (of the order of one stellar magnitude) is fully accounted for by the variation in temperature, and



Stellar spectra. All spectra are shown as negatives: the absorption lines appear white on a black background

- Appear wither the autonomous background of a control of the control of the control of a control
- A part of the spectral sequence showing the gradual changes in line intensities for several subdivisions in spectral class between FO and M2 in stars of moderate luminosity
- Multiple interstellar absorption lines in two stars: Ca II K in (a) and (o); Ca II H in (b) and (d). The very broad and diffuse line in (b) and (d) is the stellar line H€

the elementary pulsation theory would predict maximum radius and, hence, minmum atmospheric pressure halfway from minimum toward maximum radial velocity. Evidently the hydrogen atmosphere is expanded at the time of maximum light, and the phenomenon is only indirectly related to the pulsation. The long-period variables are probably also pulsating stars. Their spectroscopic changes have been described principally by P. W. Merrill and A. H. Joy at Mount Wilson. All of these stars show a fairly close relation between period and average spectral class, and a close relation between period and luminosity. Probably lelated to the long-period variables are several other groups of variable stars, designated as the irregular and the semregular variables. The spectra of these stars show interesting changes. Many of them, like the long-period variables, have strong, variable emission lines. The Cepheid variables show emission lines in very few

Abundance of Elements.—The question has often been asked whether the two-dimensional spectral classification outlined previously is sufficient to classify every normal star within the precision of modern spectroscopic measurements. The importance of at least one additional parameter, namely, abundance of atoms of different elements, is strongly indicated by a number of data. The question is difficult because nearly all the observed differences in the line spectra of the stars are caused by differences in temperature and pressure But there are a number of striking cases where these parameters appear to be insufficient. Thus, R. H. Curtiss, and later H. N. Russell, showed that the predominant appearance of TiO in classes K and M, and of compounds of C in classes R and N is probably caused by real differences in the abundances of O and C.

Russell's calculations found an interesting application in the work of L. Berman on the spectrum of the irregular variable R Coronae Borealis. In this star the H lines are much weaker than is consistent with its class, while the features due to C are too strong. Berman found that among the elements present in its atmosphere carbon contributes 69%, hydrogen 27%, nitrogen less than 0.3%, and the metals about 4% by volume. In the

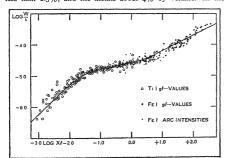


FIG. 3.—THE CURVE OF GROWTH OF THE SUN'S SPECTRUM ACCORDING TO K. O. WRIGHT

The abscissa are logarithms of the relative numbers of atoms (here designated as  $X_i$ ) effective in producing the line and which can be inferred from multiplet and supermultiplet relations in spectroscopy, or from laboratory measurements. The ordinates are logarithms of the equivalent width (W) of the lines divided by their wave lengths (A). The curve is profully local to  $X_i$  in its lower left portion and is proportional to  $\sqrt{X_i}$  in its upper right portion. The bending over is the result of the thermal motions of the atoms in the sun's atmosphere

sun D. H. Menzel finds 82% of hydrogen, 18% of helium, 0.003% of carbon and 0.01% of nitrogen.

Another interesting case of abnormally low bydrogen abundance was observed by I. L. Greenstein in v Sagittarii. The compromise class of this star is A, which is usually characterized by very strong lines of H. In reality these lines are very weak It turns out that He is about roo times as abundant as H, and H is about roo times as abundant as Fe. But the great majority

of the stars and nebulae have abundances similar to that of the sun, with hydrogen about 8,000 times more abundant than all the metals taken together.

In addition to differences of abundance there are several other small factors, as yet unexplained, which cause a certain amount of uncertainty in the spectral classification. These factors are quite unimportant when the purpose of the classification is to serve in the study of the structure of the galaxy and of its statistical properties. But they assume great interest in purely astrophysical studies. Among them are the following: (a) among the hotter stars (class B) there are some, like the star Maya in the Pleiades, which have abnormally weak lines of all elements; (b) among the stars of class A the spectral sequence divides out into several parallel branches; one branch is characterized by strong lines of Si II, others are strong in Mn II or in Sr II, still others have weak Ca II or strong metallic lines. It is not possible to reconcile these differences with the theory of ionization, and it is not reasonable to suppose that such striking differences in the abundances of the elements affect only this particular portion of the spectral sequence.

Cor Caroli Stars.—A remarkable group of stars of intermediate class shows abnormally strong lines of rare earths, especially Eu II and Gd II. In some of them the lines of the rearcearths are variable in intensity, while in others there are periodic variations in the intensities of lines of Cr II and of other lines commonly present. The best known representative of this group is Cor Caroli, whose period is five and one-half days. P. Swings has found strong lines of doubly ionized rare earths, in addition to the singly-ionized elements The variations are not easily explained by the theory of ionization as changes in temperature and pressure, and the velocity curves, which are different for different elements, are neither those of binary motion, nor those of ordinary pulsation.

Spectroscopic Binaries.-Unusual spectroscopic phenomena have been observed in a number of close double stars not otherwise identified with one of the preceding groups. Among these are the following: (a) In several eclipsing variables consisting of supergiant components which eclipse one another, the light of one component is observed to shine through the extended atmosphere of the other (5 Aurigae). In one case (6 Aurigae) the light of the brighter and smaller component shines through a considerable thickness of the substance of the larger and fainter component. Incidentally, this fainter component has a diameter about 3,000 times that of the sun and a temperature low enough to classify it as an infra-red star. (b) The absorption lines of several eclipsing variables show changes in intensity and distortions of their velocity curves, which indicate the presence in these systems of streams of gas which do not strictly belong to either component but which flow in complicated orbits through the system. (c) A combination of these streams with a spiral of outflowing gaseous material satisfactorily accounts, according to Struve and Kuiper, for the complicated changes in emission and absorption lines of  $\beta$  Lyrae. (d) There is a well-known tendency among components of close double stars to have more nearly similar spectra than is predicted from other considerations. This is attributed to the reflection of light of one component by the other. The reflection effect probably causes asymmetry in the profiles of spectral lines (fainter component of α Virginis). (e) There are peculiar periodic variations in the relative intensities of components of double-lined spectra, which have not been ex-

## LINE PROFILES

By means of a spectrophotometer it is possible to measure the intensity of a star's radiation at successive wave lengths, from one edge of a spectral line to the other. When the results of these measurements are expressed in units of the intensity of the continuous spectrum in the immediate neighbourhood of the line and are plotted as ordinates against the wave lengths as abscissae, the resulting curve is designated as the profile (or contour) of the line. The unit can, of course, be given in ergs per cm², per sec, if the effective temperature of the star is known and if

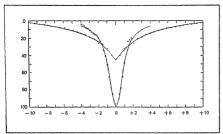


Fig. 4 —PROFILES OF THE HYDROGEN LINE  ${\rm H}\beta$  in a star of low atmospheric pressure (e. aurigae) and in one of high atmospheric pressure ( $\gamma$  peass)

The broadening is caused by the combined Stark effect of charged electrons and ions upon the radiating atoms of hydrogen. The abscissas are angstrom units and the ordinates are percentages of abscrption

the only approximately correct assumption is made that the star radiates as a black body. The profiles of faint lines are strongly affected by the finite resolving power of the spectrograph. For these it is customary to integrate the profiles and to express them in units of one angstrom of complete absorption. These values are designated as the equivalent widths of spectral lines. But for strong lines, like those of Ca II in the sun, the hydrogen lines in the A stars, etc., it is possible to derive physically significant profiles whose interest consists in the information they yield concerning the variation of the lineabsorption coefficient with wave length and the character of the propagation of light through the atmospheres of the stars. Important information can be obtained from a curve in which the equivalent widths of the absorption lines are plotted as ordinates against the corresponding numbers of atoms effective in producing each line, as abscissae. Such curves are designated as curves of growth because they indicate the manner in which the intensity of a line grows as the numbers of atoms are increased.

Radiation Damping.-Many lines, like those of Ca II, in the sun, have broad profiles with very deep, narrow pointed centres, where the residual light is only from 1 to 10% of the continuous spectrum, and with wings which extend very far to both sides (fig. 2). These profiles are well represented by an absorption coefficient which is inversely proportional to the square of the distance from the centre of the line. Physical theory suggests that this is the common form of the absorption coefficient of a single, undisturbed atom, where the gradual damping of the radiation in consequence of the loss of energy is the sole broadening influence. Since the mathematical form of this expression is known for a single atom of Ca II, it is possible from the observed profile to derive the number of absorbing atoms of Ca II per cm2. in the atmosphere of the sun. This was first done by Unsöld, who used earlier measurements by K. Schwarzschild. In some spectral lines, for example, those of Mg I in the sun, or some lines of He I in B stars, the profiles are similar in shape to those given by radiation damping but their widths are much greater-just as though the constant of the formula were several times as great as that predicted by atomic theory. This phenomenon is explained by the effect of collisional damping, which was first introduced into physical theory by H. Lorentz and later extended by Weisskopf and Wigner to include processes where atoms do not actually collide, but experience close approaches to one another. This form of broadening is important in dwarf stars of low luminosity, and is unimportant in giants of high luminosity. In both types of broadening the equivalent width of a line increases as  $\sqrt{N}$ , where N is the number of absorbing atoms. For example, we know that the line K of Ca II is formed by twice as many atoms as the line H. In consequence the equivalent widths of the two lines in the sun are in ratio  $\sqrt{2}$  to 1.

Thermal Doppler Effect.—In a stellar atmosphere the atoms because of the symmetrical form of the Stark effect splitting in are never quite undisturbed. They are moving about in all directions. H. this was not sufficient to prove the existence of Stark effect

tions because of the high temperatures prevailing in these regions, and these motions are presumably in accordance with statistical theory. Although every single atom radiates in accordance with radiation damping, some atoms are approaching while others are receding. The fraction which moves with a velocity v is, in accordance with Maxwell's law (see Kinetic Theory of Matter), proportional to  $e^{-(v/v_0)^2}$ , where  $v_0$  measures the average speed of the atoms. But if an atom moves with a velocity v in the line of sight it absorbs not in the normal position of the line but at a distance of  $\Delta \lambda = \frac{\lambda - v}{2}$ . If  $v_0$  were very large, then

radiation damping would be relatively unimportant. The profiles would be bell-shaped, in accordance with Maxwell's formula, and the equivalent widths would increase as N, and not as  $\sqrt{N}$ . For normal stellar temperatures radiation damping predominates for all but the very faintest lines. We therefore have a gradual transition in the relation between equivalent width and N, at first it varies as N, then as  $\sqrt{N}$ . The corresponding bending of the curve of growth, as this relation is called, was observed in the sun by Minnaert, by Allen and by others. (Fig. 3).

Turbulence.-The curves of growth of many stars, such as a Persei or  $\epsilon$  Aurigae, show a transition from the N to  $\sqrt{N}$ relation at an equivalent width which is much too large to be explained by thermal motions. Moreover, these curves show a region of transition between the two major branches of the curve of growth, where the equivalent width changes little with N, and remains almost horizontal. This phenomenon, first noticed by Struve and Elvey, is explained in terms of turbulent motions in the atmospheres of the stars. It is not known how large the volumes of gas are which are subject to these motions but they must be considerably smaller than the entire depth of the atmosphere, because otherwise the phenomenon would manifest itself differently in the curve of growth and would suggest convection. and not turbulence. The largest average turbulent velocity measured is about 67 km./sec., for the star 17 Leporis. The best analogue on the earth are the thermals which form on sunny days, but it must be remembered that the causes of the two phenomena are not the same.

Stark Effect.—In the presence of an electric field the spectral lines of many atoms are disturbed. In hydrogen the lines are split into several components, in helium some lines are little affected while some are displaced toward the red and others are displaced toward the violet and completely new lines, never seen without electric fields, appear in the spectrum. It has never been

possible to detect even the slightest evidence of a uniform electric field in the sun or stars. But the atmospheres of all stars contain vast numbers of charged particles, namely, free electrons and ions, each of which carries its electric charge and may in its thermal flight through the atmosphere come close enough to a radiating atom to produce an appreciable Stark effect. We observe a combination of countless cases of this sort, with all possible distances between neighbouring particles and all orientations. The observed line should therefore have a blurred appearance,

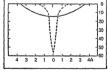


FIG. 5.—PROFILES OF THE LINE MG II 4481 IN VEGA (----) AND IN ALTAIR (-----).

The line in Altair is broadened by the rapid rotation of the star. These profiles were obtained from the spectrograms shown in Plate II (9 and 10). The abscissar are angstrom units, and the ordinates are percentages of absorption of the continuous spectrum

and its form can be predicted by a combination of statistical and physical theories.

The profiles which result from an application of the theory by Doppler effect. The wings are exceedingly broad and the centres of the lines are appreciably raised, so that the residual intensities may be as great at 50% of the continuous spectrum. Such profiles are observed in the hydrogen lines of dwarf stars, but because of the symmetrical form of the Stark effect splitting in the hydrogen spectrum of Stark effect of the symmetrical form of the Stark effect splitting in the hydrogen spectrum of Stark effect.

m stars. The proof came when the lines of He I in B stars were found to show appreciable broadening in those lines which are sensitive to electric fields and no broadening in those lines which are not sensitive to it. Stellar spectra also show several of the new lines forbidden by the quantum theory in the absence of fields; and the permitted lines show systematic shifts m accordance with the theory. The Stark effect is appreciable in ordnary dwarfs and is very large in white dwarfs. It can be used to determine the luminosity of a star, because of the close relations between this quantity and the atmospheric density.

Rotation.-In many stars, especially of classes O. B. A and F. all lines appear blurred, even those which are not sensitive to Stark effect, while at the same time the curve of growth shows no appreciable turbulence. The equivalent widths of the lines are not altered by this broadening influence and the great widths are obtained at the expense of the central intensities. In some cases it has been shown that the widths of the lines are proportional to the wave lengths, if corrections are made to reduce them to the same equivalent width. Since the Doppler effect is proportional to \(\lambda\) and since no physical alteration of the absorption coefficient can fail to influence the curve of growth, or the equivalent widths of the lines, the conclusion is justified that we are dealing with some form of Doppler effect. Axial rotation. radial expansion and convection suggest themselves. The effect of expansion is to produce an unsymmetrical profile which is deepest at the point of greatest negative displacement  $\Delta\lambda_0$ , and merges with the continuous spectrum at  $\Delta\lambda = 0$ . Since we can see only one hemisphere of an expanding star, the line does not extend into positive values of  $\Delta\lambda$ . Neither the asymmetry nor the preference for negative displacements agrees with the observations. We are left with rotation and convection.

To decide between them Struve and Shajn made numerous determinations of line profiles in close spectroscopic binaries. In these stars the components are almost in contact and it is reasonable to suppose that their rotational periods are equal to the period of orbital revolution. All have very broad and shallow lines, and this phenomenon is the more conspicuous the shorter the period. Since no such relation is expected in the case of convection, the "dish-shaped" line profiles can be attributed to axial rotation. In a few eclipsing binaries, for example in Algol, the line profiles become unsymmetrical during the partial phases of the eclipse and, as Rossiter and McLaughlin have shown, it is possible to derive from them the rotational velocity at the equator. The observed values range from o to about 300 km./sec., with a few which exceed this value.

A statistical study of the frequencies of different rotational velocities shows that the stars do not all rotate uniformly, and the observed distribution is not simply a result of random orientations of the axes. The largest values are observed in several bright-line B stars. When the bright-line stars are considered alone, the distribution does seem to be due to the geometrical factor alone. It is probable that the rotations of all of these stars are so rapid that they may actually lose material at their equators. In a general way, according to W. W. Morgan, the broadest rotational lines occur in stars of low luminosity and the lines become progressively narrower with increasing luminosity. In all close spectroscopic binaries observed prior to 1945 the direction of axial rotation is the same as that of orbital motion, but in a few close systems (U Cephei) the rotational period is shorter than the orbital period.

Central Intensities.—It has been previously stated that even in those lines which are strong enough and broad enough not to be seriously affected by the finite resolving power of the spectrograph the central intensities are not exactly zero, and this remains true after instrumental corrections have been applied. Very accurate central intensities in solar lines have been measured by C. D. Shane at the University of California, who used an interferometer to increase the purity of the spectrum. The origin of these central intensities is interesting; according to physical theory the line-absorption coefficient never becomes infinitely great. Yet, the value predicted by radiation damping is so great that the ordinary absorption formula \$I10=e^{-kt}\$, where

k is the absorption coefficient and l is the length of the path in the absorbing medium, would require that the central intensity to be so small that it could not be observed to differ from zero.

We are here concerned with a problem of great importance, namely, the manner in which the radiation is propagated through the star's atmosphere. The corresponding theory has been developed by Karl Schwarzschild, Edward A. Milne, Arthur S. Eddington, Bengt Stromgren, A. Unsold, S. Chandrasekhar and others. The fundamental difference from the ordinary formulation of this problem comes from the fact that the atoms not only absorb, but they also re-emit radiation, and that this re-emitted radiation is thrown in all directions, while the absorption takes place in radiation directed outward from the star The central intensities in a star which is devoid of an extended chromosphere come from this re-emission. In a shell, like that of Pleione, where the absorbing gas is very far from the source of the continuous spectrum, the photosphere, only a small fraction of the re-emitted radiation is projected upon the apparent disk of the star, as would be seen by the observer if he had a sufficiently large telescope. Hence the absorption process is essentially that described by the exponential formula, and the central intensities are so close to zero that they have not been measured. But in a normal star of approximately the same temperature the central intensities may be as high as 50% of the continuous spectrum. There are two possibilities: an atom may, after a process of absorption, immediately re-emit the same line: this is the case of pure scattering. Or the atom may after a process of absorption lose track of the quantum, allowing it to be absorbed again and re-emitted a number of times, so that the energy which finally is re-emitted by the original atom is a kind of statistical average over all possible processes and is then determined by the Kirchhoff-Planck function. This is the case of pure absorption. In reality, both cases may be realized in the stars. Lines of high excitation potential, like those of H and He, probably ap-

In reality, both cases may be realized in the stars. Lines of high excitation potential, like those of H and He, probably approach the second case, while resonance lines, like H and K of Ca II, approach the first case. Schwarzschild has shown that for pure absorption the central intensity is that which corresponds to the temperature of the outermost, and hence, the coolest layers of the stellar atmosphere. This, incidentally, is also the intensity of the continuous radiation at the extreme limb of a star's disk. Hence, if we observe the central intensities of H and He I in a B-type star we obtain a measure of the darkening of the star's continuous radiation from centre to limb.

Unsöld found that in the star  $\tau$  Scorpli the central intensities which are almost 50%, are still too small to accord with the usual theory of the limb dalkening. He would have expected an even higher central intensity. The discrepancy can be used to improve the theory of the continuous absorption coefficient, which determines very largely the phenomenon of limb darkening.

Some puzzling differences in the central intensities of lines of Fe I were found by L. Spitzer, Jr., in  $\alpha$  Orionis and several similar cool supergiants. There is a pronounced tendency for the central intensities to be greater as the excitation potential increases, and there are several abnormally shallow lines. The latter are members of multiplets whose other members behave normally, but they all happen to have identically the same upper level. There is good reason to believe that this particular level is overpopulated because it is fed by a special process pointed out by A. D. Thackeray—there is a strong line of Mg II 2705.52 which almost coincides with the Fe I line 2795.00. If the former were in emission-it cannot be observed because it lies too far in the ultra-violet-this would stimulate the absorptions in the Fe I line and overpopulate the required level. Such abnormal re-emissions are designated as fluorescence. In some late-type variables the abnormal Fe I lines appear actually in emission, while the other members of their multiplet are present only in absorption.

Convection.—Adams and his co-workers at Mount Wilson have found that in many stars—especially in giants and super-giants—there are appreciable differential radial velocities between different sets of lines. In some M-type supergiants many lines are double, while others are single. In a Orionis the violet

components are sharp and strong, while the red components are weak. All the double lines arise from very nearly the ground state of the neutral or ionized atoms. This phenomenon is undoubtedly caused by differential motions within the enormously extended atmosphere of the supergiant star. Similar motions may account for the differences in displacement between absorption and emission lines in M-type variables, as observed by Merrill,

Joy, and others.

Centre to Limb Differences .- The most powerful method for testing theories of line formation consists in the study of line profiles at different distances from the centre of the sun. K. Schwarzschild showed that if a line is produced by the re-emission process designated as pure absorption, it should completely disappear at the extreme limb of the sun; in the case of pure scattering, on the other hand, the line should persist at the limb. From the measurements by Schwarzschild, H. H. Plaskett, Miss M. G. Adam, J. Houtgast, M. Minnaert and others, it is known that all strong solar lines become somewhat weaker at the limb but they do not disappear (fig. 2). Very faint lines, however, not only do not show this weakening but they even become slightly stronger. The interpretation of these observations is difficult and involves a number of physical data which are not available. The most extensive work on the interpretation of solar lineprofiles is by B. Strömgren. In the stars we usually observe line profiles integrated over the entire disk. But in a few eclipsing variables in which a large, dark star centrally eclipses a small, bright star there is a chance of observing the spectrum from the limb of the small star immediately before and immediately after totality. In this manner R. O. Redman, and later O. Struve, found some evidence that the lines of hydrogen almost disappear at the limb of the hot component of U Cephei.

# GASEOUS NEBULAE

The spectra of the gaseous nebulae consist of a weak continuous spectrum and a set of strong emission lines. The former shows a conspicuous discontinuity at \(\lambda\) 3647 and is therefore, in part, caused by the process of recombination of protons with free electrons. But the continuous spectrum of some of the nebulae in the ordinary photographic region is too strong to be entirely due to the Paschen continuum. It is probable that most, if not all, of it is caused by diffuse scattering of starlight by small solid particles in the nebulae. The line spectra contain many features which were not identified previous to 1927. In that year I. S. Bowen attributed all the principal "nebulium" lines to forbidden transitions between metastable levels of some of the more common atoms, [O II], [O III], etc.

From the work of E. Hubble it is known that the nebulae derive their light from hot stars located within their confines. The ultra-violet continuous radiation of these stars, especially that on the violet sides of the Lyman limit of hydrogen and the corresponding limits of He I and He II, is absorbed by the atoms of the nebula. In this manner the principal permitted lines are excited because they are radiated when the excited atoms fall back, either directly or by cascading, to their ground levels. In the process of cascading some atoms will find themselves in the low-energy metastable levels, where they are caught for a long time because there are no further permitted transitions downward. The atoms can get out only by one of three processes, all requiring long intervals of time; they can swallow another quantum of energy and return to a higher level; they can collide with another particle and make use of the kinetic energy of the collision to escape the trap; or they can patiently await their release in the form of a forbidden transition which, despite its name, is not entirely impossible but occurs, on the average, once for every 108 permitted transitions.

In all laboratory experiments collisions are too frequent to allow enough forbidden transitions to take place. In the atmospheres of the stars the radiation is so intense that quanta fly about everywhere in large numbers and atoms which find themselves in the trap have plenty of opportunity to get out by absorption. But in the nebulae, collisions are very rare and the density of quanta is low. Hence, large populations of atoms

accumulate in the metastable levels, and despite the relative infrequency of a forbidden transition the forbidden lines appear with great strength.

Bowen has shown that while the process of cascading will furnish appreciable populations in the metastable levels, the forbidden lines are relatively so strong, compared with the permitted lines of the same ions, that another process must also be postulated. It consists of collisions of unexcited ions with free electrons. Although collisions are insufficient to remove an appreciable fraction of atoms from an excited level to a higher level, with a large change in energy, they are very efficient in producing small energy changes and, therefore, account satisfactorily for the observations. Bowen has discovered a third process of nebular excitation, namely, fluorescence. By a chance coincidence the wave length of one of the strongest (though unobserved) emission lines produced by the primary process of recombination, He II 303.780, agrees almost precisely with the permitted line O III 303.799. In consequence, the emission of He II stimulates an abnormally large number of atoms of O III to absorb and to jump to the upper level of the O III line. Hence, they cascade downward, producing strong lines of certain members of various multiplets, while other members remain invisible. These mutilated multiplets have been observed by W. H. Wright.

The energies contained in the emission lines of a nebula are the result of conversion by the atoms of ultra-violet continuous radiation of an exciting star. Since the former can be measured, we obtain a measure of the unobservable ultra-violet light of a hot star; on this basis H. Zanstra has developed a theory for determining the temperature of the exciting stars. This method in the hands of D. H. Menzel and his associates gave excellent results and led to the realization that while the temperatures of the stars range from 3,000° to 100,000°, the electron temperature of the nebular gas is usually of the order of about 10,000°. The farthest ultra-violet continuous radiation of the star is absorbed in its immediate vicinity. Hence the lines of He II are limited to a small volume around the star. On the other hand, elements of lower ionization potential, like He I and H, occur at greater distances. This gives rise to an apparent stratification in the nebulae. Of great interest are the absorption lines of He I observed by O. C. Wilson in the Orion nebula. All these lines have metastable lower levels.

A subject closely related to that of the nebulae is that of interstellar gas. It manifests itself in two forms: as absorption lines of abundant elements in their ground levels, observed on the background of the continuous spectra of distant stars, and as emission lines of H, [O II], [N II], etc., in many large areas of the Milky Way. The emission lines, as well as the absorption lines, are produced through excitation by the combined light of the stars.

The density and the temperature of this field of radiation can be computed for the neighbourhood of the solar system. Since we observe interstellar lines of Ca I and Ca II, we can form the ratio w'/n in Saha's ionization formula, appropriately amended for the effect of dilution in the radiation. We then have only one unknown quantity, the electron pressure. This turns out to be equivalent to about 10 electrons per c.c., a value which is consistent with the observed surface brightness of luminous hydrogen over large areas of the Milky Way.

C. S. Beals, R. F. Sanford and W. S. Ádams have found many stars with multiple interstellar absorption lines showing that the gas consists of clouds having individual motions. Andrew Mc-Kellar, Theodore J. Dunham, Jr., Walter S. Adams and G. Herzberg have found and identified several interstellar molecules, such as CH. CH<sup>\*</sup>, and CN.

A theory of interstellar emission has been developed by B. Strömgren. Because of the gradual exhaustion of the ionizing stellar radiation in the gas he added a term to Saha's formula to take care of this exponential absorption. It turned out that the boundary between the region where H is ionized and the region where it is unionized is fairly sharp. The regions of ionized hydrogen are identified with the observed areas of luminous hydrogen.

#### PLANETS AND COMETS

The planets shine by reflected light and their spectra show the usual solar spectrum; the distribution of continuous energy is modified by the colour of their surface structures or by the scattering of their atmospheres. The solar lines are displaced by the orbital and rotational motions of the planets and, in addition, there are absorption bands produced in these atmospheres. Measurements of radial velocity have been extensively used to determine the periods of rotation, especially in the case of Neptune and the law of motions of the rings of Saturn. Differential radial velocities between the planet and the earth are also important to distinguishing between absorption bands of water vapour and of oxygen, which are strong in our own air.

Adams concluded in 1941 that water vapour, if at all present on Mars, constitutes not more than 5% of that in air, and probably very much less. Nor is there any free oxygen in excess of that in air. But the red colour of the desert areas on Mars suggests the existence of large quantities of oxygen in the form of compounds, such as rust. There may also be enough water vapour to give rise to thin sheets of ice at the polar caps.

Adams and Dunham found two new bands of carbon dioxide on Venus, while A. Adel and V. M. Slipher estimated that the amount of carbon dioxide above the cloud layer of Venus is several hundred metre-atmospheres. The spectra of Jupiter, Saturn, Uranus and Neptune show conspicuous bands in the red and infrared regions. They were identified by R. Wildt in 1932 as ammonia and methane. Several successful attempts have been made by Dunham and by Adel to determine the temperatures from the distribution of intensity in the various bands. Thus, for Venus, Adel found so? C., from the carbon dioxide bands. The ammonia band is strongest in Jupiter, and becomes progressively weaker in Saturn, Uranus and Neptune. The methane bands, on tures Thus, for The the other hand, increase greatly from Jupiter, with 0.5 mile-atmosphere (amount of gas whose absorption of light is equivalent to a mile-long column of the same gas at standard atmospheric pressure), nme-ong count of the same gas at standard atmosphere, pressure), to Neptune, with 25 mile-tamospheres, according to Slipher and Add. In 1944, G. P. Kuper found the bands of methane on the largest satellite of Saturn, Titan. They are a little weaker in the satellite than in the planet. None of the other satellites in the solar system, nor pluto, shows any of the bands with the spectrograph used by Kuper

The spectra of the comets are characterized by emission bands of CN, C2, CH, OH, NH, CH<sup>+</sup>, CH2 in the heads, CO<sup>+</sup> and Na<sup>+</sup> in the tails. P. Swings has shown that the bands are excited by solar radiation. Since the latter is not uniform, like that of a black body, but is broken up by many strong absorption lines, the excitation to various molecular levels in the comet is quite abnormal, and the resulting intensities of the individual lines within the bands are dif-

ferent from those observed in the laboratory.

### THE SUN

Since a separate article on the sun (q v.) contains a description of its spectrum, only the principal features have been briefly mentioned in the foregoing sections to the extent to which they are valuable in turnishing independent information to the study of astronomical spectroscopy. There remains, for completeness, the problem of the spectroscopy. There rem spectrum of the corona.

The corona consists of an inner zone having a continuous spectrum, ionization level in the sun's atmosphere is about 8 volts. If we insert ionization level in the sun's atmosphere is about a volts. If we have these values, one after the other, in the ionization equation and use the same value of  $T=5040^\circ$  C, which is approximately correct for the sun's atmosphere, we obtain  $\log_{10} p_c/p_c=806$ . This is impossible, since there would not be enough gas left to show any lines. Evidently we must adopt for the corona a very much higher temperature, perhaps one of the order of 1,000,000, to obtain a reasonable pressure. The origin of this high temperature is not known. Because of the extremely tenuous nature of the corona, this high temperature ot the extremely tenuous nature of the corona, this high temperature does not make itself felt on the earth; what we experience as the heating action of the sun is the radiation of the photosphere whose temperature is more nearly 6,000°. The strongest coronal lines,  $\lambda\lambda$  5,903, 6,975 of [Fe XIV] and [Fe X] and some others, were found by Adams and Joy in the peculiar star RS Ophiuchi. Thus, there is a link between the spectra of the stars and that of the solar

BIBLIOGRAPHY.—History of Astronomical Spectroscopy: H Kayser, Handbuch der Spectroscopie, vol. I (1900). Efficiency of Slit Spectrographs. J. E. Keeler, Sideral Messenger, vol. 10, p. 433 (1891).

Photometry of solar spectrum "Photometric Atlas of the Solar

Photometry of solar spectrum "Photometric Atlas of the Solar Spectrum," The Observatory, (Utreth, Netherlands, 1940).

Wave lengths of solar lines, "Revision of Rowland's Preliminary Table of Solar Spectrum Wave Lengths" (Mount Wilson Observatory), Carnegie Institution of Washington Publications, no. 396 (1928). Methods for observing the extreme infra-red region of the spectrum:

P. Swings, Publications of the Astronomical Society of the Pacific, vol. 56, p. 220 (1944), and vol 57, p. 16 (1945). Construction of astronomical Spectrographs: G. Z. Dimitroff and J. G. Baker, Telescopes and Accessories (1945).

J. G. Baker, Telescopes and Accessories (1945).
Spectral classification: The Harvard system is described by Miss Cannon in the introduction to each volume of the Henry Draper Catalogue (Harvard Annals, vols 91-99, 1918-194); The method of Morgan and Keenan is described in An Allas of Stellar Spectra (1943). Interpretation of spectral classification. A. Unsöld, Physik der Sternatmospharen (Betlin, 1938); S. Rosseland, Theoretical Astrophysics (October 1938).

(Oxford, 1936). Catalogue of radial velocities of stars, nebulae and clusters: J. H. Moore, Publications of the Lick Observatory, vol 18 (1932).

Moore, Publications of the Lick Observatory, vol. 18 (1932).
Physical results of astronomical spectroscopy and line profiles: L
Goldberg and L. H. Aller, Atoms, Stars, and Nebulae (1943); D. B
McLaughlin, O Struve and D. H. Menzel, "Astronomical Symposium,
Western Reserve Academy," (reprinted from Popular Astronomy,
vols. 46 and 47, 1938-1939); P. W. Merrill, Spectra of Long-Peniod
Variable Stars (1940).
Planets: Theodore Dunham, Jr., "Knowledge of the Planets in

Planets: Theodore Dunham, Jr., "Knowledge of the rianets in 1938," Publications of the Astronomical Society of the Pacific, vol 51, p. 272 (1939); F L Whipple, Earth, Moon, and Planets (1941). Comets: P. Swings, "Cometary Spectra," Monthly Notices of the Royal Astronomical Society, vol. 103, p. 86 (London, 1943).

(O. Sr.)

SPECTROSCOPY, X-RAY. The discovery by Max von Laue in 1912 that X-rays could be diffracted by crystals created a new branch in spectroscopy. Whereas the ruled gratings with linedistances of say 1/1,000 of a mm, are powerful tools to register the ordinary optical spectra with wave-lengths down to about 2.000 Ångström units (10-8 cm.), the natural crystals with distances between the atomic layers of a few A. units may serve as diffraction gratings for the radiation belonging to the domain of the X-rays with wave-lengths of the order of 10 to 0.1 A. units.

These figures for the wave-lengths studied by ruled gratings and for the region accessible with crystal gratings show that there was a considerable gap from about 2,000 to 10 Å.U. left. As will be seen later in this report methods have been developed which allow a registering also of this intermediary region.

Historical Remarks .- That the X-rays produced in an ordinary X-ray tube are complex and differ in quality when the vacuum of the tube, or primarily the tension on the tube, is varied was noted by Röntgen himself in his first papers dealing with the new radiation. It was shown early that the X-radiations became more penetrative as the tension of the tube was raised. The degree of penetration (usually measured in terms of the thickness of aluminium necessary to reduce their intensity by half) was used as a means of characterizing the quality of the radiation.

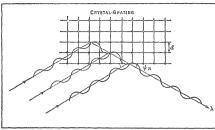
It was by this means also that C. G. Barkla was able to show that the different elements when excited so as to give off X-rays all have their own "characteristic" radiations. For instance for an element such as silver Barkla showed the existence of two "characteristic" radiations called the K- and L-radiation having very different penetrating power.

The K-radiation from this element is reduced to half its intensity after passing through a sheet of aluminium about 1 mm. thick whereas the L-radiation is diminished in the same degree after it has passed through only 0.004 mm. of aluminium.

These two characteristic radiations, the K-series and the Lseries, were experimentally verified for a great number of elements. The measurements of their penetration in aluminium showed that their "hardness" increases regularly for both series when the atomic weight of the emitting element increases.

Corresponding to the emission of the characteristic fluorescent radiation of a certain element, Barkla and his collaborators, especially Sadler, showed the existence of a remarkable abnormality in the absorption of the X-rays. This was the first indication of what is now called the absorption-spectra in the field of X-rays, and which have been shown to be intimately connected with the emission spectra or characteristic radiation of the elements.

Basis of the X-ray Spectroscopy.—The diffraction patterns which Friedrich and Knipping obtained on allowing a fine beam of X-rays to pass through a crystal as suggested by Laue induced W. H. and W. L. Bragg to perform experiments, which formed



the first step of the development of the X-ray spectroscopy As the Braggs showed, a monochromatic X-ray beam is reflected by a cleavage face (or any other atomic plane) of a crystal according to the ordinary laws of optical reflectuon, ie., the incident and the reflected beams are in the same plane and this plane is perpendicular to the reflecting face, and further the angles between these two beams and the reflecting face are equal. In addition to these laws the following condition must be fulfilled if reflection is to occur, namely:

$$n\lambda = 2d\sin\psi_n$$
 (1)

where  $\lambda$  is the wave-length of the monochromatic radiation, d is the distance between two adjacent atomic layers parallel to the reflecting plane,  $\psi_n$  the angle between the beam and the plane and n indicates the "order" of the reflection. (Fig. 1.)

This equation, generally known as Bragg's law, forms the basis for measuring the wave-lengths of X-rays. It may be mentioned that this law needs a small correction, due to the fact that the wave-length is slightly different in a vacuum (or air) than in the crystal.

Spectrometric Methods.—The arrangement for the spectroscopic analysis of an X-ray beam is shown diagrammatically in

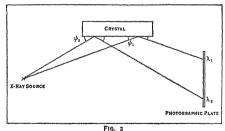


fig. 2. The different monochromatic rays which constitute the beam coming from the X-ray source (or slit) are reflected by the crystal at different angles and directions according to the Bragg law (1) as the angles may vary from  $\psi_1$  to  $\psi_2$  only such rays are reflected whose wave-lengths have values between  $\lambda_1$  and  $\lambda_2$  where

$$n\lambda_1 = 2d\sin\psi_1$$
  
 $n\lambda_2 = 2d\sin\psi_2$ 

On the photographic plate therefore there is found, after exposure and developing, a spectrum ranging from  $\lambda_1$  to  $\lambda_2$ . The region of wave-lengths can be varied by turning the crystal.

From the position of a certain spectral-line on the photographic plate its wave length is computed by equation (1).

Exciting of X-ray Spectra.—To excite the X-ray spectrum of a substance a small prece of it is placed on the anticathode (3a, 3b) of an X-ray tube After the tube has been exhausted to a suitable vacuum a high potential (10 to 150 kilovolts) is applied to the electrodes of the tube. By this means the anticathode is bombarded by the electrons forming the cathode rays. The kinetic energy of the electrons imparted to the bombarded atoms is partially transformed into heat, light, etc., and partially to X-rays. We will here deal exclusively with the last mentioned rays and more especially with the question as to how this radiation varies with the material on the anticathode.

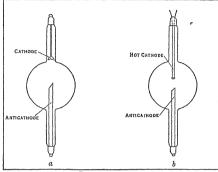


FIG 3 .-- X-RAY TUBES

As to the X-ray tube and its working there are two main ways of producing the cathode rays used for bombardment. In the first type (3a) the tube has a vacuum of o.or to o.oor mm. Hg. The high tension in this case gives rise to ionization of gas remaining in the tube and the positive ions formed are thrown against the cathode (of aluminium) and on their collision set free a number of electrons. The electrons travel in the opposite direction—from the cathode to the anticathode—and bombardment of the anticathode gives rise to X-rays characteristic of the substance of the anticathode. In the second type (3b Coolidge-tube) the vacuum of the tube is much lower.

In this case the electrons forming the cathode rays are supplied by the heated filament (usually of tungsten) in the cathode.

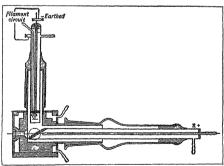


FIG. 4.-METAL X-RAY TUBE WITH HOT CATHODE FOR SPECTROSCOPIC USE

For analyzing purposes it is often necessary to change the substance on the anticathode and the tube must be built in such a way that the anticathode is easily detachable. This can be accomplished by mounting the anticathode in a special joint. A

tube—designed for spectroscopic purposes which permits rapid change of both cathode and anticathode is shown in fig. 4. The tube itself is built of metal with water cooling to permit a very high output of energy. Further a small window of aluminium or goldbeater's skin makes it possible to study the radiation of longer

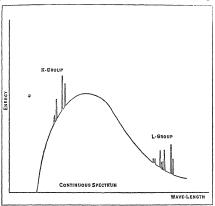


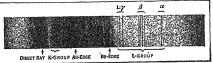
FIG. 5

wave-lengths which are absorbed by the glass walls of an ordinary tube

Another way of exciting X-ray spectra is to irradiate the substance with an intense beam of X-rays. In this case the substance emits "secondary" rays which, with a few exceptions, are identical with the X-radiation sent out by the same substance used as an anticathode in an X-ray tube. This method does not however give the same intensity as the former.

Different Kinds of X-ray-spectra.—The X-ray spectrum emitted from an arbitrary substance is built up of two kinds of radiation, one of which shows a continuous distribution over a wide range of wave-lengths, the other consisting of a few monochromatic rays overlapping the former (see fig. 5). The first mentioned radiation corresponds to the "white" light of ordinary optics, whereas the second is analogous to the line-spectra. The continuous spectrum contains the greater part of the energy of radiation and is therefore the most important part for medical and many other applications of the X-rays. This part of the X-ray spectrum shows qualitatively no dependence on the radiating substance, the intensity only being different from various anticathodes.

The line-spectra on the other hand are characteristic of the



FROM SIGGRANN, "SPEKTROSKOPIE DER RONTGENSTRAHLEN" (SPRINGER)
FIG. 6.—SPECTRUM FROM A COOLINGE TUBE WITH TUNGSTEN ANTI-

emitting substance. They correspond to the K- and L-radiation of Barkla, but analysis has shown that each of these radiations consists of a group of monochromatic spectral-lines.

In addition to the emission-spectrum of X-rays there is also an absorption-spectrum analogous to the absorption-spectra of ordinary optics. Such spectra are obtained when a sheet of thin foil of some substance is placed between the X-ray source and the photographic plate. Instead of a continuous blackening from the white X-radiation the plate shows one or more sharp edges where

there is a rapid change in the blackening—the so-called "absorption-edges". The wave-lengths of these absorption-edges show an intimate relation to the characteristic line-spectrum of the substance used as absorbing screen. Such absorption-spectra were first obtained by Duc Maurice de Broglie and given right interpretation by Sir William Bragg and M. Siegbahn Fig. 6 is a reproduction of a spectral-plate showing these three kinds of spectra.

The Continuous Spectrum.—As already mentioned the "white" or continuous radiation from an X-ray tube covers a rather wide region of wave-lengths. The diagrams of fig. 7 give an idea of the distribution of the energy of the different wave-lengths at voltages from 20 to 50 kilovolts. The curves of distribution always start at a definite minimum wave-length (\lambda\_{mm}). The value of this wave-length decreases with increasing voltage.

It has been found empirically and verified by many investigators that this wave-length  $(\lambda_{\min})$  or its corresponding frequency

$$\left(\nu_{\max} = \frac{1}{\lambda_{\min}}\right)$$
 obeys the Einstein law

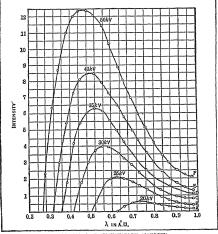
introduced the equation may be written

 $\nu_{\max} = \frac{e^{\nu}}{h}$  (2) where  $e^{\nu}$  is the charge of the electron, V the tension on the tube and h = Planck's constant. If the numerical figures of e and h are

$$\lambda_{\min} = \frac{12 \cdot 3}{V} \tag{3}$$

where the wave-length is expressed in  $\hat{A}.U.$  (10-8 cm.) and V in kilovolts

The total amount of energy, that is, the integral energy included by the distribution-curves in fig. 7, has also been measured



FROM SIEGBAHN, "SPEINFOSKOPIE DER RONTGENSTÄRLER" (SPRIKGER)
FIG. 7.--INTENSITY DISTRIBUTION OF THE CONTINUOUS RADIATION
FROM A TUNGSTEN ANTICATHODE AT VARIOUS VOLTAGES

by many investigators. As the result of these researches it can be stated that the total energy is proportional to the square of the voltage on the tube.

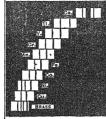
Further it has been found (by G. W. C. Kaye and others) that for different elements used as anticathode the total radiation is proportional to the atomic number of the element.

Already in the early days of X-ray technique it was found advantageous to use heavy elements as anticathodic materials for the medical X-ray tubes, an observation which is in agreement with the last general law.

The Line-spectra.—In 1913 and 1914 the young English physicist H. G. J. Moseley published two very remarkable papers

in the Philosophical Magazine entitled "The High-frequency spectra of the elements." The two papers contain the first announcement of the birth of a new branch of optics. Moseley showed in these publications that there existed in the realm of X-rays line-spectra of the same type as was known in ordinary optics and at the same time that these new spectra were built up in a much more simple and regular way than is generally the case in the spectra which had previously been studied.

Two groups of spectral-lines were found. One of these groups was identified with the K-series of Barkla; the other, of longer



FROM PHILOSOPHICAL NAG. 1913, SER. 6,
VOL. 26, PL XXIII (TAYLOR AND FRANCIS,
LONDON)
FIG. 8.—THE K-SERIES OF THE
ELEMENTS CA TO CU, AND OF BRASS

of Barkla; the other, of longer (Cu. Zn) wave-length and of more complex structure, corresponds to the L-series. Fig. 8 is a reproduction from Moseley's paper of spectra of successive elements from Ca (atomic number 20) to Zn (30). It shows in the most beautiful way how regularly the spectra—in this case the K-group—repeat themselves from one element to the next. With increasing atomic number (here from co to 30) of the emitting element the line-group is displaced in regular steps towards the shorter wave-length. This rule is not confined only to these elements and this group, but is universally confirmed by all X-ray spectra.

In 1916 M. Siegbahn discovered a new series of still greater wave-lengths called the M-series. The existence of series outside the K- and L-group had already been suspected earlier by reasons of analogy. In the later development of X-ray spectroscopy higher series, N, O, etc, have been found.

A general scheme of the X-ray spectra is given in the diagram go which contains the strongest lines of the three groups K, L and M at every third element from Na (11) to U (92). The diagram shows how all three series are regularly displaced to longer wave-lengths as one proceeds from the heavier elements to the lighter. If the spectrum of some special element, say Tungsten, a material commonly used for the anticathode, is considered, it will be seen that there are big gaps between the three groups where no lines are to be found. This fact is of predominant importance in interpreting the spectra in their relation to the structure of the atom.

As to the structure of the different groups it may be mentioned that the K-group generally consists of 4 lines  $(\alpha_1 \alpha_2 \beta_1 \beta_2)$  the L-group of more than 20 lines (the strongest lines designated by  $\alpha_1 \alpha_2$ ,  $\beta_1 \beta_2 \beta_3 \cdots$ ,  $\gamma_1 \gamma_2 \cdots$ ) and finally the M-group of about 20 lines.

Most of the X-ray spectra consists of a very easily absorbed radiation so that in using an ordinary X-ray tube they will no reach outside the glass-walls. In the diagram in fig. 9, only the small portion between the vertical lines o and r Å.U. includes the radiation given off by the technical X-ray tube. Hence for the study of X-ray spectra, one is confined to the use of tubes with thin foils as windows and spectrometers built for vacuum.

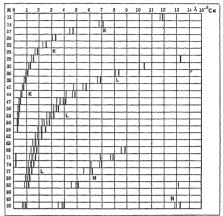
The Absorption Spectra.—As already mentioned the absorption spectra, obtained by putting a screen of the substance between the X-ray source and the spectral plate, usually have the appearance of a sudden, sharp drop in the blackening of the plate.

The study of these spectra has shown that there is always one absorption-edge in the region of wave-lengths where the K-group of the same element is located. In the region of the L-group there are three absorption-edges and finally in the domain of the M-group experiments have revealed five edges.

As to the K-absorption-edges the measurements of their wave-

lengths show that they have, if not exactly, very nearly, the same values as those of the line with the shortest wave-lengths within the K-group.

How the three absorption-edges of the L-group are located relative to the L-emission-lines is shown in figure 10. As seen from this diagram, here also the edge with the shortest wavelength agrees with the shortest emission-line. It is reasonable to suppose that the L-group may be divided in three sub-groups of



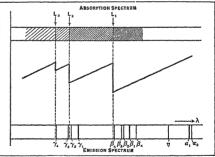
FROM SIEGBANN, "SPEKTROSKOPIE DER RONTGENSTRAHLER" (SPRINGER)
FIG. 9.—DIAGRAM SHOWING THE STRONGEST LINES OF THE SEVERAL
X-RAY SERIES FOR EVERY THIRD ELEMENT

lines of which every one is related to one of the three edges as is the case in the K-group. A numerical analysis of the material strongly supports this view as will be stated later.

Analogous results concerning the five edges within the M-group indicate the existence of five subgroups in this series.

Connection Between Emission- and Absorption-spectra.

—As soon as reliable measurements of the two kinds of X-ray



FROM SIEGRAMM, SPEKTROSKOPIE DER RONTGERNSTRAMLER" (SPRINGER)
FIG 10.—DIAGRAM OF THE ABSORPTION AND THE EMISSION SPECTRUM
SHOWING THE RELATIVE POSITIONS OF DISCONTINUITIES AND LINES

spectra, line- and absorption-spectra, had been performed it was clear that there existed a very intimate relation between them. If the frequencies of the absorption-edges are indicated by

K for the one absorption-edge within the K-group

 $L_1 L_{11} L_{111}$  for the three absorption-edges within the L-group  $M_1 M_{11} M_{111} M_{11} M_2$  for the five absorption-edges within the M-group it is found that the differences between some of these values give exactly the frequencies of some of the emission-lines. For in-

stance the differences  $K-L_{II}$  and  $K-L_{III}$  give the values of the frequencies of the two strongest lines of the K-group namely  $K\alpha_1$  and  $K\alpha_2$ . On calculating the difference between some of the above M-values and the K-value other lines belonging to the K-group are obtained.

In the same way a difference between  $L_D$   $L_H$  and  $L_{III}$  with some of the values of the higher absorption-edges ( $M_I$   $M_{II}$ ...) gives emission-lines of the  $L_{\rm F}$ orup. Now these connections between the absorption and emission-spectra allow an extension which seems highly probable. The frequencies obtained by calculating the difference between the three L-values and the M-values include only part of the L-emission-lines, but supposing the existence of higher absorption-frequencies  $N_I$   $N_{\rm III}$   $N_{\rm III}$ ...  $O_I$ ... of suitable frequencies the remaining L-lines may be accounted for as differences between absorption-frequencies. The existence of these higher absorption edges has not as yet been directly experimentally proved but they are strongly supported by the fact that also lines of the M-group may be calculated from them in the same way as were the L-lines.

If this hypothesis is right we should expect that there are for the heaviest elements seven absorption-edges, five O and probably three P-edges.

Now it may be added that not all the numerical differences between two arbitrary absorption-values correspond to emissionlines. Some of these "calculated" lines for some reason or other do not exist or are too faint to be observed. They belong to what are called "forbidden" transitions.

Physical Interpretation of the X-ray Line-spectra and the Structure of the Atom.—According to the Bohr-Rutherford hypothesis the atoms are built up of a positive nucleus of comparatively small dimensions which is surrounded by a number of electrons. If this general picture of the atom is accepted the X-ray spectra furnishes us with a lot of valuable information regarding the feature of the electronic part of the atom. Then plausible calculations show that the X-ray series of highest frequencies, the K-series, must be connected with the innermost part of the electronic atmosphere of the atom. The other series consequently correspond to successive outer shells of the atom.

In the X-ray absorption-spectra according to this view we find the different energy-levels pictured, which correspond to the energy-output necessary to remove one or other of the electrons of the atom. In consequence we speak of the K-level, the L-levels, etc. of the atom. Correspondingly we speak of different groups of electrons within the electron atmosphere of the atom: the K-shell, the L-shell, etc. Each of these shells may contain several electrons: the K-shell 2, the L-shell 8, the M-shell 18, etc., when they are all completed.

After one electron has—by absorption of energy—been thrown out from its place within the atom its place will soon be filled up by an electron which through the attraction of the positive nucleus falls from some of the outer shells into the empty place. This means a diminishing of the energy of the atom, the superfluous energy being sent out as an X-ray wave. In this way we understand the emission of, for instance, the K-line in the following manner. One of the two electrons belonging to the K-shell has by absorption of energy been removed, its place is taken up an electron from the L-shell, accompanied by emission of the  $K\alpha$ -line. As after this process there is an empty place in the L-shell this may again be filled say by an M-electron with emission of an L-line and so on.

It is seen that this picture of the absorption and emissionprocess is in conformity with the connection between the two kinds of spectra discussed in the preceding paragraph.

As to the structure of the electronic shells of the atoms some general conclusion may be drawn from the empirical knowledge of the X-ray spectra, which, as just mentioned, may be interpreted as coming from the different layers of the electronic atmosphere of the atom.

First the fact that the X-ray spectra of all the elements show a very big resemblance to each other and change from element to element mainly by moving toward higher frequencies must mean that the electronic layers within the atom have the same general

structure for all elements. The increasing of the frequencies is readily understood by the increasing positive charge of the nucleus and the accompanying strengthening of the attractive forces acting on the electrons.

Secondly the appearance of the distinct and widely separated groups: K, L, M... indicates that the electronic atmosphere of the atom consists of distinct layers or shells with decreasing energy-contents beginning with the innermost shell, the K-shell followed by the L-shell, the M-shell and so on.

Thirdly all these shells or groups of electrons (except the K-group) are divided into subgroups as indicated by the existence of more than one absorption-edge or energy-level within every main group.

Further information regarding the structure of the atom is obtained by considering the completeness or rather lack of completeness of the X-ray spectra of the different elements. If one starts with the heaviest element, uranium (with atomic number 92) and proceeds towards the lightest elements it is found that successively and systematically a number of spectral lines (and consequently also absorption-edges) vanish. That means the successive peeling off of electronic shells whereby the number of possible transitions between the groups is reduced. The remaining lines and edges of every atom consequently show directly the number of layers and furnish us with a means of mapping out the electronic structure of the different elements. If we confine ourselves to the inert gases the empirical study of the X-ray spectra suggests the existence of the following shells filled with a number of electrons as given in Table I.

X-ray Spectra and Chemical Constitution .- The most striking difference between the ordinary optical spectra and the X-ray spectra is the fact that the former show a marked resemblance between elements with the same chemical character and change considerably from one group of chemically analogous elements to another whereas in the X-ray spectra no indication of the chemical nature of the elements is to be found. This is readily understood by the picture of the atom and its relation to the spectra which has just been given. From this interpretation the optical spectra arise from the surface of the atom which is also the seat of the chemical bounds, while the X-ray spectra are given off from the inner parts of the electronic atmosphere of the atom. But of course it is to be expected that a small influence may be seen if an atom emitting an X-ray is acted upon by neighbouring atoms. This is a question of the sensitivity or accuracy in the methods of studying the X-ray spectra. By increasing the precision of the measurements it has been possible to detect a number of such effects as just mentioned. It was first found by Bergengren that the K-absorption edge at phosphorus was a little displaced for different modifications of this element. Such an effect was then also found using different compounds of several light elements, especially sulphur, chlorine, etc. It was further found that in some cases the absorption in the neighbourhood of the edge had a complicated structure, which was for the same element dependent on the kind of crystal grating of the compound used for the investigation.

But the line-spectra are also in a certain degree influenced by the chemical bonds as shown by Lundquist, Bäcklin, Ray, etc.

Finally we may in this connection point out the service that the X-ray spectroscopy has rendered as a method of chemical analysis and for the detection of new elements. On the suggestion of Bohr that the element with atomic number 72 may be sought in minerals containing its homologue Zirkon, Coster and Hevesy succeeded in identifying this new element by its X-ray spectrum. Berg, Noddack and Tacke gave convincing evidence of the unknown element 75 by X-ray methods.

Ultra Soft X-rays.—As mentioned in the introduction, the crystal grating method has its limitations in so far as wave-lengths longer than the distance between the atomic layers, say 10 or 20 A.U., may not be selectively reflected. This is clear from the Bragg law (1) which shows that  $\lambda$  cannot be larger than 2d.

Fortunately it was found that ruled gratings when used in nearly grazing incidence gave nice spectra of the radiation with wave-lengths down to the region where the crystals had their

TABLE I

	K	Lī	Lu Lu	Mı	Мп Мш	Mrv Mv.	Nı	Nи Niii	Niv Nv	Nvi Nvii	Or.	Оп Опт	Oiv. Ov.	Pı	Рп. Рш
2. Helium	2														
10 Neon	2	2	6												
18 Argon	2	2	6	2	6	l									
36. Krypton	2	2	6	2	6	10	2	6							
54. Xenon .	2	2	6	2	6	10	2	6	10		2	6			
86. Radon	2	2	6	2	6	10	2	6	10	14	2	6	10	2	6

limits. This method was first used by Millikan for the optical spectra and then by Compton and Doan, Siegbahn and others for the study of the ultra soft X-ray spectra.

Of foremost interest is the possibility this opened to make a direct measurement of the atomic distances by comparison with the known grating-constants for the ruled gratings. Subsequently in this way a very exact determination of the value for the fundamental electric unit, the electronic charge was carried out by Bäcklin. It was further possible to extend the different X-ray spectral series into the new wave-length region and to find some lines belonging to higher series N- and O-series. (See also QUANTUM MECHANICS; RADIATION, RAYS; RADIOACTIVITY, NATURAL; SPECTROSCOPY.) (M. SIE.)

SPEE, MAXIMILIAN, COUNT VON (1861-1914), German sailor, was born in Copenhagen on June 22, 1861. He entered the German navy in 1878 and from 1887 to 1888 was Hafenkommandant (commander of the port) in German Cameroon. In 1908 he was made chief of staff of the German North sea command, and at the end of 1912 took over the Far Eastern Squadron. On Nov. 1, 1914, he was engaged by Admiral Cradock off Coronel, on the Chilean coast, and defeated the British squadron. On Dec. 8, 1914, however, he was attacked by Admiral Sturdee's cruiser squadron. The Germans were heavily defeated in the battle that took place. This is usually known as the battle of the Falkland Islands, and in it Spee himself went down with his flagship, the "Scharnhorst." (See Coronex; Falkland Islands, and in it Spee himself went down with his flagship, the "Scharnhorst." (See Coronex; Falkland Islands).

SPEED, JOHN (1552-1629), English historian and cartographer, was the son of a London tailor, and followed his father's trade, being admitted member of the Merchant Taylors company in 1580. He settled in Moorfields, where he built himself a house. He was enabled to devote himself to antiquarian pursuits through the kindness of Sir Fulke Greville, whom Speed calls the "procurer of my present estate," and through his patron's interest he also received a "waiter's room in the custom-house." His important works are: Theatre of the Empire of Great Britaine (1611), a series of 54 maps (with descriptive matter) of different parts of England, which had already appeared separately, and in which he was helped by Christopher Saxton, John Norden and William White, and History of Great Britaine under the Conquests of the Romans . . . to . . . King James (1611). Speed brought some historical skill to bear on the arrangement of his history; in preparing it he received help from Sir Robert Cotton. William Smith, Henry Barkham and Sir Henry Spelman. Although he repeated many of the errors of older chroniclers he added on the whole a substantial contribution of valuable material for the history of his country. He died in London on July 28, 1629.

Other maps of his, beside those in the Theatre, are in the British Museum. Another edition of the Theatre is Theatrem Magnae Britanniae latine, redditum a P. Holland (London, follo, 166). He wrote Genealogies Recorded in Sacred Scriptures (1611), and a similar work, A Cloud of Winessess (1616). These passed through numerous editions, and were frequently prefixed to copies of the Bible. An account of Speed's descendants is to be found in Rev. J. S. Davies's History of Southampton (1883), which was founded on ms. material left by John Speed (1903–1981).

SPEEDOMETERS, instruments for measuring linear speeds—more particularly the speeds of road vehicles—and graduated in miles (or kilometres) per hour. They are driven either from one of the road wheels, or from the transmission, through a flexible shaft and a gear mechanism. Account is taken of the diameter of the road wheel and of the gear ratio between the wheel and the speedometer shaft. Speedometers carry a so-called odometer, which indicates distance.

Main Principles.—The oldest speedometers depend on centrifugal force. A pair of weights is carried on a revolving shaft, in such a manner that they may move out from the axis as in the Watt conical pendulum governor, being restrained by a spring The faster the shaft revolves, the farther the weights will move out from the axis of rotation. An indicator records the speed.

A second principle very extensively used is that of magnetic drag. A cup of sheet aluminium is mounted on a spindle and held in the "zero" position by a spiral spring. A permanent magnet whose lines of force pass through the wall of the cup is rotated inside the latter at a speed proportional to that to be measured. The rotation of the magnet induces currents in the aluminium cup and the reaction between these currents and the magnetism of the magnet produces a drag on the cup, which causes it to turn around its axis against the resistance of the spring, and in proportion to the speed of the magnet. A scale printed on the outside of the cup shows through an opening in the face of the instrument, and the scale reading in line with a mark on the face indicates the speed

A third principle made use of is based on the fact that speed is the quotient of distance by time. Instruments based on this principle comprise an odometer and a clockwork, measuring distance and time respectively, and they effect the operation of division mechanically. A further principle is that of the magneto and voltmeter. A magneto generator has the characteristic that the voltage generated by it varies with the speed at which its armature is driven. Therefore, if a magneto is placed in diving connection with a road wheel and its terminals are connected to a voltmeter whose scale, instead of in volts, is graduated in miles per hour, the combination will serve as a speedometer. This type is particularly adapted for use where it is desirable to take readings at a long distance from the road wheel as the only connected.

tion is by wires. (P. M. H.)

SPEEDWELL, the name applied to the herbaceous species

WOOLLY SPEEDWELL (VERONICA

of the genus Veronica (family Scrophulariaceae); the British forms are herbs with bright blue flowers. The genus Veronica contains about 250 species, temperate, alpine and arctic, many of which are shrubs or trees with handsome spikes of flowers, and are often cultivated. The woody species, rarely known as speedwell, are especially characteristic of the mountains of New Zealand. Some 15 speedwells occur in North America, including several that have been naturalized from the old world. Culver'sroot (Veronica virginica), found (VERONICA across the continent, was formerly much used in medicine.

SPEENHAMLAND SYSTEM, a system of poor relief adopted by the Berkshire magistrates in 1795, by which the wages of labourers were supplemented from the poor-rates up to a certain level, an additional dole being permitted for each child. At a critical moment the Berkshire justices were forced to adopt a desperate remedy, but it was a permicious plan, for it unfairly transferred the burden of wages from the employer to the rate-payer, tencouraged the farmers to pay inadequate wages, and degraded the labourer to the position of a pauper. The system lasted until

the new Poor Law of 1834; it was never in force in Scotland or the north of England.

SPEKE, HUGH (1656-c. 1724), English writer and agitator, was a son of George Speke (d. 1690) of White Lackington, Somerset. Educated at St. John's College, Oxford, Hugh Speke joined the Green Ribbon Club, and in 1683 he was put in prison for asserting that Arthur Capell, earl of Essex, had been murdered by the friends of the duke of York. In prison Speke kept a printing-press, and from this he issued the Address to all the English Protestants in the Present Army, a manifesto written by the Whig divine Samuel Johnson (1649-1703), urging the soldiers to mutiny. In 1687 he was released, and in 1688 he served James II. as a spy in the camp of William of Orange. In December of this year a document, calling upon the Protestants to disarm their Roman Catholic neighbours was freely circulated, and much damage was done to property in London before it was found that it was a forgery. Speke asserted his authorship in his Memoirs (1709), revised as The Secret History of the Happy Revolution in 1688 (1715). Speke died in obscurity before 1725.

SPEKE, JOHN HANNING (1827-1864), English explorer, discoverer of the source of the Nile, was boin on May 4, 1827, at Jordans, Somersetshire. He entered the Indian Army in 1844. He served under Sir Colin Campbell's division in the Punjab. When on furlough Captain Speke explored the Himalayas, and crossed into Tibet. In 1854 he joined Richard Burton in Somaliland, as narrated in What led to the Discovery of the Source of the Nile (London, 1864). In April 1854 Speke was wounded by Somalis. Invalided home, he volunteered for the Crimea and

served with a regiment of Turks.

In 1856 Speke joined Burton in exploration of the African lakes, especially Nyassa. The route to Nyassa was closed by the Arabs, and the travellers left Zanzibar in June 1857 by a more northerly route. They learnt from an Arab trader that further inland were three great lakes-and Speke assumed that the most northerly would be the source of the Nile. In January 1858 the travellers reached Lake Tanganyika. By June they were back at Kazé, and here Speke induced his chief, who was ill, to allow him to attempt to reach the northern lake. Marching north for 25 days, on July 30 Speke reached a creek, along which he travelled till, on Aug. 3, he saw it open up into the waters of a lake extending northward to the horizon. He no longer doubted that this lake-the Victoria Nyanza-was the source of the Nile. Returning to Kazé (Aug. 25) he made known his discovery to Burton, who did not believe Speke's theories.

Speke had the support of Sir Roderick Murchison, president of the Royal Geographical Society, under whose direction a new expedition was fitted out. Of this expedition Speke had the command, his only European companion being Captain (afterwards Colonel) J. A. Grant (q.v.). The expedition, over 200 men all told, started from Zanzibar in Oct. 1860 and reached Kazé on Jan. 24, 1861. The Victoria Nyanza was again reached, at its south-west corner, in Oct. 1861. Following the western shores of the lake Speke crossed the Kagera Jan. 16, 1862, and arrived at the capital of Uganda on Feb. 19 following. Here he was detained by the king Mtesa, for some months, but at last prevailed on the chief to furnish him with guides, and on July 28 Speke stood where the Nile issued from the lake. The travellers were not permitted to visit another large lake (the Albert Nyanza) of whose existence and connection with the Nile they learned. As far as possible Speke and Grant followed the course of the Nile, and on Dec. 3 came in touch with the outside world once more. On Feb. 15, 1863, they arrived at Gondokoro. At Gondokoro they met Sir Samuel (then Mr.) Baker, generously giving him the information which enabled him to discover the Albert Nyanza.

In the same year (1863) Speke published his Journal of the Discovery of the Source of the Nile, a work written in a frank, attractive style. His conclusions were disputed by Burton and McQueen in The Nile Basin (1864), it being argued in this work that Tanganyika was the true Nile source. Speke was to discuss the question with Burton at the geographical section of the British Association at Bath on Sept. 16, but he accidentally shot

himself while out after partridge on Sept. 15.

See, besides the works mentioned, Sir R. F. Burton, The Lake see, besides the works mentioned, i. H. F. Button, Inc Lake Regions of Central Africa (1860; J. A. Grant, A Walk across Africa (1864); T. D. Murray and A. S. White, Sir Samuel Baker: a Memoir (1895); The Times (Sept. 17 and 19, 1864); Sir H. H. Johnston, The Nile Quez' (n.d. [1903]).

SPELL, a word of Teutonic origin meaning something "spoken." In general terms, the belief underlying the use of spells is that the wish that they embody will be fulfilled, regardless of its goodness or badness, so long as the formula has been correctly pronounced. Broadly speaking, then, spell and prayer, like

magic and religion to which they severally belong, can be dis-

tinguished by the nature of the intended purpose.

Ritual is to be seen in relation to its moral context as a whole. For instance, the judicial oath may have lost some of its special significance as a religious act of binding force, but, taken in connection with the solemn endeavour, of which it forms a part, to administer justice in the light of the truth, its validity can hardly be said to have been affected. Or, again, charges of formalism as regards the details of religious worship are recklessly bandled about, when the spirit and not the letter of the observance should alone be regarded as relevant to the issue Next, as regards the criterion of intelligibility, we must make sure in using it that we are not making our own ignorance the measure of the intrinsic value of the rite alleged to be without meaning Just as any foreign tongue is gibberish to the unlearned, so we may be deaf to the most eloquent symbolism if we have not a key to the sense.

To take an example from Australia, if members of the witchetty grub totem desire to secure a harvest of these grubs for the benefit of the community, they repair in procession to certain stones that remind them by their shape of witchetty grubs and rub their stomachs with these stones, thus indicating the precise destination to which the symbolized delicacies are meant to find their way. Moreover, this pantomime is reinforced by oral means in the solemn declaration, "We have eaten much food"; where, let the perfect tense be noted, as if for the man

of faith the thing were as good as done.

The chief deity of the Masai goes by the name that simply means "The Rain"; and the simplest of their rites consists in crying out "Rain! Rain!" in chorus (see PRAYER). Here the question whether this is prayer or spell ought not to turn on the degree of personality attaching to the god, and still less on a grammatical point such as the possible use of the imperative mood. Surely the religious character of the whole proceeding is sufficiently established by the fact that "The Rain" is for the Masai, the reputed giver of all good things.

In primitive rite the verbal formula tends to be accessory to the dramatic part of the procedure. Sometimes it is but descriptive of the action, "We are doing so and so," though sometimes the purpose is added, "We are doing so and so, that so and so may happen." Thus the efficacy of the rite, words and all, is apt to seem self-contained. The rite has man : (q.v.), which is almost to say "It works, I know not why" in one pregnant word. Correspondingly, it becomes a perilous instrument for the ordinary man to handle, and its use is reserved for the man with manathe expert who is strong enough to wrestle with mysteries. Now to be vested with esoteric attributes in one's own eyes no less than in the eyes of the rest bears hard on the weakness of the flesh. True, the wonder-worker may be ready to admit that his mana possesses him rather than he it. An Australian medicineman, for instance, who had given way to European strong drink, became convinced that his healing power had left him and in a spirit of befitting humility retired from practice. Or, again, we have the Malay wizard whose spell explicitly announces that some power greater than himself is working through him: "It is not I that am burying him (in the form of a waxen image), it is Gabriel who is burying him."

In Melanesia and elsewhere a man owns a ritual and charms so completely that he can bequeath them to a son. Nay, he can even sell them in the open market, and in such a case we expressly learn that the oral part of the rite-the muttered spell-is what the money is paid for, since it is what the owner can most easily hide and so keep to himself. At this point the spell has clearly become a non-moral thing, a mere trade secret. It will degenerate still further into abracadabra. The folklorist is constantly coming across oral survivals in the mouths of peasants that once were medical recipes or even prayers couched in Latin. Afterwards, when reduced to mere rigmarole, these have been treasured by the unlettered for the sake of the sheer mystery lurking in the unfamiliar sounds.

(R. R. M.)

BIBLIOGRAPHY.—W. Hertmüller, Im Namen Jesu (1903); R R. Marett, "From Spell to Prayer" in The Threshold of Religion (1914); W. W Skeat, Malay Magic. See also Mana; Prayer; RITUAL.

SPELLO (Hispellum, q v.), a town of Umbria, 1,030 ft. above sea-level. Pop. (1936), 2,731 (town); 6,578 (commune). S. Maria Maggiore contains some of Pinturicchio's finest frescoes (1501), "The Annunciation," "The Adoration" and "Christ in the Temple."

SPELMAN, SIR HENRY (c. 1564-1641), English antiquary, was the eldest son of Henry Spelman, of Congham, Norfolk, and the grandson of Sir John Spelman (c. 1495-1544), judge of the king's bench He was educated at Walsingham School and Trinity college, Cambridge. With Sir Robert Cotton and William Camden, he belonged to the Society of Antiquaries, which declined, and Spelman's efforts to revive it in 1614 were frustrated by James I. Spelman proposed to write a work on the foundations of English law, based on early charters and records; as a preliminary to this task he began to compile a glossary, the first volume of which, Archaeologus in modum glossarii, was published at his own expense in 1626. He continued to work at the subject until 1638. A second volume, Glossarium archaiologicum (1664) appeared after his death. His Codex legum veterum statutorum regni Angliae, quae ab ingressu Gulielmi I usque ad annum nonum Henry III. edita sunt was published by David Wilkins in his Leges anglo-saxonicae (1721). Spelman's most important work, Concilia, decreta, leges, constitutiones in re ecclesiarum orbis britannici (2 vols., 1636-64), is an attempt to place English church history on a basis of genuine documents. Spelman took a prominent part in public business until his death (Oct. 1641). He was buried in Westminster Abbey.

SPENBOROUGH, an urban district in the West Riding of Yorkshire, England, 5 mi. S.S.E. of Bradford on the L.M.S.R. Pop. (est. 1938) 36,420. Area 12,9 sq.mi. It is a busy manufacturing district situated in the Spen Valley. The chief industries are the manufacture of woollen goods, machinery and chemicals. and coal mining. The urban district was formed in 1915 and combined the three former urban district was formed in 1915 and combined the three former urban districts of Cleckheaton, Gomersal and Liversedge. In 1937 its area was enlarged by the addition of the urban districts of Birkenshaw and Hunsworth and the rural district of Hartshead, besides other land.

SPENCER, ANNA GARLIN (1851-1931), U.S. clergywoman, was born in Attleboro, Mass., on April 17. She early discovered the power and magnetism of her speaking voice and while on the staff of the Providence Journal (1868-78), lectured on social problems. After her marriage to the Rev. William H. Spencer (Unitarian) in 1878, her husband encouraged her to preach in liberal pulpits. In 1891 she was ordained as minister of the Bell Street chapel (Independent), Providence, R.I., where she officiated for 14 years. From the beginning interested in women's rights, Mrs. Spencer participated actively in the Rhode Island Women's Suffrage association, and in the national women's rights conventions, where she emphasized the contributions women could make to society, the theme of her book, Woman's Share in Social Culture (1913). Her own contributions were of wide scope in local and national charities and reforms. To list a few, she was first chairman of the Women's Section of the World Peace conference organized in 1907, associate director and staff lecturer at the New York School of Philanthropy (1903-13), associate leader of the New York Society for Ethical Culture (1903-09), director of the American Ethical Union's Summer School of Ethics (1908-11), Professor of Sociology and Ethics at the Meadville (Pa.) Theological school (1913-18), and lecturer at the University of Chicago (1918) and thereafter occasionally at Teacher's college, Columbia university, Besides many articles and pamphlets, she wrote several books, among them the History of

the Bell Street Chapel Movement (1903) and The Family and its Members (1923). While director of the Family Relations division of the American Social Hygiene association (the moral education movement was one of her lifelong interests), she died on Feb. 12, 1931 (L A G)

SPENCER, HERBERT (1820-1903), English philosopher, was born at Derby on April 27, 1820. His father, William George Spencer, was a schoolmaster, and his parents' religious convictions familiarized him with the doctrines of the Methodists and Quakers. He declined an offer from his uncle, the Rev. Thomas Spencer, to send him to Cambridge, and so was practically self-taught During 1837-46 he was employed as an engineer on the London and Birmingham railway; in 1848-53 as sub-editor of the Economist. From about this time to 1860 he contributed numerous articles to the Westminster Review, which contain the first sketches of his philosophic doctrines. He also published two larger works, Social Statics in 1850, and Principles of Psychology in 1855. In 1860 he sent out the syllabus of his Synthetic Philosophy in ten volumes, which he completed in 1896 with the Principles of Sociology. He died on Dec. 8, 1903.

Spencer's significance in the history of English thought depends on his position as the philosopher of the great scientific movement of the second half of the 19th century, and on his friendship with men like Darwin, G. H. Lewes, and Huxley. He trees to express in a general formula the belief in progress which pervaded his age, and to erect it into the supreme law of the universe But to the specialists in sciences which were advancing rapidly to results which often transformed their initial assumptions, Spencer has often appeared too much of a philosopher and defective in specialist knowledge; to the technical philosophers he has not seemed philosophic enough.

Spencer claims, with some reason, that he was always an evolutionist. But his notions of what "evolution" is developed gradually. At first he seems to have meant only the belief that progress is real, and that the existing order of nature is the result of a gradual process. In Social Statics (1850) he still regards the process teleologically, and argues after the fashion of Paley that "the greatest happiness is the purpose of creation" (ch. iii § 1). In The Development Hypothesis (1852) he objects strongly to the incredibility of the special creation of the myriad forms of life, without, however, suggesting how development has been effected. In Progress, its Law and Cause (1857) he adopted Von Baer's law, that the development of the individual proceeds from the homogeneous to the heterogeneous. This is at once connected with the nebular hypothesis, and subsequently "deduced" from the ultimate law of the "persistence of force," and finally supplemented by a counter-process of dissolution, all of which appears to Spencer only as "the addition of Von Baer's law to a number of ideas that were in harmony with it." Spencer welcomed Darwin's Origin of Species (1859) and enriched its doctrines with the phrase "survival of the fittest"; but he did not give up the (Lamarckian) belief in the hereditary transmission of the modifications of organisms by the exercise of function.

Of his First Principles (1862) the first part shows that while ultimate metaphysical questions are insoluble they compel to a recognition of an inscrutable Power behind phenomena which is called the Unknowable; the second part is devoted to the formulation of the Law of Evolution. In the first part Spencer's argument rests on Mansel's Limits of Religious Thought and Hamilton's "philosophy of the conditioned" (and so ultimately on Kant), and tries to show that in scientific and religious thought the ultimate terms are "inconceivable" (not by him distinguished from "unimaginable"). In science, the more we know the more extensive "the contact with surrounding nescience." In religion the vital and constant element is the sense of mystery. This is illustrated by the difficulties inherent in the conception of Cause, Space, Time, Matter, Motion, the Infinite, and the Absolute, and by the "relativity of knowledge," which precludes knowledge of the Unknowable, since "all thinking is relationing." Yet of the Unknowable we may have an "indefinite knowledge," positive, though vague. Hence both science and religion must recognize as the "most certain of all facts that the Power which the Universe manifests to us is utterly inscrutable." In the edition of his First Principles, published in 1900, he adds a "postscript" which shows some consciousness of the contradiction involved in his knowledge of the Unknowable, and finally contends that his account of the Knowable in part ii. will stand even if part i. be rejected. But, in reality, a really inscrutable Unknowable would destroy all confidence in the order of nature and render all knowledge precarious.

In part ii. Spencer recognizes successively likenesses and unlikenesses among phenomena (the effects of the Unknowable), which are segregated into manifestations, vivid (object, non-ego) or faint (subject, ego), and then into space and time, matter and motion and force, of which the last is symbolized by our experience of resistance, and is that out of which our ideas of matter and motion are built. Hence the Persistence of Force is the ultimate basis of knowledge. From it Spencer deduces the indestructibility of matter and energy, the equivalence and transformation of forces, the necessity of a rhythm, of Evolution (i.e., integration of matter with concomitant dissipation of motion) and Dissolution, and finally the statement of the Law of Evolution as "an integration of matter and concomitant dissipation of motion, during which the matter passes from an indefinite incoherent homogeneity to a definite coherent heterogeneity, and during which the retained motion undergoes a parallel transformation." This process of evolution is due to "the instability of the homogeneous," the "multiplication of effects" and their "segregation," continuing until it ceases in complete "equilibration." Sooner or later, however, the reverse process of Dissolution, with its absorption of motion and disintegration of matter must prevail, and these oscillations of the cosmic process will continue without end. It appears, therefore, that Spencer ultimately describes the Knowable in terms of the mechanical conceptions of matter and motion, and this gives a materialistic colouring to his philosophy.

In the Principles of Biology (1864) the chief points are the definition of life as the continuous adjustment of internal to external relations, and the consequent emphasis on the need of adapting the organism to its environment. This does not sufficiently recognize that the higher organisms largely adjust external to internal relations and adapt their environment to their needs. His universal process of Evolution seems to give Spencer a criterion of "higher" and "lower" "progression" and "degeneration," independent of the accidents of actual history. The higher (at least in times of "evolution") is the more complex, whether it invariably survives or not. On the other hand, he advances too easily from the maxim that function is prior to structure to the conclusion that the results of use and disuse are immediately incarnate in structural adaptations capable of hereditary transmission, an inference that has involved him in controversy with Weismann's school.

In his Principles of Psychology (1870-72) Spencer advocates the genetic explanation of the phenomena of the adult human mind by reference to its infant and animal ancestry. On the fundamental question, however, of the psychophysical connection and the derivation of mind from matter, his utterances are neither clear nor consistent. On the one hand, his whole formulation of Evolution in mechanical terms urges him to compose the mind out of homogeneous units of consciousness (or "feeling") "similar in nature to those which we know as nervous shocks; each of which is the correlative of a rhythmical motion of a material unit or group of such units" (§ 62); on the other hand, he is ready to amend nervous into psychical shocks, which is no doubt what he ought to have meant but could not say without ruining the illusory bridge between the psychical and the physiological which is suggested in the phrase "nervous shock." And he admits (§ 63) that if we were compelled to choose between translating mental phenomena into physical and its converse, the latter would be preferable. But he finally leaves the relation between the unknowable "substance of Mind" and the unknowable "substance of Matter" to the Unknowable. To the theory of knowledge Spencer contributes a "transfigured realism," to mediate between realism and idealism, and the doctrine that "necessary truths," acquired in experience and congenitally transmitted, are a priori to the

individual, though a posteriori to the race, to mediate between empiricism and apriorism.

In the Principles of Sociology (1877–96) Spencer's most influential ideas have been that of the social organism, of the origination of religion out of the worship of ancestral ghosts, of the natural antagonism between nutrition and reproduction, industrialism and warfare. Politically, Spencer was an individualist of an extreme laises faire type, and it is in his political attitude that the consequences of his pre-Darwinian conception of Evolution are most manifest. But for this, he would hardly have established so absolute an antithesis between industrial and military competition, and would have been readier to see that the law of the struggle for existence, just because it is universal and equally (though differently) operative in every form of society, cannot be appealed to for guidance in deciding between the merits of an industrial or military and of an individualist or socialist society.

In the Principles of Ethics Spencer, though relying on the intrinsic consequences of actions for the guidance of conduct, conceives the ethical end in a manner intermediate between the hedonist and the evolutionist. The transition from the evolutionist criterion of survival to the criterion of happiness is effected by means of the psychological argument that pleasure promotes function and that living beings must, upon pain of extinction, take pleasure in actions conducive to their survival. Conduct being the adjustment of acts to ends, and good conduct that which is conducive to the preservation of a pleasurable life in a society so adjusted that each attains his happiness without impeding that of others, life is valuable only if it conduces to happiness. On the other hand, life must in the long run so conduce because a constant process of adjustment is going on which is bound to lead to a complete adjustment which will be perfect happiness. Spencer concludes that the sense of duty must diminish as moralization increases In this reasoning Spencer overlooks the possibility of an expansion of the ethical environment. If this is as rapid as the rate of adaptation, there will be no actual growth of adaptation and so no moral progress. Complete adaptation to an infinitely receding ideal is impossible, but Spencer considers that he can both anticipate such a state, and lay down the rules obtaining in it, which will constitute the code of "Absolute Ethics." He conceives it as a state of social harmony so complete that even the antagonism between altruism and egoism will have been overcome; everyone will derive egoistic pleasure from doing such altruistic acts as may still be needed. Originally the socially salutary action was in the main that which was enjoined on the individual by his political and religious superiors and by social sentiment; it was also in the main that to which his higher, more complex and re-representative feelings prompted. Hence the fear with which the political, religious and social controls were regarded came to be associated also with the specifically moral control of lower by higher feelings, and engendered by coercive element in the feeling of obligation. Its authoritativeness depends on the intrinsic salutariness of self-control, and must cease with the resistance of the lower feelings. Hence Spencer concludes that the sense of duty must diminish as moralization increases. In the preface to the last part of his Ethics (1893) Spencer regrets that the Doctrine of Evolution has not furnished guidance to the extent he had hoped," but his contributions to ethics are not unlikely to be the most permanently valuable part of his philosophy.

losophy.

After completing his system (1806) Spencer continued to revise it, and brought out new editions of the Biology (1808-90) and First Principles (1900). The dates of his chief works are as follows: 1822, Letters to the Nonconformist, "The Proper Sphere of Government"; 1850, Social Statistics; 1822, The Theory of Population (6, part vi. of Biology): "The Development Hypothesis" (in Essays, vol. i.) 1833; The Universal Potulate (6, Psychology, part vii.); 1843, "the Genesis of Science" (in Essays, vol. ii.); 1855, Principles of Psychology (2, 10.); 1857, Progress, its Law and Cause (Essays, vol. i), 1835, Essays (containing most of his contributions to the Westminster Review, 1865, vol. i; 1885, vol. iii.); 1854, Education: Intellectual, Moral, Physical; 1666, Errt Principles (and ed., 1867; 6th, 1906); 1864-67, Principles of Psychology (and ed., in a vol.); 1873, The Study of Sociology; 1876, vol. i, The Principles of Sociology; vol. ii., Coremonial Institutions, 1887, Vol. ii. The Principles of Sociology; vol. ii., Coremonial Institutions, 1887, Vol. iii. Ecologic 1879, The Dala of iii. Ecologic 1879, The Dala of

Ethics (part i of Principles of Ethics in 2 vols.; part iv., Justice, 1891; parts it, and itt., Inductions of Ethics and Ethics of Individual Life, 1892; parts v. and vi., Negative and Positive Beneficence, 1893). 1884, Man versus the State. 1886, Factors of Organic Evolution. 1893, Inadequacy of Natural Selection. 1894, A Rejoinder to Professor Weismann and Weismannism once more. 1897, Fragments. 1902, Facts and Comments. An Autobiography in 2 vols. appeared posthumously in 1904. For a useful summary of his chief doctrines by Spencer himself see his preface to Collins's Epitome of the Synthetic Philosophy: see also I. A. Thompson, H. Spencer (1906); W. H. Hudson, H. Spencer (1908).

SPENCER, JOHN CHARLES SPENCER, 3RD EARL (1782-1845), English statesman, better known by the courtesy title of Lord Althorp, which he bore during his father's lifetime, was the son of George John, 2nd Earl (1758-1834), who served in the ministries of Pitt, Fox and Grenville, and was first lord of the admiralty from 1794-1801. John Charles was born at Spencer House. London, on May 30, 1782, and was educated at Trinity college, Cambridge. He represented Okehampton (1804), St. Albans (1806) and Northamptonshire (1806). When Lord Grey's administration was formed at the close of 1830 the chancellorship of the exchequer combined with the leadership of the House of Commons was entrusted to Lord Althorp. The budget was a failure, but this misfortune was soon forgotten in the struggles over the Reform bill, in the preparation and success of which Lord Althorp played an important part.

The death of the 2nd Earl Spencer in Nov. 1834, called his son to the upper house and was the occasion of Melbourne's dismissal by King William IV. He was the first president of the Royal Agricultural Society (founded 1838), and a notable cattle-breeder. He died at Wiseton on Oct. 1, 1845.

See Sir Denis Le Marchant, Memoir (1876); W. Bagehot, Biographical Studies (1881); E. J. Myers, Lord Althorp (1890).

SPENCER, JOHN POYNTZ SPENCER, 5th EARL (1835-1910), English statesman, was the son of the 4th Earl and his first wife. Born on Oct. 27, 1835, and educated at Harrow and Trinity college, Cambridge, he was a member of parliament for a few months before he succeeded to the earldom in Dec. 1857. His long career as a Liberal politician dates from his acceptance of the office of lord-lieutenant of Ireland under Gladstone in 1868, a post which he retained until 1874. When the Liberals returned to power in 1880 he was appointed lord president of the council, but in 1882 he entered upon a second term of office as lord-lieutenant of Ireland. In the Liberal administration of 1886 he was lord-president of the council, and from 1892 to 1895 he was first lord of the admiralty. From 1902 to 1905 he was the Liberal leader in the House of Lords, and early in 1905, was discussed as a possible Liberal prime minister. He died on Aug. 13, 1910. The fine library, collected at Althorp by the 2nd earl, was sold by him for £250,000 to Mrs. Rylands, the widow of a Manchester merchant, who presented it to that city.

SPENCER, a town of Worcester county, Massachusetts, U.S.A. Pop. (1950) 7,047. Spencer was settled in 1721 and incorporated in 1753. One of its houses was the birthplace of three inventors: William Howe, Tyler Howe and Elias Howe, Jr., who invented respectively the "Howe truss" bridge, the spring bed and the sewing machine

SPENDER, JOHN ALFRED (1862-1942), British journalist, was born at Bath, the son of a doctor, and educated at Bath college, and at Balliol college, Oxford. Adopting the career of a journalist, he was editor of the Eastern Morning News, Hull, from 1886 to 1890 and then was with the Pall Mall Gazette in London. When the Westminster Gazette was established in 1893, he became an assistant editor and from 1896 to 1922 was its editor, leaving just after it became a morning paper. As editor of the Westminster Spender won general respect, not only as a brilliant writer but as the possessor of an exceptionally fair and balanced mind. He held a high place in the councils of the Liberal party and his services to the state included membership of the royal commission on divorce and of the Milner Mission to Egypt. A slight volume, The Comments of Bagshot (1907), revealed Spender at his best. Other works include The Indian Scene (1912); The Foundations of British Policy (1917); Life, Journalism, and Politics (2 vols. 1927); A Short History of Our Times (1934); Men and Things (1937). He died on June 21, 1942 SPENER, PHILIPP JAKOB (1635–1705), German the-ologian, was born on Jan. 13, 1635, at Rappoltsweller in Upper Alsace. He won his degree of master at Strasbourg (1653) by a disputation against the philosophy of Hobbes. In 1666, he was chief pastor in the Lutheran Church at Frankfort-on-Main. Here he published his two chief works, Pia desideria (1675) and Allgemeine Gottesgelehrtheit (1680), and began that form of pastoral work which resulted in the movement called Pictism. In 1686 he accepted the invitation to the first court chaplaincy at Dresden. But the elector John George III. was offended by his chaplain's candour. Spener refused to resign his post, and the Saxon government hesitated to dismiss him. The difficulty was solved by his promotion (1691) to the rectorship of St. Nicholas in Berlin with the title of "Konsistorialrat." The university of Halle was founded under his influence in 1694. Spener was exposed to the abuse of orthodox Lutheran theologians. In 1695 the theological faculty of Wittenberg formally laid to his charge 264 errors. He died on Feb. 5, 1705. His last important work was Theologische Bedenken (4 vols., 1700-02), to which was added after his death Letzte theologische Bedenken, with a biography of Spener by C. H. von Canstein (1711). Though "the father of Pietism," the extravagances of the movement cannot be ascribed to him personally.

Spener was a voluminous writer. The list of his published works comprises 7 vols. folio, 63 quarto, 7 octavo, 46 duodecimo; a new edition of his chief writings was published by P. Grünberg in 1889, See W. Hossbach, Philipp Jabob Spener und seine Zeit (1828, 31d ed., 1861); A. Ritschl, Geschichte des Pielismus, ii. (1884); E. Sachsse, Urrprung und Wesen des Pielismus (1884); P. Grünberg, P. J. Spener (2) vols (2802-1006). (3 vols., 1893-1906).

SPENGLER, OSWALD (1880-1936), German philosopher, was born at Blankenburg in the Harz on May 29, 1880. He studied mathematics and natural history, with history and art. This rare combination is the foundation of the peculiar character of Spengler's work, in which unexpected parallels between scientific truths of physics and mathematics and the artistic and other cultural achievements of an epoch of history are drawn. He completed in 1914 the first version of Der Untergang des Abendlandes (1918, rev. ed. 1922; Eng. trans. The Decline of the West, by C. F. Atkinson).

Other works of Spengler, chiefly concerned with contemporary political problems are: Preussentum und Sozialismus (1920); Pessimismus (1921); Politische Pflichten der deutschen Jugend (1924); Neubau des deutschen Renches (1924). See M. Schroeter, Der Streit um Spengler, etc. (1922).

SPENSER, EDMUND (?1552-1599), "the prince of poets in his time," was born in London-Oldys says, in East Smithfield -probably in 1552, possibly in 1549. (The date depends on whether Sonnet 60, written when Spenser was 41, belongs to 1593 or to 1590: v. infra.) His mother's name, he tells us, was Elizabeth: his father has been conjecturally identified with John Spenser, a journeyman cloth-maker. Later, the poet claimed kindred with the Spencers of Althorpe in Northamptonshire, and had his claim allowed; but the poverty of his home is shown by the grants made to him out of the Nowell bequest as a poor scholar of Merchant Taylors' school. There, under the great Mulcaster, he laid the foundations of his wide, if inexact, scholarship; best of all, he learned from Mulcaster to "worship the English," and to believe it as capable of great poetry as any language. He was still at school when, in 1569, he supplied some verse translations from Marot and du Bellay to Van der Noodt's Theatre of Worldlings. Van der Noodt, it is true, took the credit of these verses to himself: but they were included, with some alterations, in the Complaints volume of 1591 (v. infra), and we need not doubt that they are Spenser's. The rhymed stanzas after Marot at least bear his mark: the blank-verse renderings from du Bellay are inferior, and were considerably altered and tagged with rhymes for the re-issue of 1591.

In this same year he entered Pembroke hall, Cambridge, as a sizar, matriculating on May 20. He remained at Cambridge for seven years, as was then not unusual, proceeding B.A. in 1572 and commencing M.A. in 1576. His health was poor; but he read

SPENSER 205

widely, especially in philosophy and rhetoric, studying Italian as well as Latin, Greek and French, and training himself for poetry. His studies profited from the friendship of Gabriel Harvey, a fellow of his college, a conceited pedant, but a real scholar, and sincerely attached to Spenser, though his friendship may not always have been quite disinterested nor his literary advice wase. Literature, however, stirred the mind of Cambridge less than theology. In the ecclesiastical controversy with which the university had seethed ever since Cartwright's brief tenure of the chair of divinity (1569–70), Spenser took the Puritan side. But he was neither sectary nor ascetic. He had a hatred of popery (inflamed by the Bartholomew massacre) and contempt for the hirelings who "for their bellies' sake" had climbed into the Anglican fold

who "for their bellies' sake" had climbed into the Anglican fold. What he did on leaving Cambridge is still a mystery. He had missed his fellowship, and must look about him for a profession or a patron. The view that he went to live with relatives in Lancashire, though buttressed by appeals to family tradition and to the language and scenery of the Calender, rests at bottom on

no ascertained fact.

But in the "North-parts" (Drayton brings Rosalind to the Cotswolds; Aubrey says that she was related to Sir Erasmus Darwin's lady, who was a Wilkes of Hodnell in Warwickshire), Spenser fell in love with the Rosalind of the Shepheardes Calender, of whom again we can say only that she was a lady of higher rank than his, who enjoyed, but did not reward, her young poet's devotion. In 1577 we seem to get a glimpse of Spenser in an unexpected quarter. In the View of the Present State of Ireland Irenaeus tells how he witnessed the execution of Murrogh O'Brien, which took place at Limerick in July, 1577. In the rest of that dialogue Irenaeus represents Spenser himself, and it is natural though not inevitable to conclude that he does so in this place also. But no other evidence has been found for this visit; Phillips's statement that Spenser was secretary to Sir Henry Sidney may be discounted, since he has probably confused Sidney with Grey. Yet Irenaeus's account of this hideous incident reads like the words of an eye-witness, and the visit, if it occurred, would point to a connection with the Sidney-Leicester circle earlier than 1579.

After this we are on firmer ground. We know that in 1578 Spenser was secretary to John Young, bishop of Rochester, who had been master of Pembroke hall while Spenser was a student. The bishop of Rochester (Episcopus Roffensis) is the Roffyn of the Shepheardes Calender: the fable of Roffyn's dog and the wolf may glance at the old Roman Catholic bishop, Thomas Watson, who was committed to Young's custody in Feb. 1579. Much of the Shepheardes Calender was apparently written at Rochester, where also Spenser first conceived the idea of the wedding of Thames and Medway. If Spenser at this time thought of entering the Church, he changed his mind on a nearer view of its condition, for by Easter 1579 he was in Westminster, sharing rooms with Harvey and holding "long conference" with him. There was a third party to their discussions, one "E.K.," to be identified probably with Edward Kirke, once a fellow-sizar of Spenser's at Pembroke. The notion that E.K. is a mask for Spenser himself has been disproved by Dr. Herford. It is not unlikely, indeed, that the "Mistress Kerke" in Westminster, who took charge of letters for Spenser in October of this year, was E.K.'s mother, and that all three were living in her house. Among other things they discussed Spenser's début as an author. He had several pieces ready or nearly ready-Dreams, Legends, Court of Cupid, Pageants, The English Poet (in prose), and the Shepheardes Calender. It was decided to bring out the last, and to bring it out in classical style with introduction, notes and glossary by E.K., even as Muretus edited the first book of Ronsard's Amours. E.K. wrote the introduction forthwith-it is dated from London, April 10, 1579-and got to work on the notes.

Harvey's Letter-book gives us an amusing picture of Spenser that summer. He is reading some law, evidently with an eye to diplomatic or administrative work; he has blossomed into a courtier and a gallant, bearded and moustachioed, Italianate, Frenchified. At what date, and in what sense, he entered Leicester's service we do not know precisely. At all events on Oct. 5 he writes from Leicester house to tell Harvey that he expects to go

abroad in a week, "most what" at Leicester's charges—the "most what" shows that he was not entirely dependent on Leicester's bounty—and that "gentle Mr. Sidney" has proposed that they two should correspond. The tour apparently never took place, for his next letter of ten days later says no word about it, but is all concerned with quantitative verse and with doubts about the publication of his Slumbers. He has been to Court and expects to go again; Sidney and Dyer have him "in some use of familiarity." The Shepheardes Calender was licensed on Dec. 5, and published anonymously; the dedication to Sidney is by "Immerito."

The Shepheardes Calender.—The Calender consists of 12 pastoral ecloques in the artificial style of Virgil, Mantuan, Sanazzaro and Marot, which admits real persons and current events in a pastoral guise From all these precursors Spenser borrowed ostentatiously, above all from Marot, whom E. K. nevertheless belittles, perhaps because the Pléiade had eclipsed him. Derivative and conventional as it is, the Calender made an epoch in English literary history, not so much by naturalising pastoralism as by showing (under cover of the pastoral convention) what English could do in many kinds and metres. The couplets of the satires and fables are intentionally rude, and the rhymeless sestina is mere virtuosity; but the elegiac stanzas of the complaints recaptured the metrical secret of Chaucer, and the lyric staves of the paean and the dirge extended the range of English song. In all these measures he made free use of alliteration, dear to English ears, though abused by his contemporaries and frowned on by the classicists. For his reform of poetic diction Spenser had before him the example and precepts of the Pléiade. Like them, he sought to embellish the beggarly vocabulary of contemporary verse, partly by foreign loan-words, but mainly by drawing on native sources, by archaisms, pseudo-archaisms and dialect words. He was in search of a vocabulary fit for the heroical poem that he already contemplated. But the new poet had to care not only for words but for the order of his words and the structure and juncture of his sentences. Here Spenser scored his greatest success, eschewing obscurity and looseness, and giving his syntax a movement, too copious perhaps, but admirably fluent, in lucid, easy yet well-knit sentences. Syntactically, Spenser is one of the simplest of poets.

The Shepheardes Calender may not have fulfilled all Spenser's hopes, but it went into a second edition in 1581. Sidney praised it judiciously, or judicially, but durst not approve its rustic diction. However, Spenser had many other arrows in his quiver. In April 1580 he is full of projects for the immediate publication of his Dying Pelican and Dreams; his Latin Stemmata Dudleiana will need "more advisement" before it can be "sent abroade," but the quantitative Epithalamion Thamesis shall be "shortly set forth." Under the influence of Sidney, Dyer and Drant, he had come for the moment to take quantitative verse more seriously. But he is more eager to proceed with the Faerie Queene, of which he sent Harvey specimens. Harvey thought little of them, preferring the (lost) Nine Comedies in the manner of Ariosto. Moreover, the poet is in love again, this time with better hopes. Harvey's compliments to Mea Domina Immerito, Mea Bellissima Collina Clouta, taken with an obscure passage in Daphnaida (11. 64-66), which reads like consolation tendered by one widower to another, have led some scholars to believe that Spenser married this "second Rosalind." But there is no other evidence for the marriage, nor is the lady ever heard of again. These letters of April 1580 give no hint of any friction with Leicester. But now Spenser seems to have made a false step. The queen had dallied for years with the project of marrying the duke of Alençon. In Jan. 1579 his agent Simier came to England and Alençon himself paid a flying visit in August to press his suit in person. He was ugly, dwarfish and half her age, but the queen smiled on him, called him her "grenouille" and Simier her "petit singe." The Puritans took alarm. Sidney remonstrated in such plain terms that the queen forbade him the Court. He retired to Wilton to write his Arcadia, and Spenser probably never saw him again. This was in Jan. 1580.

It was at this juncture apparently that Spenser drew his pen. He had begun a fabliau of an ape and a fox, satirising the Parson Trullibers and other humbugs of the day. Now, catching at Elizabeth's trick of animal nick-names, he brought his ape and fox to a court of beasts. The ape becomes Alençon-Simier, the fox is Burghley, who was believed to favour the marriage. Their misrule when they have stolen the lion's skin foreshadows the fate of England under a French king-consort. But Spenser misjudged the situation. Leicester had concluded that the wind stood fair for France, and trimmed his sails accordingly. Spenser was snubbed, and the satire, which was circulating in manuscript as Mother Hubberds Tale, was called in, but not before it had come to Burghley's ears. The tale of Spenser's discomfiture is told in Virgils Guat, killed by the man whose life it had saved. Such is the most plausible explanation of this obscure episode. At all events, abandoning all his projects of publication, Spenser accepted a secretaryship to Lord Grey of Wilton, the newly appointed Lord Deputy of Ireland.

In Ireland.—Grey landed in Dublin in Aug. 1580 and set himself at once to the task of suppressing Desmond's rebellion. He was a stern Puritan, to whom the pope was Anti-christ and the Papist rebels were traitors at once to God and their queen. Spenser soon had proof of his quality. A band of Spanish and Italian filibusters had landed in Kerry to support the Munster rebels and occupied a fort near Smerwick. Grey marched against them, forced them to surrender unconditionally, held the officers to ransom, and put the men to the sword. Then he ravaged Munster, leaving famine to complete the work. On campaigns Spenser saw "such wretchednesse as that any stonye harte would have rued the same." With Grev's recall in 1582 Spenser lost his secretaryship; but in the previous year he had acquired a clerkship for the faculties (i.e., licences and dispensations) in the Dublin chancery; and he had begun to obtain leases of forfeited houses and lands at modest rents which he did not always pay. At one of these houses, New Abbey in Co. Kildare, he seems to have resided occasionally in 1583 and 1584. But his headquarters were still in Dublin. We get a pleasant glimpse of him there in Ludovick Bryskett's Discourse of Civil Life. Bryskett tells us how a distinguished company, including the primate of Armagh, and soldiers like Norreys and St. Leger, met at his cottage near Dublin. Spenser suggested that their host should read them his translation of Giraldi da Cinthio's Discourse of Civill Life; which Bryskett accordingly did. The reading lasted for three days, being interspersed with discussions. On the third day Spenser interposed again, urging (to our astonishment) Aristotelian objections to the immortality of the soul. But Bryskett is simply putting into his mouth the arguments given by Giraldi to Torquato. It is doubtful, indeed, if this famous discussion ever took place at all, for Bryskett imitates Giraldi not only in the substance of his dialogue but in its setting. But if it never actually occurred it must be such as might have occurred.

In 1585 the centre of Spenser's interests began to shift to Munster. In that year he is found acting as deputy to Ludovick Bryskett in the clerkship of the council of Munster. In 1586 he held the prebend of Effin in Co. Limerick; and in that same year; under the Government's scheme for the plantation of Munster, he obtained a perpetual lease of Kilcolman Castle in Co. Cork with 3,028 acres of land. His resignation of his clerkship for the faculties in 1588 probably means that he then began to live at Kilcolman, where tradition says that his sister Sarah kept house for him. Here in 1589 he received a momentous visit from Raleigh. He had been engaged on the Faerie Queene intermittently for nearly ten years, receiving a fresh stimulus from Tasso's Gerusalemme Liberata, which reached him probably about the time of Lord Grey's recall. By 1589 three books were completed. Raleigh at once perceived their superlative merits and carried Spenser off to England to lay his poem at the queen's feet. It was licensed on Dec. 1, 1589 and published in 1590 with a dedication to the queen. Its reception can only be described as reverential. The great English epic so long awaited had appeared.

Spenser remained in England for more than a year, enjoying his fame, making friends with brother-poets, entertained at country houses, and acknowledged by his kinswomen of Althorpe,

Lady Carey, Lady Strange, and Lady Compton and Mountegle. But Burghley had not forgiven him; the substantial preferment for which he hoped was whittled down to a pension of £50 a year, and in 1591 he returned to Ireland a disappointed man Before leaving, he arranged for the publication of some of his minor poems, which appeared in 1591 as Complaints.

Complaints .- Of the Complaints, the Visions of Petrarch and Visions of Bellay are refurbishings of his schoolboy translations. The Ruines of Rome, a rendering of du Bellay's Antiquitez de Rome is clearly a juvenile production also. In the same kind, but much superior, is the original Visions of the Worlds Vanitie, in which, from Harvey's remarks, we may fairly recognize a fragment of the Dreams of 1580. The Teares of the Muses, mentioned in A Midsummer Night's Dream, V. i. 52, where Theseus dismisses it as "some satire, keen and critical," is an unconvincing complaint of the neglect of poetry, more excusable in 1580 than in 1590. The Ruines of Time laments various members of the Dudley family, including Sidney and Leicester, who had died in the previous decade: its present form belongs to 1590; but it probably incorporates some material collected for the Latin Stemmata Dudleiana; and the "Pageants" at the end may be another fragment of the Dreams. Mother Hubberds Tale was strengthened by the addition of a brilliant and bitter denunciation of the wretchedness of the suitor's state; and Spenser bated no jot of his satire on Burghley. Virgils Gnat, a free rendering of the Culex, has already been described. The one entirely new poem in the volume is Muiopotmos, which clearly belongs to 1590. Its theme recalls Sonnet 71, and may have been suggested simply by the sight of Lady Carey at her drawn-work. In spite of the grim ending the tone is so light-hearted that it seems perverse to read an inner meaning into this "airy trifle," with Burghley as the spider. Yet no reader would have suspected an inner meaning in Virgils Gnat but for the dedication to Leicester.

On reaching home, or so he would have us believe, Spenser wrote Colin Clouts Come Home Againe, dedicating it to Raleigh "from my house of Kilcolman the 27, of December 1501." It was not published, however, till 1595, when it appeared in one volume with Astrophel.

Colin Clout; Astrophel.—Colin Clouts Come Home Againe is the most charming of Spenser's poems. He is again in Arcady, telling his fellow-shepherds of his voyage with the Shepherd of the Ocean, his reception by the mighty Cynthia, her court, her ladies and brave poets. Then the note changes to the old complaint of courtly falsity and praise of the shepherd's life. The whole poem is exquisitely written, in "an easy running verse with tender feet." There is nothing more attractive in Spenser than Colin's chivalrous defence of Rosalind.

Astrophel is the prelude to a set of pastoral elegies on Sidney by several hands. The second "number," the Lay of Clorinda, though credited to Sidney's sister, is demonstrably from Spenser's pen. If Astrophel seems conventional and frigid we must remember that Spenser had already lamented Sidney in the Ruines of Time, and that the Sidney whom he now laments is not the hero of Zutphen but the author of the Arcadia.

Colin's praise of the shepherd's life prepares us to find that Spenser, though disappointed of preferment in England, and harassed by law-suits with his Irish neighbour Lord Roche, had begun to love his Munster home and to weave its legends and scenery into his verse. Towards the close of 1592, on the orthodox view of the Amoretti, he fell in love with Elizabeth Boyle and married her on June 11, 1594. He celebrated his wooing in the Amoretti and his wedding in the Epithalamion, which were entered together at Stationers' Hall in November 1594, and published together in 1595. It is highly probable that some of the Amoretti had already done service to express an amour courtois for Lady Carey during his English visit. It is probable that Elizabeth Boyle was the orphan daughter of Stephen Boyle, of Bradden in Northamptonshire, who had accompanied her brother

'Yet the dedication of Daphnaida is dated "London this first of Januairie, 1591" (i.e., 1592 n.s.). No convincing explanation of this discrepancy has been offered. On the whole it is easiest to believe that Spenser, writing on New Year's Day, used the new style, i.e., that his 1501 means our 1501.

Alexander when he went to Ireland to seek his fortune under the protection of their kinsman Richard Boyle, afterwards earl of Cork. The view that she was a widow, having been married to one Tristram Peace in 1588 or 1589, at present lacks documentary confirmation, and is hard to reconcile with Burke's statement that she bore seven children to her third—on this view her fourth—husband, Sir Robert Tynte, after 1612 or 1613.

Amoretti; Epithalamion .- The Amoretti are love-sonnets, all but one in a form which Spenser made his own, consisting of three linked quatrains and a couplet. It had already been used in Scots, but Spenser may have got it direct from Marot. Though it lacks the pyramidal strength of the Petrarchan form, and the freedom of the Shakespearean, its "linked sweetness" suits Spenser's style. Many of these sonnets are imitated from French or Italian, especially from Desportes and Tasso: for one a Spanish original has been found. They are all graceful, but only the famous sonnet on Easter can be called great. The Epithalamion, on the other hand, is by common consent the greatest of all weddingsongs; rich in poetic allusions and in echoes from his own earlier poems, as if Spenser had gathered up all the fruits of his study and all the flowers of his fancy to present them to his bride. Here for once his whole nature speaks, flesh and spirit reconciled in the sacrament of marriage. The stanza, suggested by the Italian canzone, is magnificent far beyond anything previously heard in English. The structure of the whole poem is as perfect as that of its parts.

Towards the end of 1595 Spenser, having finished three more books of the Foerie Queene, came to London to publish them. During this year he also published his Prothalomion and Fourne Hymnes, and composed or revised his Veue of the Present State of Ireland, which, though entered at Stationers' Hall in 1598, was not allowed to be printed without further authority, and, in fact, did not see the light till 1633.

Prothalamion; Hymnes; Veue of the Present State of Ireland.—The Prothalamion graced the wedding of two of the Earl of Worcester's daughters, who were married together from Essex house. Though it lacks the glow and sweep of the Epithalamion, it is, if possible, even more perfect in metre and diction.

The hymns of Heanvenlie Love and Heavenly Beauty were written in 1596 to propitiate two pious noblewomen and counteract the hymns in Honour of Love and in Honour of Beautie written in his youth. So Spenser avers; but to print the earlier hymns was scarcely the way to ensure their oblivion.

In the Veue of the Present State of Ireland Irenaeus expounds to Eudoxus the causes of the Irish troubles and propounds a cure. Irish laws, customs and religion must all be reformed on the English model. But subjugation must precede reform. Vacillation has been the curse of the Government. Let them now bring over 10,000 foot and 1,000 horse, plant these in six convenient garrisons, give the rebels 20 days in which to surrender, and then hunt down relentlessly all who stand out. Two winter campaigns will break their spirit. Let a fresh offer of pardon then be made, and rebellion will be at an end. There follows a detailed scheme, supported by statistics, for the administration of the pacified areas, ending with a proposal for the appointment of a lieutenant-general, Essex being clearly indicated. Political antagonism and racial antipathy combined with religious hatred to blind Spenser to the Irish cause.

During this second visit to England Spenser's hopes of preferment were centred in the Earl of Essex, but again he sued in vain. He returned to Kilcolman, probably in 1597, and resumed the Faerie Queene. In Sept. 1598 he was recommended for the sherifidom of Cork. But preferment came too late: in October Tyrone's rebellion had broken out, the Munster Irish rose, Kilcolman Castle was burned and Spenser fled with his family to Cork. From Cork he was sent to London with a dispatch which bears date Dec. 9, 1598. Along with it he brought a brief note of his own in which he reiterated the policy of the View. On Jan. 16, 1599 he died. He was buried in Westminster Abbey close to Chaucer; many nobles attended his funeral, and his fellow-poets brought elegies which they threw into his grave with the pens that had written them. Spenser's tragic reversal of fortune

and sudden death gave rise to a crop of legends. Ben Jonson told Drummond that one of Spenser's children perished in the flames of Kilcolman Castle and that he himself died "for lack of bread." It is only too likely, after all he had gone through, that Spenser collapsed on reaching London, and was a dying man before his friends could learn of his condition and come to his aid. Two more cantos of the Faerie Queene with two stanzas of a third were published in 1609; if more was written, as is probable, after 1596, it is irrecoverably lost.

The Faerie Queene.-Spenser's place among the great poets depends on the Faeric Queene, a fragment of a great poem which was to have been "disposed," as the title informs us, "into XII. bookes fashioning XII. morall vertues," each virtue embodied in a knight, and the whole designed "to fashion a gentleman or noble person in vertuous and gentle discipline"-at once a chivalric romance and a handbook of morals and manners; nay more-for Spenser would emulate Virgil as well as Ariosto-a national epic to the glory of England's Elizabeth. Such a threefold cord is not easily twined. Yet the task seemed feasible to Spenser, because to him the eternal war of good and evil, which was his essential theme, was embodied in the struggle of Protestant England against her Catholic foes. Book I indeed may be read not inconsistently either as a mere romance, or as the spiritual experience of an elect Christian, or as a history of the English Church in the sixteenth century. But in Book II. the story stands still for nearly two whole cantos; the tale of Hellenore in Book III. is told with a gusto ill calculated to fashion a gentleman in virtuous discipline; in Book IV. the poet grows so careless of his characters that he lets the long-parted lovers come together without recognizing one another; the recent history of Book V. has little allegorical or romantic interest; and Book VI. ends in a burst of sheer pastoralism in which the poet forgets his allegory as completely as the hero forgets his quest. Only Spenser's contemporaries could fully appreciate the historical element, and some of it even to them can only have had the interest of a roman à clef; yet it strengthens the texture of the poem, and gives figures like Arthegall and Satyrane some firmness of outline.

The allegory was treated with respect for two centuries; Milton thought "our sage and serious poet" a better teacher than Scotus or Aquinas; modern criticism has too often followed Hazlitt in commending the poem to readers with the assurance that the allegory won't bite them. But to ignore the allegory is to ignore the informing purpose of the whole, without which the story would be a mere series of ill-joined episodes, and much of the imagery meaningless, some of it grotesque or even repulsive. The ethical, as distinct from the structural, value of the allegory must depend on the worth of the ideas it embodies, as its poetical value depends on the imaginative force of their embodiment. Spenser was not an original nor a systematic thinker. His philosophy is a blend of Platonism refracted through Ficino, Aristotelianism of the scholastic tradition, and Christianity with a Calvinistic bias. And the elements do not perfectly combine. Thus the doctrine of love and beauty, by which Ficino thought to reconcile the love of woman with the love of God, this doctrine, brilliantly expounded in the first two Hymns, is fundamentally irreconcilable with the scheme of salvation through the atoning sacrifice of Christ which is expounded in the third Hymn. The poet was a sincere and militant Christian, but also a man sensitive to the allurements of the world and the flesh; he knew self-distrust. and weariness, and regret for evanescent youth, and is never so moving as when he writes out of such experiences or turns from this unstable life in longing for the eternal rest.

Of the romance itself, with its wealth of imagery and melody, there has never been but one opinion. Like all Spenser's work it is highly imitative. He rifled romantic literature for incidents and situations. The descriptions in which he excels constantly recall works of art—picture, tapestry, pageant or masque. But he owed much also to real life; he was recommended for his sherifidom as "not unskilful or without experience in the wars"; and his journeys through the wild woods of Munster and his intercourse with soldiers like Grey and Norreys yielded many a hint for the background and characters of the F.O. Its diction.

archaic but not rustic, and rich in strange coinages and terms of chivalry, is in keeping with its remote and old-world air. Not less appropriate is the stanza which he invented, not by "extending" the ottava rima or the rhyme royal, but by adding to the linked quatrains which he had used in the SC. an Alexandrine such as Ferrars had employed to tip his sestets. The elements are not new; the miracle lies in their combination. It is not a perfect stanza for narrative, nor indeed is Spenser a perfect storyteller; but its amplitude fits the slow tempo of his thought, as he unrolls his leisurely pageants or ponders on time and change. Its power must not be judged by single stanzas, but by the cumulative effect as stanza after stanza rolls in, each ninth wave breaking higher than the rest.

Spenser has not Chaucer's genial breadth, nor Milton's art, nor Wordsworth's vision; but in the purely poetic gifts he is inferior to Shakespeare alone. The "school of Spenser" was small and short-lived, quite eclipsed in the next generation by Jonson and Donne; but in a wider sense all later English poets

have been his scholars.

Beeston described Spenser to Aubrey as a little man, with short hair, little band and little cuffs-a description that fits the Pembroke College portrait better than the beruffled exquisite of the Dupplin portrait. These two portraits, whether genuine or not, do aptly illustrate the two sides of Spenser, scholar and Puritan on the one hand, courtier and man of affairs on the other; fundamentally a poet, sensitive and fastidious, yet responsive to the claim of affection or of honour. "Entire affection hateth nicer hands"; "No service loathesome to a gentle kind"; "The noblest mind the best contentment has"-in such lines we hear his authentic voice.

BIBLIOGRAPHY .- Dates of first issues are given above. Folios in 1609 BIBLIOGRAPHY.—Dates of first issues are given above. Folios in 1609 (F.Q. only), 1611—13, 1671, 1670 (said to have been "overseen" by Dryden). Editions by J. Hughes (1715), H. J. Todd (1805), F. J. Child (1855), J. P. Collier (1862), R. Morris and J. W. Hales (1860), A. B Grosart (1883—84), R. E. N. Dodge (1908), J. C. Smith and E. de Sélincourt (1909—10). F.Q. only by R. Church (1758), J. Upton (1758), K. M. Warren (1897—1900). S.C. by C. H. Herford (1805). Fourer Hymnes by L. Winstanley (1907). Commentaries and criticisms by J. Jortin (1714), T. Warton (1752), G. L. Craik (1845), R. W. Church (1879), J. J. Higginson (S.C. only) (1912), E. Legouis (1923), W. L. Renwick (1925). Much of the recent work on Spenser has been done by American scholars: F. I. Carpenter, E. A. Greenlaw, J. Erskine, J. B. Fletcher, P. W. Long, C. G. Osgood, F. M. Padelford, C. H. Whitman, etc. Most of it is available only in periodicals, Car-C. H. Whitman, etc. Most of it is available only in periodicals. Carpenter's Reference Guide (1923), Osgood's Concordance (1915), and Whitman's Subject Index (1918) are indispensable for detailed study. (T. C. SM.)

SPENSERIAN STANZA, a verse-form so called from its invention by Edmund Spenser for his Faerie Queene (1590). Its origin is disputed; Schipper derives it from the Old French ballade (q.v.), others from the Italian ottava rima. Probably, however, it is Chaucer's eight-line Monk's Tale stanza, with a ninth line (an alexandrine) added, a feature which gives the stanza its beauty. The rhyme-scheme is a b a b b c b c c + (the + denoting the extra foot in the last line). Spenser's sonnet-scheme is somewhat similar. The stanza was hardly used in the 17th century, though Giles and Phineas Fletcher made for themselves adaptations of it. About 1740 it was revived, by Akenside (Virtuoso, 1737), Shenstone (Schoolmistress, 1742) Thomson (Castle of Indolence, 1748); followed by Beattie (Minstrel, 1771) and Mrs. Tighe (Psyche, 1805). Since 1850 it has been rarely employed. It is a purely English form.

SPERANSKI, COUNT MIKHAIL MIKHAILOVICH (1772-1839), Russian statesman, the son of a village priest, spent his early days at the ecclesiastical seminary in St. Petersburg (Leningrad), where he rose to be professor of mathematics and physics. His brilliant intellectual qualities attracted the attention of the government, and he became secretary to Prince Kurakin. In 1806, the emperor Alexander I. took him to the conference of Erfurt and put him into direct communication with Napoleon, who described him as "the only clear head in Russia." They discussed Russian reforms.

From 1809 to 1812 Speranski was all-powerful; he replaced the earlier favourites, becoming practically sole minister. In 1810 and the first half of 1811 Speranski was still in high favour,

and was the confidant of the emperor in that secret diplomacy which preceded the breach of Russia with Napoleon.

On the eve of the struggle with Napoleon, Alexander, conscious of his unpopularity, conceived the idea of making Speranski his scape-goat, and so mobilising Old Russian sentiment against revolutionary France. The grand-duchess Catherine, Karamzin, Rostopchin and the Swedish general Baron Armfield, intrigued to involve him in a charge of treason. Alexander did not credit the charge, but on March 29, 1812 he dismissed him from office. Reinstated in the public service in 1816, he was appointed governorgeneral of Siberia, for which he drew up a new scheme of government, and in 1821 entered the council of state. He died on Feb. 11, 1839, at St. Petersburg.

See the biography (in Russian) by M. Korff (St. Petersburg, 1861) and the works of V. Vagin (St. Petersburg, 1872, Moscow, 1905). SPERMACETI, a wax found in the head cavities and blubber of the sperm whale (Physeter macrocephalus), where it is dissolved in the sperm oil while the creature is living (from Lat. sperma, seed, and cetus, a whale). It also occurs in other Cetacea (see WHALE OIL). It is mainly cetin or cetyl palmitate, C15H31CO2C16H33. The substance is used in making candles, in the dressing of fabrics, in medicine and surgery, and in cosmetic preparations. (See Oils, Fats and Waxes.)

SPERMOPHILE, a name applied to a group of squirrel-like rodents (Citellus), widely distributed in the northern hemisphere. Most spermophiles hibernate and all have internal cheek pouches. In Russia they are known as sousliks and in the United States as ground squirrels or gophers. (See Ground Squirrel; Sous-LIK.)

SPERMOPHYTA or SPERMATOPHYTA, the name often used in botany to denote the seed-plants, including the true flowering plants, or angiosperms (q.v.), and the conifers and their allies or gymnosperms (q.v.)

SPERM WHALE (Physeter catodon), the largest of the toothed whales, called also cachalot, its size being about equal to those of the Arctic right whale. The head is about one-third of the length of the body, massive, high and truncated in front. It owes its size and form to the accumulation of a peculiar form of fatty tissue in the large hollow on the upper surface of the skull. The oil contained in cells in this cavity, when refined, yields spermaceti, and the sperm oil of commerce comes principally from the thick covering of blubber, which envelops the body. Ambergris, used in perfumery, is a concretion formed in the intestine, and found floating on the sea. (See CETACEA; SPERMACETI.)

SPERRY, ELMER AMBROSE (1860-1930), American inventor, was born at Cortland, N.Y., on Oct. 12, 1860. He began early to experiment with electric arc lights and in 1879 established a factory in Chicago to manufacture an improved model which was highly successful. He then turned his attention to the development of electric mining machinery, invented the electric rotary and the chain undercutting machines, devised and built his own electric mining generator and other mining apparatus and established another factory to manufacture this machinery. He next designed an electric locomotive for industrial work, and developed motor and transmission machinery for street cars, which resulted in the founding of the Sperry Electric Railway Co. of Cleveland. About 1900 he established a research laboratory in electro-chemistry at Washington, D.C., where he invented the chlorine detinning process and also the electrolytic process for producing white lead from impure by-product lead. In 1915 he announced his high-intensity arc searchlight, built upon an entirely new principle, allowing a brilliancy as high as 900 candle-power per square millemetre, whereas 160 was the highest obtainable previously. The electrical and mechanical means of operating, as well as the mechanism to control the high temperatures of the arc, represented a difficult engineering achievement. These searchlights have become the standard for the principal armies and navies of the world and are in use for aircraft and coast beacons, the largest giving a white light of 1,500,000,000 candle-power which can be seen for upwards of 150 miles.

Sperry's most important inventions were based upon the application of the gyroscope in which he was always greatly interested.

Chief of these is the gyrocompass (q v.), first installed on the battleship Delaware in 1911. This compass, unaffected as it is by iron and steel, entirely superseded the magnetic compass on submarines and battleships and was placed likewise on merchant ships. Upon it the whole complicated system of modern naval gunnery was developed. (See Gunnery, Naval.) Sperry also designed and manufactured electrically sustained gyros for torpedoes which enabled them to complete long trajectories with a high degree of accuracy. During World War I he also developed aerial torpedoes with automatic gyrocontrol which proved effective at a range of 35 mi. Quantity manufacture had begun when the war ended. Further experiments yielded the gyropilot for the steering of ships, the automatic gyropilot for stabilizing aeroplanes, the gyroscopic roll and pitch recorder for the testing of ships, and, finally, a gyroscopic ship stabilizer which was installed on a number of ships in the United States, British, Italian and Japanese navies. The motion of a ship in the waves is almost completely neutralized by antomatic counter movements of the gyroscopes.

Sperry served after 1915 as a member of the naval consulting board, and published numerous scientific papers. He died at Brooklyn on June 16, 1930.

See "The Engineering and Scientific Achievements of Elmer A. Sperry," in Mechanical Engineering, vol xlix (1927).

SPES, properly bona spes ("good expectation," i.e., hope), a goddess worshipped in Rome from an uncertain but doubtless early date (temple in the Forum Holitorium, or vegetable market, vowed during the first Punic War, cf. Tibullus i, 1, 9, cf. ii, 6, 21). Possibly she was originally an agricultural deity, not the personification of hope in general.

See Wissowa, Religion und Kultus, 2nd ed , p. 329.

SPESSART, a highland forest district belonging mainly to the Bavarian province of Lower Franconia, but in the north to the Prussian province of Hesse Cassel.

SPEUSIPPUS (4th century B.C.), Greek philosopher, son of Eurymedon and Potone, sister of Plato, is supposed to have been born c. 407 B.C. He was bred in the school of Isocrates, but when Plato returned to Athens c. 387, Speusippus became a member of the academy. In 361, when Plato undertook his third and last journey to Sicily, Speusippus accompanied him. In 347 the dying philosopher nominated his nephew to succeed him as scholarch, and the choice was ratified by the school. Speusippus held the office until his death in 339.

Of his many philosophical writings nothing survives except a fragment of a treatise On Pythagorean Numbers. It is gathered in regard to his theory of being that whereas Plato postulated as the basis of his system a cause which should be at once Unity, Good and Mind, Speusippus distinguished Unity, the origin of things, from Good, their end, and both Unity and Good from controlling Mind or Reason; whereas Plato recognized three kinds of numbers-firstly, ideal numbers, i.e., the "determinants" or ideas; secondly, mathematical numbers, the abstractions of mathematics; and thirdly, sensible numbers, numbers embodied in things-Speusippus rejected the ideal numbers, and consequently the ideas; Speusippus traced number, magnitude and soul each to a distinct principle of its own. In his theory of knowledge he held that a thing cannot be known apart from the knowledge of other things; for, that we may know what a thing is, we must know how it differs from other things, which other things must therefore be known; accordingly, in the ten books of a work called "Ομοια, he attempted a classification of plants and animals; the results thus obtained he distinguished at once from "knowledge" and from "sensation" holding that "scientific observation" though it cannot attain to truth, may, nevertheless, in virtue of a certain acquired tact, frame "definitions." In his theory of ethics he denied that pleasure was a good, but seemingly was not prepared to account it an evil.

Hence, though, like Plato, Speusippus studied the differences of natural products with a view to classification, he did not agree with Plato in his conception of the significance of the results thus obtained; i.e., while to Plato the definition derived from the study of the particulars included in a natural kind was an approximate definition of the idea in which the natural kind originated, to Speusippus the definition was a definition of the particulars studied

and, strictly speaking, of nothing else. Thus while Plato hoped to ascend through classificatory science to the knowledge of eternal and immutable laws of thought and being, Speusippus, abandoning ontological speculation, was content to regard classificatory science not as a means but as an end and to rest in the results of scientific observation.

In abandoning the theory of ideas-that is to say, the theory of figures and numbers, the possessions of universal mind, eternally existent out of space and time, which figures and numbers when they pass into space and time as the heritage of finite minds are regarded as things-Speusippus had the approval of both the Platonists generally and Aristotle. But, whereas the new scholarch, confining himself to the detailed examination of natural kinds, attempted no comprehensive explanation of the universe, Aristotle held that a theory of its origin, its motions, and its order was a necessary adjunct to the classificatory sciences. In nearly all of his references to Speusippus, Aristotle insists upon this fundamental difference in procedure. Conceiving that the motions of the universe and its parts are due to the desire which it and they feel toward the supreme external mind and its several thoughts, so that the cosmical order planned by the divine mind is realized in the phenomenal universe, Aristotle thus secures the requisite unification, not, indeed, of mind and matter, for mind and matter are distinct, but of the governing mind, the prime unmoved movent, since it and its thoughts are one. On the other hand, when Speusippus distinguishes One, Good and Mind so that Mind, not as yet endowed with an orderly scheme, adapts the initial One to particular goods or ends, his theory of nature appears to his rival "episodical"; i.e., to consist of a series of tableaus wanting in dramatic

Speusippus and his contemporaries in the school exercised an important and far-reaching influence upon Academic doctrine. It would seem that Academic scepticism began with those who had been reared by Plato himself, having its origin in their acceptance of the scientific element of his teaching apart from the ontology which had been its basis.

BIBLIOGRAPHY — J. G. F. Ravaisson, Speusippi de primis rerum principiis placita (1838); Chr. Aug. Brandis, Geschichte der griechischromischen Philosophie, II, ii, t. (1852); Zeller, Die Philosophie d Griechen, II, i (Leipzig, 1875); Mullach, Frag. Phil. Graecorum, iii (1881); and Überweg, Grundriss der Gesch. der Philosophie, Bd. I (1926).

SPEY, river in the highlands of Scotland, rising from Loch Spey (1,143 ft.) in the Corrievairack forest, Invernesshire about ro mi. S.S.E. of Fort Augustus. It runs about roo mi. N.E. and enters the Moray firth at Kingston. It is one of the longest and most rapid rivers of Scotland, famous for its salmon fishing and is fed by waters from the Monadhliath hills, the Grampians and the Caimgorms. There is a great deal of glacial drift in the Spey valley. It is now largely denuded of its conifers by felling. The lower section of the valley is known as Strathspey.

SPEYER or Spires, a town and episcopal see of Germany, in the Rhineland palatinate, situated on the left bank of the Rhine. at the mouth of the Speyerbach, 16 mi. S. of Mannheim by rail. Pop. (1950) 31,841. Speyer, known to the Romans as Augusta Nemetum or Nemetae, and to the Gauls as Noviomagus, appears under the form of Spira about the 7th century. Captured by Julius Caesar in 47 B.C., it was repeatedly destroyed by the barbarian hordes in the first few centuries of the Christian era. The town had become an episcopal seat in the 4th century; but heathenism supervened, and the present bishopric dates from 610. In 830 Speyer became part of the Frankish empire. The contentions between the bishops and the citizens were as severe as in any other city of Germany. The situation of the town opposite the mouths of several roads through the Rhine valley early fostered its trade; in 1294 it rose to be a free imperial city. It enjoyed great renown as the seat of the imperial supreme court from 1527 until 1689. Numerous imperial diets assembled there. From 1801 until 1814 it was the capital of a department of France; but it was restored to Bavaria in 1814.

A basilica of sandstone, the cathedral has a peculiar importance in the history of architecture as probably the earliest Romanesque basilica in which the nave as well as the side arcades was vaulted from the first. Built in 1030–1061 by Conrad II and his successor, this church has had a chequered history, its disasters culminating in 1689, when the soldiers of Louis XIV burned it to the bare walls and scattered the ashes of eight German emperors. Restored in 1772–1784 and provided with a vestibule and façade, it was again descerated by the French in 1794; but in 1846–1853 it was once more thoroughly restored and adorned in the interior with gorgeous frescoes. Speyer, although rebuilt in 1697, has never recovered from the injuries inflicted by the French in 1689. Its manufactures include paper, tobacco and cigars, sugar, machines, lead, vinegar, beer and musical instruments.

SPEZIA, or La Spezia, a city of Liguria, Italy, 49 ft. above sea level. Pop. (1951), 109,978 (commune). It is the chief naval harbour of Italy; was adopted as such in 1861 though Napoleon I had entertained the idea. The Bay of Spezia (anc. Portus Lunae) is sheltered from all except southerly winds, and on its western shore are numerous openings, which afford perfectly safe anchorage in all weathers. The entrance is protected by forts, while a submarine embankment, 2 mi. long, renders it secure. Its important arsenal dates from 1870. The establishment of San Vito is devoted entirely to the production of artillery; that of San Bartolomeo is exclusively used for electrical works and the manufacture of submarine weapons, especially torpedoes. The museum contains a unique collection of menhirs from the neighbourhood cut into the form of human figures. Spezia probably arose after the destruction of Luna. It was sold by the Fieschi in 1276 to Genoa. The town was fortified by its new possessors and made the seat of a governor of some importance. It became a city in the 16th century.

Spezia and its naval installations were heavily bombed by the Allies in World War II.

SPHALERITE, a sulphide of zinc, ZnS, crystallizes in the tetrahedral class of the isometric system. The name derives from  $\sigma\phi\alpha\lambda\epsilon\rho\delta\rho$ , "treacherous," in allusion to the ease with which the dark coloured, opaque varieties are mistaken for the lead sulphide galena. The synonyms blende and zincblende, from the German blind, "blind," similarly allude to the fact that it does not yield lead. The crystal structure of sphalerite is based on a tetrahedral, four-co-ordinated framework of zinc and sulphur atoms in which the bonding is essentially covalent. The structure is similar to that of diamond, and may be imagined as derived therefrom by the alternate substitution of zinc and sulphur atoms for carbon. The unit cell dimension is 5.40 A.

The common crystal forms are the tetrahedron and the dodecahedron. The crystals frequently occur as simple or multiple contact twins, or as complicated lamellar intergrowths, in which the twin axis is [111]. Sphalerite ordinarily occurs in massive granular form, less commonly as fibrous aggregates with a layered structure or as dense microcrystalline masses. It has a welldeveloped dodecahedral cleavage, and the fracture is conchoidal. The hardness is  $3\frac{1}{2}$  to 4, and the specific gravity of pure material is 4.0. The colour varies widely. Generally it is a shade of brown, but some sphalerite is green, yellow or, in crystals of high purity, almost colourless. Material containing iron is brownish black or black. Sphalerite may fluoresce when irradiated with ultraviolet light or X-rays, and some specimens emit light when scratched with a sharp point (triboluminescence). According to the formula, ZnS, sphalerite contains 67.1% Zn and 32.9% S. Usually, however, it contains iron in solid solution up to a limit of about 26%, and both manganese and cadmium may be present in small amounts.

Sphalerite, the most common zinc mineral, and galena, the most abundant ore of lead, are intimately associated in most of the important deposits of these metals. Other associates include chalcopyrite and pyrite among metallic minerals, and quartz, barite, dolomite, calcite and siderite as gangue minerals. In the United States the most important deposits of sphalerite are found in the Mississippi Valley region. There it occurs chiefly with chalcopyrite, galena, marcasite and dolomite in solution cavities and brecciated zones in limestone and chert. Similar deposits occur elsewhere—in the region of Silesia in Poland, the Moresnet

district in Belgium, and North Africa. Sphalerite also has world-wide distribution as an ore mineral in hydrothermal vein deposits, in contact metamorphic zones and in high temperature replacement deposits. Crystals of outstanding beauty and perfection are found in cavities in a dolomite rock in the Binnenthal, Switz., and a transparent variety of a golden colour occurs at Picos de Europa, Santander, Sp. Fine specimens also come from Cornwall, Derbyshire and Cumberland in England, and from Bottino in Tuscany, It.

SPHENE or Titanite, a mineral consisting of calcium titanosilicate, CatīsiOs, crystallizing in the monoclinic system. The crystals vary considerably in habit, but are generally thin and wedge-shaped; hence the name sphene (Gr.  $\sigma\phi\dot{\eta}\nu$ , a wedge). The colour is green, yellow, brown or black, and the lustre resinous to adamantine; crystals are transparent to opaque. The hardness is 5.5, specific gravity 3.5. Sphene is cut as a gem stone, though it is rather too soft to stand much wear; owing to its high dispersive power it gives brilliant flashes of prismatic colours. As small crystals, it is found in igneous rocks (granite, syenite, trachyte, phonolite, etc.), and also in gneiss, schist, crystalline limestone and pegmatite.

SPHENISCIDAE: see Penguin. SPHENODON: see Reptiles.

SPHERE, in Greek geometry, the solid generated by the revolution of a semicircle about its diameter as an axis. In modern elementary geometry it is more generally considered as the spherical surface so generated, or as the locus of points at a constant distance from a fixed point called the centre. The constant distance is called a radius, and any line segment through the centre and limited at both ends by the sphere is called a diameter. In the geometry of surfaces it is defined as the quadric surface passing through the circle at infinity. Any section made by a plane cutting a sphere is a circle, being a great circle if the plane passes through the centre, and otherwise a small circle. The solid cut off by the plane of a great circle, is a hemisphere; that cut off by the plane of a small circle, a segment. In analytical geometry, the equation of a sphere in rectangular Cartesian co-ordinates is  $x^2+y^2+z^2=a^2$ , and in polar co-ordinates it is r=a. If the centre is  $(a, \beta, \gamma)$ , the Cartesian equation becomes

$$(x-a)^2+(y-\beta)^2+(z-\gamma)^2=a^2$$
.

The surface of a sphere is found by the formula  $S=4\pi r^2$ , the area being four times that of a great circle. The volume is  $\frac{4}{3}\pi r^3$ . Analogous to the propositions of plane geometry and trigonometry is a series of propositions relating to the sphere. (See Analytical Geometry; Astronomy; Geodesy; Projective Geometry; Solids, Geometric; Surface; Trigonometry.)

SPHERES OF INFLUENCE. "Spheres of influence" is a diplomatic term which signifies the claim on the part of a state to exclusive control within a foreign territory. This control can be economic, military or political, or it may concern the overall government of the territory. The territory which is made the object of a sphere of influence may be either politically unorganized, as were some of the African territories which were transformed into spheres of influence toward the end of the 19th century, or it may be under the sovereignty of a weak government, as were, for instance, Morocco, Ethiopia and Persia when they were divided into spheres of influence at the beginning of the 20th century. The term may refer to a political claim to exclusive control, which other nations may or may not recognize as a matter of fact, or it may refer to a legal agreement by which another state or states pledge themselves to refrain from interference within the sphere of influence.

It is in the latter, legal significance that the term first gained currency in the 1880s. Its coming into usage was closely connected with the consummation of the colonial expansion of the European powers in Africa and Asia. The last stage of that expansion was characterized by the endeavour of all major colonial powers to carry on the mutual competition for colonies peacefully through agreed-upon procedures and the appeal to common standards of action rather than adoption of violent means. Agreements on spheres of influence served this purpose. Thus, the agreement

between Great Britain and Germany in May 1885, the first to make use of the term, provided for "a separation and definition of their respective spheres of influence in the territories of the Gulf of Guinea." In it "Great Britain engages not to make acquisitions of territory, accept Protectorates, or interfere with the extension of Guinea which lies east of" a defined line. "Germany engages not to make acquisitions, accept Protectorates, or interfere with the extension of British influence in that part of the coast and interior of Guinea which lies between the line as above described . . . and the British Colony of Lagos. Both Powers agree to withdraw all Protectorates which they have already established within the limits hereafter assigned to the other party . . . Germany declares herself ready . . . to refrain from making acquisitions of territory or establishing Protectorates on the coast between the Colony of Natal and Delagoa Bay."

This agreement was followed by many of a similar nature, of which article vii of the agreement between Great Britain and Germany of July 7, 1890, concerning East Africa may be regarded as typical. Its text is as follows: "The two Powers engage that neither will interfere with any sphere of influence assigned to the other by Articles I to IV. One Power will not in the sphere of the other make acquisitions, conclude Treaties, accept sovereign rights or Protectorates, nor hinder the extension of influence of the other. It is understood that no Companies nor individuals subject to one Power can exercise sovereign rights in a sphere assigned to the other, except with the assent of the latter."

Agreements of this type concerned territories politically unorganized and therefore subject to occupation by whatever nation complied with the rules of international law relative to the acquisition of unoccupied territory. Agreements of another type, often called spheres of interest, refer to territories which are already politically organized and are to be transformed into a sphere of influence of one of the contracting parties. This type is exemplified by article ii of the Anglo-French agreement of April 8, 1904, concerning Morocco. It provides: "The Government of the French Republic declare that they have no intention of altering the political status of Morocco. His Britannic Majesty's Government, for their part, recognize that it appertains to France, more particularly as a Power whose dominions are conterminous for a great distance with those of Morocco, to preserve order in that country, and to provide assistance for the purpose of all administrative, economic, financial, and military reforms which it may require. They declare that they will not obstruct the action taken by France for this purpose. . . ."

Of the legal effects of such agreements, three are worthy of note. First, agreements establishing spheres of influence create rights and obligations between the contracting parties only. States which are not parties to the agreement are legally free to acquire within the sphere of influence whatever rights they can; they have, however, for political reasons generally refrained from interference and acted as though they, too, were bound by the agreement. Second, such agreements do not affect by themselves the actual control over the territories concerned. So long as the state in whose favour a sphere of influence has been established chooses not to exercise its exclusive rights within that sphere, the actual control over it remains in the hands of those who exercised it when the agreement was concluded. Third, once the state in whose favour a sphere of influence has been established makes use of its rights within that sphere, all states, whether or not they are parties to the agreement, are excluded from the territory to the extent that the former state exercises actual control.

When the period of colonial expansion came to a close with the outbreak of World War I, spheres of influence in the legal sense lost much of their importance. From then on, the term was used more and more for the unilateral political claims of great powers, as old as political history itself, to a predominant position in the territories of other nations, especially those adjacent to their own. Thus, it can be said that the Monroe Doctrine, especially in its application after the time of Theodore Roosevelt, established the western hemisphere as a sphere of influence for the United States. In the aftermath of World War II, the Soviet Union created a sphere of influence as a political fact in the territories of

the nations of eastern Europe and of the Balkans, with the exception of Greece (and later Yugoslavia). The political division of the Balkans into spheres of influence in the political sense was foreshadowed in the agreements concluded between Great Britain and the Soviet Union in 1944 and on the face of them intended only to facilitate military operations and not to outlast the war. These agreements were opposed by U.S. Secretary of State Cordell Hull, who was not "a believer in the idea of balance of power or spheres of influence as a means of keeping the peace" (from Cordell Hull, The Memoirs of Cordell Hull, vol. in, p. 1452, copyright 1948 by Cordell Hull, the Macmillan Company, 1948). Regardless of their evaluation, it seems that spheres of influence in the political sense are an inevitable concomitant of the struggle for power of sovereign nations. (See International Law; Monroe Doctrine)

BIBLIOGRAPHY.—M. F. Lindley, The Acquisition and Government of Backward Territory in International Law (London, 1926); Frederick L. Schuman, "Regionalism and Spheres of Influence," in Hans J. Morgenthau (ed.), Peace, Security and the United Nations (1946); W. W. Willoughby, Foreign Rights and Interests in China, and ed, vol. 1, pp. 130–168 (1927).

**SPHERICAL HARMONICS** are certain functions which occur in the theories of gravitation, electricity, hydrodynamics, and many other branches of mathematical physics.

If a number of particles of masses  $M_1, M_2, \dots, M_m$ , attracting according to the inverse-square law, are placed at points  $A_1, A_2, \dots, A_m$ , the potential of these masses at any point P, i.e., the work done by the gravitational attractions in bringing a unit mass from an infinite distance to P, is

$$\frac{M_1}{A_1P} + \frac{M_2}{A_2P} + \cdots + \frac{M_m}{A_mP}.$$

If now the points  $A_1, A_2, \dots, A_m, P$  are referred to a set of rectangular co-ordinate axes, and the co-ordinates of the points are  $(a_1, b_1, c_1), (a_2, b_2, c_2), \dots, (a_m, b_m, c_m), (x, y, z)$  so that

$$A_1P = \sqrt{\{(x-a_1)^2 + (y-b_1)^2 + (z-c_1)^2\}}$$

with similar expressions for  $A_2P$ ,  $A_3P$ , ...,  $A_mP$ , and if V denotes the potential, it may be verified by partial differentiations that

$$\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2} = 0.$$

This equation does not involve the masses or the points at which they are placed, and so it is satisfied by the potential produced at a point (x, y, z), in free space, by any gravitating system; it is known as Laplace's equation, and it is frequently written in the form

$$\nabla^2 V = 0$$
,

 $\nabla^2$  denoting the differential operator  $\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$  for brevity.

Laplace's equation occurs in problems of Gravitation, Electrostatics and Hydrodynamics; the related equation  $\nabla^2 V = k \partial V / \delta t$  occurs in problems of conduction of heat, V being then a function of the co-ordinates x, y, z, and the time t, and k being a constant; and the equation  $e^2 \nabla^2 V = \partial^2 V / \partial t^2$  occurs in problems of Vibrations of air and ether, c being the velocity of sound or of light, according to the problem considered.

In order to discuss generally problems concerning the potential, it is found more effective to examine solutions of Laplace's equation than to regard the potential as the sum of a number of terms of the type M/AP, each term representing the potential produced by an attracting particle. If  $V_1$ ,  $V_2$ ,  $V_3$ , ·· are a number of solutions of Laplace's equation, and if

$$V = V_1 + V_2 + V_3 + \cdots$$

it is easily verified that

$$\nabla^2 V = \nabla^2 V_1 + \nabla^2 V_2 + \nabla^2 V_3 + \cdots = 0,$$

and so the sum of any number of solutions of Laplace's equation

is itself a solution of the equation. It is thus possible to build up a solution of Laplace's equation by adding together simpler solutions.

Now let V be any potential function, and suppose that it can be expanded by Taylor's theorem as a series of positive integral powers of x, y, z, thus

$$V = a_0+a_1x+b_1y+c_1z+a_2x^2+b_2y^2$$

$$+c_2z^2+d_2yz+c_2zx+f_2xy+a_3x^3+\cdots$$

Group together all terms which are of the same degree in x, y, z, and denote the groups of terms which are of degrees o, 1, 2,  $n, \cdots$  in the expansion by

$$Y_0(x, y, z)$$
,  $Y_1(x, y, z)$ ,  $Y_2(x, y, z)$ ,  $\cdots$ ,  $Y_n(x, y, z)$ ,  $\cdots$ , or, for brevity, by  $Y_0, Y_1, Y_2, \cdots, Y_n$ ,  $\cdots$ , so that

$$V = Y_0 + Y_1 + Y_2 + \cdots + Y_n + \cdots$$

The expression  $Y_n(v, y, z)$  is called a spherical harmonic of degree n. It may be verified that

$$\nabla^2 Y_2 + \nabla^2 Y_3 + \cdots + \nabla^2 Y_n + \cdots = \nabla^2 V = \mathbf{0}$$

so that the expression on the left vanishes identically; and since the terms written down are of different degrees, o,  $1, \dots, n-2 \dots$ , each must vanish separately, so that spherical harmonics are themselves solutions of Laplace's equation.

If the polar co-ordinates of (x, y, z) are  $(r, \theta, \phi)$ , so that

$$x = r \sin \theta \cos \phi$$
,  $y = r \sin \theta \sin \phi$ ,  $z = r \cos \theta$ ,

then  $Y_n(x, y, z)$  may be written in the form  $r^n f_n(\theta, \phi)$ , where  $f_n(\theta, \phi)$ 

is independent of r; and  $f_n(\theta, \phi)$  is called a surface harmonic. It can be proved that  $Y_n(x, y, z)/r^{2n+1}$  is also a solution of Laplace's equation, and it is called a spherical harmonic of degree -(n+1); this function and  $Y_n$  (x, y, z) are called solid harmonics.

The term spherical harmonics (German, Kugelfunktionen; French, Fonctions sphériques) is due to Lord Kelvin.

When referred to polar co-ordinates, Laplace's equation be-

$$\frac{\partial}{\partial r} \left( r^2 \frac{\partial V}{\partial r} \right) + \frac{1}{\sin \theta} \frac{\partial}{\partial \theta} \left( \sin \theta \frac{\partial V}{\partial \theta} \right) + \frac{1}{\sin^2 \theta} \frac{\partial^2 V}{\partial \phi^2} = 0;$$

this was the form of the equation originally given by P. S. de -Laplace in 1784, in a memoir on Saturn's rings.

Determination of Harmonics of Given Degree.-Let  $a_{r,s,t} x^r y^s z^t$  be an arbitrary expression of positive integral degree n in x, y, z where r, s, t are positive integers (zero included) such that r+s+t=n, and the summation extends over all possible sets of values of r, s, t. It is required to find conditions that this expression may be a harmonic.

It is readily proved that the number of terms in the expression is  $\frac{1}{2}(n+2)(n+1)$ ; if the expression is operated on by Laplace's operator, the result is an expression of degree n-2 in x, y, z, in which the  $\frac{1}{2}n(n-1)$  coefficients are linear combinations of the  $a_{r,s,t}$ . If the last expression is equated to zero,  $\frac{1}{2}n(n-1)$  equations connecting the are obtained, which have to be satisfied if the former expression is to be a harmonic. It follows that the number of independent coefficients areast is

$$\frac{1}{2}(n+2)(n+1)-\frac{1}{2}n(n-1)$$

i.e., 2n+1, and the remaining coefficients are expressible linearly in terms of them.

Consequently there are 2n+1 independent harmonics of degree n, and any other harmonic of degree n is expressible as a linear combination of these harmonics.

Take n=2 as an illustration; the expression

$$a_2x^2+b_2y^2+c_2z^2+2d_2yz+2e_2zx+2f_2xy$$

is a harmonic if  $a_2+b_2+c_2=0$ , and 5 independent harmonics of degree 2, in terms of which any harmonic of degree 2 may be expressed, may be taken to be

$$yz$$
,  $zx$ ,  $xy$ ,  $2z^2-x^2-y^2$ ,  $x^2-y^2$ .

The next step is to construct 2n+1 harmonics of degree n. This may be effected by considering the condition that

$$(ax+by+cz)^n$$

may be a harmonic, where  $a, b, \epsilon$ , are constants, and deducing the harmonics from it. By actual differentiation it follows that the condition that  $(ax+by+cz)^n$  is a harmonic is

$$a^2+b^2+c^2=0$$
;

and this condition is satisfied by taking

$$a = i \cos u$$
,  $b = i \sin u$ ,  $c = I$ ,

where u is any angle and i stands for  $\sqrt{(-1)}$ ; and so

$$(z+ix\cos u+iy\sin u)^n$$

is always a harmonic

Now suppose this expression to be expanded by the multinomial theorem, and replace cosu and sinu by their exponential values  $(e^{iu}+e^{-iu})/2$  and  $(e^{iu}-e^{-iu})/(2i)$ ; when the products of powers of  $\cos u$  and  $\sin u$  are multiplied out in this way, replace expressions such as emin, e-min by cos mu± sin mu.

It is thus possible to express  $(z+ix\cos u+iy\sin u)^n$  in the form

$$(z+ix\cos u+iy\sin u)^n = \frac{1}{2}g_0(x,y,z) + \sum_{m=1}^n [g_m(x,y,z)\cos mu + h_m(x,y,z)\sin mu],$$

where  $g_m(x,y,z)$  and  $h_m(x,y,z)$  are polynomials of degree n in x,y,z, and are independent of u; and since

$$\frac{1}{2}\nabla^2 g_0(x,y,z) + \sum_{n=1}^{\infty} \left[\nabla^2 g_m(x,y,z)\cos mu + \nabla^2 h_m(x,y,z)\sin mu\right] \equiv 0,$$

for all values of u, it is evident that  $g_m(x, y, z)$  and  $h_m(x, y, z)$  must be harmonics. As an illustration,

$$(z+ix\cos u+iy\sin u)^2 = z^2-\frac{1}{2}x^2-\frac{1}{2}y^2+2ixz\cos u$$

$$+2iyz\sin u + \frac{1}{2}(y^2 - x^2)\cos 2u - xy\sin 2u.$$

To obtain  $g_m(x, y, z)$  and  $h_m(x, y, z)$  explicitly, use Fourier's rule for determining the coefficients in a trigonometrical series, i.e., multiply the expansion of  $(z+ix\cos u+iy\sin u)^n$  by  $\cos mu$ and by  $\sin mu$ , and integrate with respect to u from  $-\pi$  to  $\pi$ It follows that

It will be proved later that these functions  $g_m(x,y,z)$  and  $h_m(x,y,z)$  are linearly independent, and so they form a set of 2n+1 independent harmonics.

The General Solution of Laplace's Equation .- It has just been seen that any harmonic of degree n may be expressed in the form

$$\sum_{m=0}^{n} a_{m}g_{m}(x,y,z) + \sum_{m=1}^{n} b_{m}h_{m}(x,y,z),$$

where  $a_m$  and  $b_m$  are constants. If now, for brevity,

$$\sum_{n=0}^{\infty} a_m \cos mu + \sum_{n=0}^{\infty} b_m \sin mu$$

be called  $\pi f_n(u)$ , it follows that any harmonic of degree n is expressible in the form

$$\int_{-\pi}^{\pi} (z+ix\cos u+iy\sin u)^n f_n(u)du,$$

where  $f_n(u)$  is a function of u; and, conversely, if  $f_n(u)$  is an arbitrary function of u, it may be verified by substituting the expression in Laplace's equation that it is a harmonic of degree n.

Next take any solution V of Laplace's equation and suppose it to be expansible in a convergent series of positive integral powers of x, y, z; group together all the terms of the same degree and replace each group of terms of the same degree n by an expression of the form

$$\int_{-\pi}^{\pi} (z+ix\cos u+iy\sin u)^n f_n(u)du;$$

it follows that

$$V = \sum_{n=0}^{\infty} \int_{-\pi}^{\pi} (z + iv \cos u + iy \sin u)^n f_n(u) du;$$

and this value of V is expressible in the form

$$V = \int_{-\pi}^{\pi} f(z + iv \cos u + iy \sin u, u) du,$$

where f denotes a function of the two arguments  $z+ix\cos u+iv\sin u$ and u; and conversely if f denotes an arbitrary function of its two arguments, the expression on the right may be shown to satisfy Laplace's equation

It is possible to remove the restriction concerning the possibility of expanding V as a series of positive integral powers of x, y, z; and hence the general solution of Laplace's equation may be

$$V = \int_{-\pi}^{\pi} f(z + ix \cos u + iy \sin u, u) du.$$

This solution was obtained by E. T. Whittaker in 1902; it may be compared with the solution of the equation

$$\frac{\partial^2 W}{\partial x^2} + \frac{\partial^2 W}{\partial y^2} = 0,$$

(known as Laplace's two-dimensional equation) namely

$$W = f(x+iy) + g(x-iy)$$

where f and g denote arbitrary functions.

Zonal, Tesseral and Sectorial Harmonics.-The 2n+1 harmonics of degree n which have been constructed take more simple forms when referred to polar co-ordinates; it is, in fact, possible to establish the expansion:

$$(z+ix\cos u+iy\sin u)^n=r^nP_n(\cos\theta)\ +\ 2\sum_{m=1}^n\frac{n!\ i^m}{(n+m)!}r^nP_n^m(\cos\theta)$$

 $(\cos m\phi \cos mu + \sin m\phi \sin mu)$  where  $P_n(\cos\theta)$  depends on  $\theta$ .

but not on 
$$\phi$$
, and  $P_n^m(\cos\theta) = \sin^m\theta \frac{d^m P_n(\cos\theta)}{d(\cos\theta)^m}$ .

From the form of the above expansion, it is evident that  $r^n P_n(\cos\theta)$  is identical with  $\frac{1}{2}g_0(x,y,z)$  so that

$$P_{\pi}(\cos\theta) = \frac{1}{2\pi} \int_{-\pi}^{\pi} \left\{ \cos\theta + i\sin\theta\cos(\phi - u) \right\}^{n} du,$$

it follows from the statement that  $P_n(\cos\theta)$  is independent of  $\phi$  that it is permissible to put  $\phi = 0$  in the last formula without affecting the result; and so

$$P_n(\cos\theta) = \frac{1}{2\pi} \int_{-\pi}^{\pi} (\cos\theta + i\sin\theta\cos u)^n du,$$

a formula known as Laplace's integral.

From the result stated, it follows that 2n+1 harmonics of degree n are

$$r^n P_n(\cos\theta), r^n P_n^m(\cos\theta)\cos m\phi, r^n P_n^m(\cos\theta)\sin m\phi,$$
  
 $(m=1,2,\cdots,n),$ 

and, from the manner in which  $\phi$  occurs in them, they are obviously linearly independent.

An alternative definition of  $P_n(\cos\theta)$  is derived from the fact that the potential produced at (x, y, z) by a unit mass at (0, 0, a) is  $1/\sqrt{x^2+y^2+(a-z)^2}=1/\sqrt{(a^2-2ar\mu+r^2)},$ 

in polar co-ordinates, where 
$$\mu$$
 denotes  $\cos\theta$ ; when this potential

function is expanded in ascending powers of r, the result is of the form

$$\frac{\mathbf{r}}{a} + \frac{rP_1(\mu)}{a^2} + \cdots + \frac{r^nP_n(\mu)}{a^{n+1}} + \cdots,$$

where  $P_n(\mu)$  depends on  $\mu$  and n only; and it may be seen from the expression in Cartesian co-ordinates that  $r^n P_n(\mu)$  is a harmonic of degree n; it is possible to identify  $P_n(\mu)$ , defined in this manner, with Laplace's integral; and it can be proved that

$$\begin{split} P_1(\mu) &= \mu, \quad P_2(\mu) = \frac{3 \, \mu^2 - 1}{2} \,, \quad P_3(\mu) = \frac{5 \, \mu^3 - 3 \mu}{2} \,, \cdots \,, \\ P_n(\mu) &= \frac{(2n)^4}{2^n \cdot (n!)^2} \left[ \mu^n - \frac{n(n-1)}{2 \cdot (2n-1)} \, \mu^{n-2} \right. \\ &+ \frac{n(n-1)(n-2)(n-3)}{2 \cdot 4(2n-1)(2n-3)} \, \mu^{n-4} - \cdots \right] . \end{split}$$

If a sphere is drawn with centre at the origin, the locus of points on the sphere at which  $P_n(\cos\theta)$  vanishes consists of the n parallels of latitude on which the cosine of the co-latitude is a root of the equation  $P_n(\mu) = 0$ ; the locus thus divides the sphere into n+1 zones, and for this reason  $r^n P_n(\cos \theta)$  is called a zonal harmonic

In like manner when  $n > m \ge 1$ ,  $P_n^m(\cos \theta)$  vanishes on n-mparallels of latitude, while cos mo vanishes on 2m meridians, and sin mφ vanishes on 2m other meridians; the sphere is thus divided into 2m(n-m-1) rectangular regions, with 2m triangular regions round each pole, and for this reason  $r^m P_n^m(\cos \theta) \cos m\phi$ and  $r^n P_n^m(\cos\theta) \sin m\phi$  are called tesseral harmonics  $(\tau \epsilon \sigma \sigma \epsilon \rho \alpha = a)$ 

For similar reasons  $r^n P_n^n(\cos\theta) \cos n\phi$  and  $r^n P_n^n(\cos\theta) \sin n\phi$ are called sectorial harmonics.

The function  $P_n(\cos\theta)$  is called a Legendre coefficient, or a Legendre function, while  $P_n^m(\cos\theta)$  is called an associated Legendre function.

Normal Solutions of Laplace's Equation.—The zonal, tesseral and sectorial harmonics are of the form  $R \Theta \cdot \Phi$  where  $R, \Theta, \Phi$ respectively involve the co-ordinates,  $r, \theta$ ,  $\phi$ , only; a solution consisting of the product of three functions each involving only one co-ordinate is called a normal solution.

Thus, if  $X \cdot Y \cdot Z$  is a normal solution of Laplace's equation in Cartesian co-ordinates, it follows, on substitution and division by XYZ, that

$$\frac{\mathbf{I}}{X} \frac{\partial^2 X}{\partial x^2} + \frac{\mathbf{I}}{Y} \frac{\partial^2 Y}{\partial y^2} + \frac{\mathbf{I}}{Z} \frac{\partial^2 Z}{\partial z^2} = 0,$$

$$\mathbf{I} \frac{\partial^2 X}{\partial x^2} = \mathbf{I} \frac{\partial^2 Y}{\partial x^2} + \mathbf{I} \frac{\partial^2 Z}{\partial z^2} = 0,$$

 $\frac{1}{V} \frac{\partial^2 X}{\partial x^2}, \quad \frac{1}{V} \frac{\partial^2 Y}{\partial x^2}, \quad \frac{1}{Z} \frac{\partial^2 Z}{\partial x^2}$ and so

must be respectively independent of x, y, z; hence they are constants. If these constants are called  $a^2$ ,  $b^2$ ,  $c^2$ , where  $a^2+b^2+c^2=0$ , we obtain the solutions

$$V = e^{\pm ax \pm by \pm cz}$$

Similarly, if ROP is a normal solution in polar co-ordinates,

$$\frac{1}{R} \ \frac{d}{dr} \left( r^2 \frac{dR}{dr} \right) + \frac{1}{\Theta \sin \theta} \ \frac{d}{d\theta} \left( \sin \theta \frac{d\Theta}{d\theta} \right) + \frac{1}{\Phi \sin^2 \theta} \ \frac{d^2 \Phi}{d \phi^2} = o,$$

and so 
$$\frac{1}{R} \frac{d}{dr} \left( r^2 \frac{dR}{dr} \right)$$
 and  $\frac{1}{\Phi} \frac{d^2 \Phi}{d\phi^2}$  must be constants, say

n(n+1) and  $-m^2$ ; and so  $\Theta$  satisfies the equation

$$\frac{1}{\sin\theta} \frac{d}{d\theta} \left( \sin\theta \frac{d\Theta}{d\theta} \right) + \left( n[n+1] - \frac{m^2}{\sin^2\theta} \right) \Theta = 0,$$

while 
$$\frac{d}{dr}\left(r^2\frac{dR}{dr}\right) - n(n+1)R = 0$$
,  $\frac{d^2\Phi}{d\phi^2} + m^2\Phi = 0$ .

Possible values of R are  $r^n$  and  $r^{-n-1}$ ; and possible values of  $\Phi$ are cos mo and sin mo. But now n and m are not necessarily integers, and so the question arises of defining  $P_n^m(\cos\theta)$  in such circumstances

This problem is dealt with by means of the hypergeometric function of Gauss defined by the equation

$$F(\alpha, \beta; \gamma; z) = 1 + \frac{\alpha\beta}{\gamma \cdot 1} z + \frac{\alpha(\alpha+1)\beta(\beta+1)}{\gamma(\gamma+1) \cdot 1} z^2 + \cdots,$$

A solution of the equation which it is convenient to adopt as the definition of  $P_n^{m}(\cos \theta)$  is

$$P_n^m(\cos\theta) = \frac{\mathrm{I}}{\Gamma(\mathrm{I}-m)} \left(\frac{\mu+\mathrm{I}}{\mu-\mathrm{I}}\right)^{\frac{1}{2m}} F(-n,\,n+\mathrm{I}\,;\,\mathrm{I}-m\,;\,\frac{1}{2}-\frac{1}{2}\mu),$$

where  $\Gamma(\mathbf{r}-m)$  denotes the gamma function of Euler which reduces to (-m)! when m is a negative integer (when m is a positive integer, this function differs from the associated Legendre function, as previously defined, by a constant factor). The theory of generalized Legendre functions is consequently merged into the wider theory of hypergeometric functions.

Cylindrical and Ellipsoidal Harmonics.—The cylindrical co-ordinates  $(\rho, \phi, z)$  of a point are defined by the equations

$$x = \rho \cos \phi$$
,  $y = \rho \sin \phi$ ,  $z = z$ .

When the solution  $e^{i(x+ix\cos u+iy\sin u)}$  of Laplace's equation is expressed in terms of such co-ordinates it becomes:

and this can be expanded in the form

$$e^{kz} \left[ J_0(k\rho) + 2 \sum_{m=1}^{\infty} i^m J_m(k\rho) \left( \cos m\phi \cos mu + \sin m\phi \sin mu \right) \right]$$

where

$$J_m(k\rho) = \sum_{n=0}^{\infty} \frac{(-1)^n (\frac{1}{2}k\rho)^{m+2n}}{n!(m+n)!}$$

This leads to the consideration of the cylindrical harmonics  $e^{kz}J_0(k\rho)$ ,  $e^{kz}J_m(k\rho)\cos m\phi$ ,  $e^{kz}J_m(k\rho)\sin m\phi$ ,

which may also be derived as normal solutions of Laplace's equation in cylindrical co-ordinates, viz.

$$\frac{\mathbf{I}}{\rho} \ \frac{\partial}{\partial \rho} \left( \rho \frac{\partial V}{\partial \rho} \right) + \frac{\mathbf{I}}{\rho^2} \ \frac{\partial^2 V}{\partial \phi^2} + \frac{\partial^2 V}{\partial z^2} = \mathrm{o}.$$

The functions  $J_m(kp)$  are known as Bessel functions (q.v.). They occur in numerous physical problems of diverse types including F. W. Bessel's investigations of planetary motion, Daniel Bernoulli's problem of a vibrating hanging chain and L. Euler's problem of a vibrating circular membrane.

The functions which occur in a similar manner when Laplace's equation is referred to a system of confocal conicoids as surfaces of reference are known as Lamb's functions; these are of a more complicated type than the functions described hitherto, because they cannot be expressed as series with simple coefficients. But when the confocal conicoids are spheroids, the substitution

$$x=(r^2-c^2)^{\frac{1}{2}}\sin\theta\cos\phi, \quad y=(r^2-c^2)^{\frac{1}{2}}\sin\theta\sin\phi, \quad z=r\cos\theta$$
 gives a form of Laplace's equation with normal solutions of the type

$$P_n^m(r/c)P_n^m(\cos\theta) \sin^{\cos\theta} m\phi$$

the spheroids being prolate; with oblate spheroids,  $\epsilon$  must be replaced by  $i\epsilon$ .

Recent Researches.—Some of the main lines along which progress has been made in recent years include methods of transforming the hypergeometric series; obtaining approximate expressions for  $P_n^m(\cos\theta)$  when n or m (or both) is large; expanding arbitrary functions of two variables as series of surface harmonics expanding arbitrary functions  $f(\mu)$  in the form  $\sum a_p P_n(\mu)$ ; obtaining approximate formulae for  $J_n(z)$  when z or n (or both) is large; obtaining formulae by which the roots of the equation  $J_n(z) = 0$  may be calculated; expanding arbitrary functions as series of Bessel functions; obtaining integral equations satisfied by ellipsoidal harmonics, and by the harmonic functions associated with confocal elliptic cylinders. These investigations all arose in the first instance out of some problem of Mathematical Physics, though many of them require the most profound methods of Pure Mathematics for their solution.

BIBLIOGRAPHY.—E. Heine, Theorie der Kugelfunktionen (1878, 1881); E. W. Hobson, "A type of spherical harmonics," Phil. Trans. of the Royal Soc. 187A (1896), pp. 443-531; N. Nielsen, Théorie des fonctions métasphériques (1911); E. W. Barnes, "A new development of the theory of the hypergeometric functions," Proc. London Math.

Soc. (2) 6 (1908), pp. 141-177; E. W. Barnes, "On generalised Legendre functions." Quarterly Journal of Math. 39 (1908), pp. 97-204; E. W. Hobson, "A general convergence theorem," Proc. London Math. Soc. (2) 6 (1908), pp. 349-395; N. Nielsen, Handbuch der Theorie der Cylinderfunktionen (Leppig, 1904); A. Gray and G. B. Mathews, A Treatise on Bessel functions (1922); W. D. Niven, The theory of Bessel functions (Cambridge, 1922); W. D. Niven, "On ellipsoidal harmonics," Phil. Trans. of the Royal Soc. 183A (1891), pp. 231-278; G. H. Darwin, "On ellipsoidal harmonics," Phil. Trans. of the Royal Soc. 195A (1901), pp. 461-557. "On the pearshaped figure of equlibrium of a rotating mass of Inquid," Phil. Trans. of the Royal Soc. 196A (1901), pp. 301-331; A. Wangerin, Theorie des Potentials und der Kugeljunktionen (1909, 1921); T. M. MacRobert, Functions of a complex variable (1917); R. Courant and D. Hilbert, Methoden der Mathematischen Physik (1904); G. F. Riemann und H. Weber, Die Differential- und Integralgleichungen der Machanik und Physik (1904); G. F. Riemann und H. Weber, Die Differential- und Integralgleichungen der Machanik und Physik (1904); G. F. Riemann und H. Weber, Die Differential- und Integralgleichungen der Machanik und Physik (1904); G. F. Riemann und H. Weber, Die Differential- und Integralgleichungen (1907); R. T. M. MacRobert, Spherical Harmonics (1927); E. T. Whittaker and G. N. Watson, A course of modern analysis (Cambridge, 1927). (G. N. W.)

**SPHEROID**, literally a sphere-like body. In geometry the term is applied to figures generated by an ellipse (q.v.) revolving about either its minor axis (giving an oblate spheroid) or its major axis (giving a prolate spheroid). If the equation of the generating ellipse is  $b^2x^2+a^2y^2=a^2t^3$ , and the ellipse revolves about the major axis (the x axis), the volume is  $\frac{4}{\pi}ab^2$ ; if about the minor axis, it is  $\frac{4}{\pi}a^2b$ . The equation of the prolate spheroid is  $b^2x^2+a^2(y^2+z^2)=a^2b^2$ , and of the oblate spheroid it is  $b^2(x^2+z^2)+a^2y^2=a^2b^2$ . (See ELLIPSOID.)

SPHERULITES, in petrology, small rounded bodies which commonly occur in vitreous igneous rocks. They are often visible in specimens of obsidian, pitchstone and rhyolite as globules about the size of millet seed, with a duller lustre than the surrounding glassy base of the rock, and when they are examined with a lens they prove to have a radiate fibrous structure. Under the microscope the spherulites are of circular outline and composed of thin divergent fibres, which are crystalline and react on polarized light. Between crossed nicols a black cross appears in the spherulite; its axes are usually perpendicular to one another and parallel to the crossed wires; as the stage is rotated the cross remains steady; between the black arms there are four bright sectors. This shows that the spherulite consists of radiate doubly refracting fibres which have a straight extinction; the arms of the black cross correspond to those fibres which are extinguished. The aggregate is too fine grained for us to determine its minerals.

Spherulites are commonest in acid glassy rocks but occur also in basic glasses such as tachylyte. Sometimes they compose the whole mass; more usually they are surrounded by a glassy or felsitic base. When obsidians are devitrified the spherulites are often traceable, though they may be more or less completely recrystallized or silicified. In the centre of a spherulite there may be a crystal (e.g., quartz or felspar) or sometimes a cavity. Occasionally spherulites have zones of different colours, and while most frequently spherical they may be polygonal, or irregular in outline. In some New Zealand rhyolites the spherulites send branching "cervicorn" processes (like stags' horns) outwards through the surrounding glass of the rock. Long, elliptical or band-like spherulites are called axiolites.

Spherulites may be ½in. or more in diameter. In composition they are a mixture of quartz and acid felspar.

Very large and cavernous spherulites have been called lithophysae; they are found in obsidians at Lipari, the Yellowstone Park, etc. The characteristic radiate fibrous structure is usually conspicuous, but the fibres are interrupted by cavities which are often so arranged as to give the spherulite a resemblance to a rosebud with folded petals separated by arching interspaces. Some of these lithophysae are rin. or more in diameter. In the crystallization of a glass there must be contraction, and it is supposed that thus the concentric cavities arise. The steam and other vapours in the magma would fill these empty spaces and exert a powerful mineralizing action on the warm rock. Analogous structures may be produced in artificial glasses, salt solutions and melts of organic substances. (J. S. F.)

**SPHINX**, the Greek name for a compound creature with lion's body and human head (Gr.  $\sigma\phi l\gamma\gamma\epsilon\nu$  to draw tight, squeeze). The Greek sphinx had wings and female bust, and the

male sphinx of Egypt (wingless) is distinguished as "androsphinx" by Herodotus The type perhaps originated in Egypt, where a defined type is usually recumbent. The most celebrated example is the Great Sphinx of Giza, 189ft. long, a rock carved into this shape, and from its situation likely to be the work of the IVth Dynasty.

According to inscriptions of the XVIIIth Dynasty in the shrine between the paws, it represented the sun god Harmachis It has recently been completely excavated and its head restored. Sphinxes of granite, etc., occur of the XIIth Dynasty and later. (See EGYPT. Art and Archaeology.) The heads of the sphinxes are royal portraits, and apparently they are intended to represent the power of the reigning Pharaoh. The king as a sphinx, in certain religious scenes, makes offerings to detities; and elsewhere he tears his enemies in pieces. Sphinxes in pairs guarded the approach to a temple, and the Great Sphinx at Giza so guards the entrance of the Nile valley.

The great temple avenues at Thebes are lined with recumbent rams, true sphinxes (a few late instances), and with the so-called criosphinxes or ram-sphinxes, having lion bodies and heads of the sacred animal of Ammon. A falcon-headed sphinx was dedicated to Harmachis in the temple of Abu Simbel, and is occasionally found in sculptures representing the king as Horus, or Mont, the war-god. It is distinguishable from the gryphon only by the absence of wings.

BIBLIOGRAPHY.—W. M. F. Petrie, History of Egypt from the Earliest Times to the XVIth Dynasty, p. 51; L. Borchardt, "Das Alter der grossen Sphinx." in Sitzungsberichte of the Berlin Academy (1897), p. 752. Baedeker's Egypt; Prisse d'Avennes, Histoire de l'art égyptien (Paris, 1878), vol. ii. pl. 26, 35, text, pp. 405, 410. (F. LL. G.)

In Assyria the sphinx appears with a bearded male head on cylinders; the female sphinx, lying down and furnished with wings, is first found in the palace of Esar-haddon (7th cent. B.C.). Sphinxes have been found in Phoenicia, one at least being winged and another bearded. They are copies of the Egyptian, both in form and posture, wearing the pshent and the uraeus, but distinguished by having the Assyrian wings. The sphinx is common on Persian gems, and the representations are finely executed. On a Persian intaglio are two sphinxes face to face, each wearing a tiara and guarding a sacred plant which is seen between them; but the sphinx, whether of the Egyptian or the Assyrian type, is not found in Persian sculptures (Perrot and Chipiez, History of Art in Persia, Eng. trans., London, 1892). In Asia Minor the oldest examples are the "Hittite" sphinxes of Euyuk. They are Egyptian sphinxes treated in the Assyrian style. They are not recumbent, and the hair falling from the head is curled, not straight, as in the true Egyptian sphinx.

In the early art of Cyprus (the half-way house between Asia and Greece) sphinxes of Greek type are not uncommon. On the other hand, on a gem of Phoenician style found at Curium in Cyprus there appear two male (bearded) sphinxes, with the tree of life between them. With regard to Greece proper, in the third tomb on the acropolis of Mycenae (c. 1600 B.C.) were found six small golden sphinxes; they are beardless, but the sex is doubtful.

Moreover, the sphinx (generally sejant, in the Greek fashion) was well-known in Minoan art. It occurs in ivory (couchant) among the Mycenean antiquities from Enkomi in Cyprus, in the British Museum. In the ancient tomb discovered in 1877 at Spata near Athens (which represents a kindred but somewhat later art than the tombs at Mycenae) were found female winged sphinxes carved in ivory or bone. Sphinxes on glass plates have been found in graves at Camirus in Rhodes and on gold plates in Crimean graves. Sphinxes were represented on the throne of Apollo at Amyclae and on the metopes at Selinus; in the best period of Greek art a sphinx was sculptured on the helmet of the statue of Athena in the Parthenon at Athens; and sphinxes carrying off children were sculptured on the front feet of the throne of Zeus at Olympia. There have been found in Boeotia terra-cotta figures of wingless sphinxes. Roman sphinxes of a late period have sometimes a man's, sometimes a woman's head with an asp on the forehead.

In Greek mythology the most famous sphinx was that of Thebes in Boeotia, first mentioned by Hesiod (Theog, 326), who calls het he daughter of Orthus and Chimaena According to Apollodorus (iii. 5, 8), she was the daughter of Typhon and Echidna, and had the face of a woman, the feet and tall of a lion and the wings of a bird She dwelt at the south-east corner of Lake Copais on a bald rocky mountain called Phicium (mod. Fagas), which was derived from  $\Phi \iota \xi$ , the Aeolic form of  $\sigma \phi_{\nu} \gamma \xi$ . The Muses taught her a riddle and the Thebans had to guess it. Whenever they failed she carried one of them off and devoured him. The riddle was this: "What is that which is four-footed, three-footed and two-footed?" At last Oedipus guessed correctly that it was man; for the child crawls on hands and feet, the adult walks upright, and the old man supports his steps with a stick. Then the sphinx threw herself down from the mountain.

Among the remains of the Mayan culture in Yucatan are found examples of sphinxes, male and female, which are not unlike those of Egypt and Asia Minor.

See Milchhöfer, in Mith. d. deutsch. archäol. Instit. in Athen (1879), p. 46 seq.; J. Ilberg, Die Splinv in der griechischen Sage und Kunst (1895); Sir R. C. Jebb's ed. of Sophoeles, Oed. Tyrann., app., note 12. (J. M. M.; H. R. H.)

SPICE-BUSH (Lindera aestivalis), a North American shrub of the laurel family (Lauraceae), allied to the sassafras and Oregon myrtle (qq.v.), native to moist woods from Massachusetts to Ontario and Michigan south to North Carolina and Kansas. It grows from 4 to 20 ft. high, with smooth fragrant twigs and foliage, and bears bright yellow flowers, which unfold before the leaves, and scarlet fruit (drupe), maturing in late summer. The similar hairy spice-bush (L. melissaefolia) is found in swamps in the southeastern states. The bark of L. aestivalis was formerly of high repute in household medicine, being used as a febrifuse.

SPIDER MONKEY, a group of tropical American monkeys known to zoologists as Ateles. They take their English name from the slimness of the body, the elongated limbs, and the long tail, the under surface of the prehensile extremity of which is naked. The thumb is rudimentary or wanting. Their long coarse hair and the broader partition between the nostrils distinguishes them from the woolly spider monkeys (Brachyteles). The species are arboreal. (See PRIMATES.)

SPIDERS, or Araneae, form a natural order of the class Arachnida (q.v.). They are distributed all over the world, from Spitsbergen, Greenland and Alaska in the north, to Tierra del Fuego, Kerguelen and Macquarie in the south, from sea level to 7,300 metres above it on Mt. Everest. They are found on the ground and on vegetation, in forests and in meadows, in swamps and in deserts, in human homes and in subterranean caves. One may see spiders skipping over the surface of stagnant water, running on the beach between tides and in the case of at least one species, living in air-filled tents under water. All spiders are easily distinguished from insects by the subdivision of their body into two portions only: the cephalothorax and the abdomen. The former is the result of a fusion of the head with the thorax. The fusion is so complete that the outlines of the head may be recognized only from the shallow depressions which separate its dorsal surface from that of the thorax. The abdomen is attached to the cephalothorax by a very slender pedicel, a feature which spiders share with some other Arachnida. But by far the most important character of spiders, separating them not only from other Arachnida, but from all other animals, is the presence of spinnerets on the abdomen. The spinnerets are modified appendages of the fourth and fifth abdominal embryonic segments and are supplied with silk-producing glands situated in the abdomen. The ducts of these glands open at the end of specially modified hairs, the socalled spinning tubes situated on the spinnerets. The silk is produced as a fluid which is pressed out of the spinning tubes and solidifies immediately on contact with the air. Among the Arachnida, the Pseudoscorpiones are also able to produce silk, but their spinnerets are at the end of the movable finger of the chelicerae; i.e., of the first pair of appendages situated in front of the mouth and the silk glands are not in the abdomen, but in the cephalothorax. Some Acari are also endowed with the ability to spin silk. In their case the 215A SPIDERS

silk glands are really modified salivary glands, as is also the case in such insects as moths. So the spiders are the only possessors of their type of spinning apparatus.

Besides common spinning tubes with very fine ducts, spiders possess also a few larger spinning tubes, so-called spigots, present in small, but fixed numbers among the hundreds of regular tubes. In some species the total number of spinning tubes was estimated to be as high as a thousand, but in others it is less than a hundred. A spider's silk thread, as seen with the naked eye, is in reality a cable composed

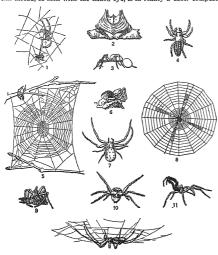


FIG. 1.-TYPES OF SPIDERS, VENOMOUS AND NONVENOMOUS

(1) Therdidis spider, wrapping a fiy in sticky throads; (2) Argloid spider, shown from behind (After Vinson); (3) Female Lycosid spider carrying egg cocono; (4) Common Attid spider (After Blackwall); (5) Epeirid spider and web (After Lulham); (6) Female Lycosa with egg sac attached to abdomen; (7) Thomasid spider (After Blackwall); (6) Argloid spider (After Hingston); (9) Grass spider (Agelena), pairing (After McCook); (10) Male Attid spider (After Bristowe); (11) Linyphid spider, on under side of her sheet web (After Blackwall); (12) Male Lycosa, in courting attitude (After Bristowe)

of many fine, individual threads. The diameter of such an individual thread is no more than three ten-thousandths of a millimetre, and in some cases, as in the inner lining of the cocoon of Agalena naevia, is less than one-tenth of a micromillimetre. Spider silk is finer, lighter and stronger than commercial silk produced by the silkworm; i.e., by the caterpillar of the silkmoth. Naturally, attempts have been made in the past to utilize spider silk, but without success. The reason for the failure lies in the cost of labour involved in the upkeep of a spider colony sufficient to produce large quantities of silk. In captivity each spider has to be kept separately and supplied with food and water, while under natural conditions the size of a garden adequate to accommodate numerous spiders, without danger of loss from overcrowding, is prohibitive from the point of view of reasonable profit. The most promising attempt at keeping spider gardens was made in Madagascar in the 19th century. The species used was the great orb-weaver, Nephila madagascarients. But even in Madagascar the cost of labour proved to be too high. At present spider silk is used only in the construction of optical instruments, because it is the finest thread available. For this purpose cocoons of northern species, such as the American Argiope auwantia, seem to be satisfactory. The length of the thread which Nephila uses in the construction of an egg cocoon varies from 1,500 to 4,000 cm etres.

All spiders have spinnerets, but one must not imagine that all make webs or snares. On the contrary, the majority of species use their silk for purposes other than the capture of insects: they spin egg cocoons, sperm webs, moulting sheets, gossamer threads, attachment discs with cables, lining of burrows, hinges for trap doors, etc., while relatively few species build snares of various types for the capture of prey. In using silk for different purposes, spiders do not use the same glands. Each spider has in its abdomen numerous glands belonging to several different types. Even males and females of the same species differ in this respect, because only females have glands producing silk for egg cocons. Only spiders which make snares to capture insects

produce silk with adhesive droplets. Since spinning of silk is so intimately connected with the activities of all spiders, it is clear that the spinning apparatus is one of the most important features of their anatomy and one of the chief factors which determined the course of their evolution.

Webs.—There are several types of webs built by spiders, more or less characteristic of whole families. One can distinguish sheet webs, funnel webs, tube webs, reticular webs, geometric orb webs, etc. In the early days of arachnology spiders were even classified in accordance with the type of web they build. Attempts have been made later in derive one type of web from another and thus to catablish trends in their evolution. Unfortunately all such attempts disregated other evidence of spider relationship and of changes involving the anatomical structure of various organs. In many cases comparatively close relatives belonging to the same family build webs of a very different type, while spiders belonging to wildly separated families may build webs of the same type. Thus so-called trap-door nests are characteristic of spiders belonging to the family Ctenizidae among the Mygalomorphae, yet some species of the Dipneumonomorph family Lycoside, notably the European Lycosa (Tarentialo) objics, make trap-door-nests of the same type. Theriduscoma nechodomae makes a little geometric spiral web, Epcirotypus gloriae, a triangular web and Wendigarda theridionina spins a single fine thread across brooks; yet all three belong to the same subfamily of orb-weaving spiders and occur in the same locality on the island of Puetto Rico. Litraphia marginata, a species common in Europe and America, builds a dome web, its close relative Linyphia communis makes an inverted dome or bowl web and another relative, Linyphia communis makes an inverted dome or bowl web and another relative, Linyphia communis makes an inverted dome or bowl web and another relative, Linyphia communis makes an inverted dome or bowl web and another relative, Linyphia communis makes an inverted dome or bowl web and another relative, Linyphia communis makes an inverted dome or bowl web and another relative, Linyphia communis makes an inverted dome or bowl web and another relative, Linyphia communis makes an inverted dome or bowl web and another relative, Linyphia com

The most complex snares are undoubtedly those of the typical geometric orb-weavers of the family Argiopidae. A finished web consists usually of three or four outer foundation lines, several inner foundation lines, many radii, a central hub, an intermediate zone and a viscissiral. Besides this many species build a tent of silk or of a leaf rolled up and held together by threads of silk. In this tent the spider hides during the day, holding in its claws the guy line which is connected with the centre of the web and which transmits the vibrations caused by entangled insects. Before the adhesive spiral is made, the spider makes a corresponding spiral of common silk. When this is finished, the adhesive spiral is attached to the radii in the space between the turns of the common spiral. The latter is now clipped off, rolled up by the chelicare and dropped to the ground as having no further use. Species of Argiope weave additional X-shaped bands called stabilimentum, although they have nothing to do with stabilizing the web. Some weave in the middle of the orb a dusc of lacework. Cyclosa covica, a little orbewaver common both in Europe and America, suspends in the vertical diameter of her web a series of silk pellets to camouflage her egg

diameter of her web a series of slik pellets to camouflage her egg coon occupying a place in the same row.

The county occupying a place in the same row. The county of the county of the county occupying a place in the same row. The county occupied web is made by Hypochilus thorelli, a peculiar relict species found in the Great Smokies and adjoining mountain ranges in the United States and having close relatives only in Tasmania and China. Its web has the shape of a truncated cone suspended by the smaller, apical end from the underside of horizontal ledges, while the web, hangs freely down and is held in place by only a few threads. The long-legged spider sits inside the web, flattened against a flat foundation sheet, which is attached directly to the surface of the rock. Another very interesting same is made by Divopis longupes of Central America. The spider is long, with very long legs, the span of which measures as much as 150 mm. and when the spider hangs fully relaxed with legs and body stretched out in a single line, it looks more like a slightly curved twig than like a spider. It is suspended from a horizontal line by a single vertical thread, holding on to it with its spinnerets and its four posterior legs. With its four anterior legs, it holds the corners of a rectangular net made of special slik produced by so-called cribellar glands. When an insect falls on top of this trap, the spider immediately displays tremendous activity by swinging the trap in a spiral motion with great speed, until the victim is completely enswathed in silk. A new trap has to be built after each capture. Hyptiotes cavatus of America and Hyptiotes paradoxus of Europe, both belonging to the family Uloboridae, make triangular snares which they swing with the family Uloboridae, make triangular snares which they swing with the said of a guy line held in their legs. Their nearest relatives of the genus Uloborus construct orb webs of the same type as the Argiopidae, but use cribellar silk for the solar.

The construction of tents was already mentioned in connection with the building of orb webs. Many spiders of other families build tents which they use as retreats or hiding places in which they find shelter from rain, cold, light and enemies, or from which they can pounce upon unsuspecting victims. The European and Asiatic aquatic spider, Argyroneta aquatica, builds her tent under water in the shape of a bell and fills it with air. Special tents are often used for moulting, during which process all spiders, even the most formidable ones, are quite helpless. Some females make complete envelops of tough silk for themselves and their brood and stay inside until the spiderlings become capable of taking care of themselves. Some species winter in special tents made for that purpose under loose bark of trees.

Egg cocons present a great variety of structure. Some are circular or oval and perfectly flat. Others are globular and smooth. The egg-shaped, pointed cocons of Latrodectus geometricus are covered with numerous little knobs. Some cocons are white, others are coloured

yenow, brown, pink or green. The cocoon of Argiope argentata is a yenow, now, now, pank we geten. The coccon or Arginge argentata is a flat, elongated hexagon, often grass-green on one side and golden yellow on the other. The coccon of Hypochius therefil is white when made, but the female then camouflages it with pieces of moss which she collects from the surface of the rock or from the ground. Most foccoons are made with at least two walls, an inner and an outer one First, the spider spins a sheet, deposits the eggs in it, covers them with rits, the spice spins a sixty appoint the eggs in it could be another sheet and binds the two together, neatly clipping the edge. Then the outer sheath is made, often of much tougher silk. In Argope aurantic, the outer sheath or envelope is almost globular, made of brown, loosely woven silk. The inner sheath is cylindical, with a round bottom and a strongly constricted neck which protrudes through the top of the outer sheath. The cocoons of Agalena naevia, the common American funnel-web spider, are fastened under bark to which their flat base is attached. They are gray, unattractive and dirty looking. The female guards them until she dies.

guards them until she dies.

Attachment, discs or anchors are made by all spiders whenever they want to be safe from injury by falling from an elevation or when they jump from one place to another. An anchor is made instantaneously by pressing the spinnerets against the surface of the object on which the spider happens to be. The pattern of an anchor is characteristic of each species and consists of numerous loops of the control of the c fine threads brought together to a median line which is then conline threats brought together to a median me which is that con-tinued as a single cable. On reaching the object of its destination, the spider either breaks off the end of the cable or, if it mtends to return, fastens the end and climbs the cable to the point of its anchorage. Silk is used for enswathing insects captured in a sna.e. This makes

their escape impossible and serves to store them as food for use at a later time. In case the insect is a dangerous adversary, such as a wasp or hornet, silk may be squirted as far as an inch from the spin-

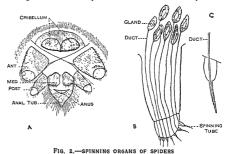
nerets, a distance sufficient to make the combat safe

nerets, a distance sufficient to make the combat safe. The maximum number of spinnerets which a spider may possess is four pairs. This number, however, is found only in the Liphistic nouphae. In some spiders the anterior median pair is transformed into a flat, perforated plate, the cribellum. In most spiders only six or four spinnerets are present. A few species are known with a single pair of spinnerets, the minimum possible, because the complete loss of spinnerets would require such a readjustment of habits, that the very existence of such creatures would become impossible. The size very existence of such creatures would become impossible. The size and shape of spinnetes, on the other hand, may vary considerably and apparently have very little to do with the type and complexity of the web. Spiders belonging to the Mygalomorph family Dipluridae have very long and slender spinnerets. They make large, irregular sheet webs or reticular webs which are usually provided with a funnel-like retreat, whereas spiders of the Dipneumonomorph family Hersiliidae, also with very long and slender spinnerets, make no webs of any kind.

Reproductive Organs.—Another character which spiders alone possess and by which they differ from all other animals is of a sexual nature: it consists in a complete separation of the male copulatory apparatus from the reproductive system pioper. The latter is situated in the abdomen in both sexes. The female has two ovaries, two oviducts and a single, very short uterus which opens in the median line

ducts and a single, very short uterus which opens in the median line between the organs of respiration belonging to the second embryonic segment. Another pair of openings is situated in front or at the sides of the genital opening. These openings lead into sperm receptacles. or the gentral opening. Iness uponings read into sperim receptactes. In more highly developed spiders the latter are connected with the uterus by special fertilization ducts. Various chitinous accessory structures, known as the epigynum, are present in many species. These are more or less intimately connected with the genital opening, are characteristic or the species of the connected with the genital opening, are characteristic or the species of the s more or less intimately connected with the genital opening, are characteristic of each species which possess them and in some way, not yet clearly understood, have to do with the act of copulation. The reproductive organs of the male are also in the abdomen. They consist of a pair of sperm glands or testes, a pair of deferent ducts and a short, common ejaculatory duct. The male genital opening is in the identical position described for the female genital opening. But the organs of copulation are in no way connected with the reproductive organs and are instead situated on the terminal joint of the pedipalpi. This is what makes them unique in the entire animal kingdom and organs and are instead situated on the terminal joint of the pedipalpi. This is what makes them unique in the entire animal kingdom and what necessitated the development of special instincts, of strictly inherited behaviour of male spiders, peculiar to sexually mature male spiders and only to them. Because the female has a pair of seminal receptacles and the male has a pair of pedipalpi, the males have a pair of copulatory organs. In its simplest form the apparatus consists of a bulb ending in a more or less curved spout or embolus. Inside the bulb a blind receptacle for sperm is situated, with a single duct which opens at the end of the embolus. The receptacles have to be filled with sperm before copulation can take place. This requires the construction of a special sperm web, the ejection of the sperm into the web and its transfer into the palpi through the opening of the embolus. How such an arrangement could have originated remains the web and its transfer into the palpi through the opening of the embolus. How such an arrangement could have originated remains a mystery. We have something similar in the case of the Ricinulei, another order of Arachinda, in which the metatarsus and tarsus of the third pair of legs in the male is modified as an organ of copulation. We find something similar, but without any structural modification, in the Solifugae, also an order of Arachinda, in which the male transfers the sperm into the genital opening of the female by means of his chelicerae. We do not know in which geological age the pedipalp of male spiders became modified as an organ of copulation. Oligocene spiders of the Baltic amber and Tertiary spiders of the Florissant shale possess fully developed copulatory organs of the same type and as complicated as recent spiders. The Mesozoic era left a single record of a tossil spider and that so imperfect that nothing can sugge record of a cossil spacer and that so imperiect that nothing can be learned from it. The tew fossil spiders from the Upper Carbon-iferous of Europe and Pennsylvanian of North America, as well as the still fewer tossils found in the Devonian red sandstone of Scotland, are not sufficient to determine whether at that distant age male spiders had as yet unmodified pedipalpi, or whether all available fossil specimens belong to the female sex or at most represent immature individuals. But it is clear that whatever the geological age may be when the pedipalpi became modified into organs of copulation, the change must have involved a corresponding change in sexual habits and this, in its turn, required a change in other habits. It is quite possible and even probable that previous to the development of organs of copulation on the pedpalpi, male spiders used a method of iertilization comparable to that of pseudoscopions. The males of these Iertilization comparable to trant of pseudoscorpions. In males of these small Arachinda attach a spermatophore to a stalk on the ground, grasp with the pincers of their pedipalpit the corresponding pincers of the female and drag her until her genital opening comes in contact with the spermatophore. Since spiders have no pincers on their pedipalpi, or for that matter on any other appendiages, males could never grasp a female in the manner of the pseudoscorpions. But they could perhaps have used their pedipalpit to hold a drop of sperm by could peniagis may ease their peningint to note a drop of sperin by simple adhesion and transferred it into the gential opening of the female in the best way possible, or may have dropped sperm onto a web and pushed the female until her genital opening came in contact with it. With the development of a special copulatory apparatus in the male, the development of sperm receptacles in the female must have gone apace until the bewildering diversity and complexity of structure and habits has been reached, by which the many thousands of species of spiders are now better distinguished than by other

Poison.—The third character which is found only in spiders among Arachnida is the presence of poison glands either in the basal joint of the chelicerae or in the cephalothoiax and opening by means of a of the chemical of in the Cephanonical and opening by means of a duct near the tip of the fang. With few exceptions the structure of the glands is the same in all spiders. It is an elongated, cylindrical sac, the walls of which have a single layer of glandular epithelial cells and an outer muscular covering composed of spirally wound, striated fibres A structureless membrane separates the two layers and another thin membrane formed by highly flattened cells protects the outside of the gland. The flow of poison is under control of the spider. In



(A) Spinnerets of Eresus latifasciatus, ventral view; (B) One of the spinnerets of Trechalea magnifica, showing slik plands and duots; (C) Greatly enlarged spinning tube of Trechalea magnifica

fact, spiders which ensnare their prey do not use their poison, while those who hunt for their prey or hide on flowers and capture insects by grasping them with their fangs when the insects come within their by grashing mean with their actings when the insects come within their reach, kill their victims with poison. All spiders, however, use their poison in self defense, when escape is impossible. Spiders of two families, Uloboridae and Heptathelidae have no poison glands.

The poison of spiders attracted early attention and was studied many times. Unfortunately, the results of most of such studies are

many times. Comortunately, the results of most of study stimes are vitiated by the application of wrong and faulty methods. Observations on the effects of bites on man and animals are of very little value even when the species of spider is known and at best may serve only as confirmatory evidence. But experiments conducted in the laboratory have also led to wrong conclusions until ways were found laboratory have also led to wrong conclusions until ways were round to get the poison in a pure state, without any admixture of other substances such as invariably happens when an entire cephalothorax is used for extraction of poison in a fluid. As now practiced, poison is obtained either by dissecting the cephalothorax and removing the glands, or still better by applying an electric current to the immobilized, live spider and collecting the pure poison as it appears in droplets at the ends of the fangs. Poison obtained in this manner may be dried, weighed and used in measured quantities and known concen-

tration. Few spiders are poisonous to man. Among these the black widow alone is dangerous in the United States, as are other closely related species in Europe, Africa, Asia and Australia. All these species belong to the genus Latrodectus of the family Theridudae and their poison is neurotoxic. The only other spiders known to have a neuro-

SPIDERS

toxic poison belong to the genus Ctenus of the family Ctenidae A Brazilian species, Lycosa raptoria, causes a creeping ulceration of the skin. Some observations point to the possibility that other species belonging to various families may be poisonous to man. But the majority—even large tarantulae—are no more dangerous to man than wasps or hornets and a great many spiders do not attempt to bite

even when taken in one's hand.

Respiratory System .- A fourth feature peculiar to spiders among other Arachnida is the presence of two types of respiratory organs in the same individual, book lungs and tracheal tubes. This peculiarity is restricted to a single suborder among the spiders, th Dipneumonomorphae, but the vast majority of spiders belong to it. It seems certain that originally spiders had two pairs of book lungs and no tracheal tubes; the second pair was later replaced by tracheal tubes and finally the first pair was also replaced by tracheal tubes. Thus we have in spiders a condition unique among the Arachmda Of late, Tasmanian spiders have been discovered in which only one pair of tracheal tubes remains.

Digestive System .- Several features, while not unique among Arachnida, nevertheless are of great importance in the life of spiders The first of these has to do with the structure of their digestive sys-The first of these has to do with the structure of their digestive system. The foregut, consisting of a pharynx, oesophagus and gizzard, is concerned only with the mechanics of ingestion. The pharynx is so structured that it acts both as a pump and a strainer, preventing coarse particles from passing into the oesophagus. The latter is merely a tube connecting the pharynx with the gizzard, but the gizzard is a second, powerful pump. The mid-gut is provided with several a story connecting the party of with the gazzard, but the gazzard is a second, powerful pump. The mid-gut is provided with several branched diverticles, the finest branches ending each in a little spherical ampulla and the whole lot of them held together by interstitial tissue. The mid-gut serves two purposes: it produces digestive enzymes and absorbs the fluid substances into which food is converted after the action of enzymes on its constituents. A pair of maxillary glands situated in the maxillary lobes of the pedipalpi also produce digestive enzymes. The mid-gut forms a large stereoral pouch in which excrements are stored before they are excreted through the hind-gut and anus. Now this arrangement of the digestive system found also in other Arachnida, makes ingestion of only fluid food possible and necessitates predigestion of food outside the body. It is a mistake to think that spiders suck blood. That is the one thing they never do. Instead, they inflict a wound with their fangs, inject digestive enzymes into the wound and as the tissues of their prey become liquefied, pump the insect dry, leaving nothing but an empty, chitinous shell behind. For some reason which is not quite clear, spiders have never learned to make use of vegetal food or even to when the latter do not move. Spiders may be fed in captivity by little pieces of raw meat, but the latter must be attached to a thin thread and dragged or dangled in front of the spider to induce the latter to

Sense Organs.—The second feature which naturally has a great influence on the entire behaviour of spiders, is the structure and funcinfluence on the entire behaviour of spiders, is the structure and function of their sense organs. Spiders belonging to different families differ greatly in this respect. Some have well developed eyes with keen vision. Such spiders have less perfectly developed tactile organs other spiders have eyes with much poorer vision and depend more on the perfection of their sense of touch. The latter is the best developed sense even in spiders with good eyes, while in species with poor eyes it is almost unbelievably fine and diversified. The body and less that padigately and check the production of the spine of the spiders and summer the spine of the spiders and spiders and spiders and spiders and spiders and spiders are spiders. and legs, the pedipalpi and chelicerae and even the spinnerets of spiders are covered with numerous hairs of various kinds, some stiff splicers are covered with indicated and so various among, some since and stout, others slender and pliable, some smooth, others provided with serrations. Many spiders have plumelike soft hair. Some hairs lie flat on the surface of the skin, others stand at an angle of 30° or more, some are erect. Not all are sensory hairs, but each sensory hair has its own nerve fibre which conveys impulses to the central nervous system. Especially fine, erect hairs arising from the centre of little drumlike membranes, are sensitive to slow currents of air. Such hairs are called trichobothria and their distribution has systematic nars are called trichobothria and their distribution has systematic value. Once the trichobothria were suspected of being capable of transmitting sound-vibrations, but this proved to be incorrect. Many spiders possess sound-producing organs, but organs of hearing have not yet been discovered, nor is it known how acute hearing is in spiders. It is probable that the range of sounds which they can perceive is quite different from the range of the human ear and presumed by much bisher.

sumably much higher.

Except for a few blind species, all spiders possess eyes which are on the carapace. The maximum and most common number is four on the carapace. The maximum and most common number is rour pairs; but spiders with three, two, or a single pair of eyes are known. Some families have only six eyes, as for example the Dysderidae; but usually the reduction in the number of eyes occurs in different genera of the same family. The so-called anterior median eyes have always of the same ranky. The same ranky are a direct retina; i.e., one in which the rods face the dioptric apparatus, consisting of a glass body and a corneal lens. The other eyes have always an inverted retina and are often supplied with a tapetum of

pigment cells, reflecting light and giving the eyes a pearly appearance. The disposition of the eyes is characteristic of whole families and is responsible for the diverging directions of the axes of the eyes. Convergent eyes do not occur in spiders. The respective fields of vision are determined by the shape and curvature of the lens, the acuity of vision by their diameter, the size of the image and the distance at which the image of two points falls on a single rod. Each pair of which the image of a size different from that formed by the other eyes forms images of a size different from that formed by the other eyes and the fields of vision are mostly quite different. Thus a fairly large potition of the horizon is covered, but only small portions are ever covered by overlapping fields of four eyes, still smaller ones by six eyes and scarcely ever by all eight eyes. The best eyes have lenses with spherical surfaces, but the acuity of vision with even the best eyes is far below that of the human eyes.

with spherical structes, but the actiny of vision with even the best eyes is far below that of the human eyes.

The olfactory sense is very poorly developed and apparently restricted to what one may call sexual odours. The males of some species are able to follow the invisible spoors left by a female on a smooth surface, such as a sheet of paper. But other scents are not perceived unless the substance is of a highly irritating nature.

Behaviour.—Spiders have a highly developed nervous system, possess memory and their reflexes may be conditioned by methods used in such experiments. But since none of the spiders developed a social state comparable to that of insects and only few species at best may be said to be gregarious, the behaviour of spiders is entirely of the type usually spoken of as instinctive. Some of these patterns of inherited behaviour appear early and persist throughout life. Others appear at the time of sexual maturity and disappear rapidly. Generally speaking, the life cycle of a spider may be pictured as follows. A spiderling, on emergence from the egg, is incapable of taking care of itself, because its digestive system is not yet fully developed. The mid-gut is filled with embryonic yolk and ingestion of food is impossible. Consequently spiderlings either stay in a web built by their possine. Consequently spliceting statics as a ma we built by their mother mother for that purpose before she died, are guarded by their mother inside a brood-cocoon, or are carried by the mother on her back, as the case may be. Their life is restricted to slow digestion of the embryonic yolk. The completion of its digestion coincides with the completion of the digestive system itself and is accompanied by the shedding of the skin and some changes in the proportions of the body. With the mid-gut emptied, hunger sets in and the spiderlings would attack and destroy each other but for the simultaneous emergence of an inherited desire to escape. Dispersal of spiderlings may be accomplished by different methods. In some species, spiderlings simply run away in all directions. But in the majority of species aerial dispersal takes place. This so-called ballooning coincides in temperate persai taxes place. This so-tailed ballooning coincides in temperate zones with the sunny days of autumn or of spring, if the eggs remain quiescent through the winter. Each spiderling climbs to the end of a blade of grass, a twig, a pole or any protruding object, raises its abdomen and spins a thin thread of silk. As this gossamer thread is caught in the breeze, the spiderling lets go of the support on which it sat, climbs to the middle of the thread and is carried by air currents to a considerable height upward and to great distances horizontally. Gossamer threads have been encountered by aeroplanes five miles above sea level and one observer stated in a letter to the author that he saw spider threads in the stratosphere. Spiderlings have been also caught in the rigging of ships several hundred miles from shore. When other currents of air finally bring them down to the ground, when dude currents of an many bring their down to the ground, the spiderlings enter upon the new phase of their life, which will last until maturity. Each spiderling follows the pattern of behaviour characteristic of the species. Some build a web, orb web, sheet web, reticular web, etc., as the case may be, others make burrows or run about on the ground among leaves, remaining vagabonds without a home. From time to time they moult, shedding the entire skin, including the corneal lens of the eyes and the lining of the fore-gut and the organs of respiration. During this period the spiders are quite helpless and cannot eat nor bite. The number of moults varies in neipiess and cannot eat nor bite. The number of moults varies in different species and even in the same species, but the usual number is seven or eight and up to 13. Males of all species and most females never moult after maturity, only some Lycosidea and Theraphosidae do so. The usual behaviour of females is not appreciably changed when they become mature, except that sexual excitation becomes manifest and they respond to the advances of a male in a manner different from that which governs their attitude toward their prey or unwelcome intruders. Otherwise they still lead the same life, build the same type of snares, etc.

In the case of males, the entire behaviour pattern changes as soon

as they mature. The filling of their palpi with sperm is now their chief concern. The males of some species use the old web for the purchief concern. The maies of some species use the old web for the purpose, merely adding a few threads of silk to which they attach the drop of sperm as it comes out of their genital opening. Other species weave special sperm webs, even if they have never built a web of any kind before. The pumping of the sperm takes from 45 minutes to a hours time. When the palpi are charged with sperm the male goes in search of a female. This is a rather hazardous undertaking, considerate the fact that no female has ever seen a male in her life and sidering the fact that no female has ever seen a male in her life and that each female is familiar only with animals suitable for food or those that must be handled as enemies. Courtship is the means by which a male overcomes the hostile attitude of a female. In jumping spiders endowed with a good sense of sight, courtship consists of a love dance in the presence of a watching female, but at some distance

from her. In spiders with a less keen sense of sight, actions involving autobiography, Finder und Erfinder (2 vols., 1890). touch or smell or a combination of these two senses take precedence Some orb weavers show a discrepancy in the time of maturation, the males maturing considerably earlier than the females. In such cases one or more males get into the web of a female and live in it until she becomes mature. In some species the male builds a tent in which he stays with the immature female, sharing food with her until she moults for the last time. Some males offer a captured insect to the female to appease her hunger. Copulation lasts but a few minutes. The palpi are used one at a time and courtship is sometimes repeated in the interim. When both receptacles of the female are filled, the relationship between her and the male reverts to that between any two relationship between are and the mane reverts to that between any two spiders of the same or of opposite sex. The male being the smaller of the two and the more agile, seeks safety in escape. The female, with the sexual desire appeased and the feeling of hunger returning, treats the male as an intruder if he persists in remaining in her we or stays too close to her on the ground. But the often repeated stories that female spiders always devour their mate after copulation are based on misinterpretation of observed instances when a male was prevented from escaping and later fell victim to the hungry female. The majority of males die naturally soon after copulation, because the supply of their energy is completely spent. In captivity a male may linger for several weeks if kept alone, but he usually refuses food and dies with the abdomen showing considerable shrinkage of all

Females live longer. In some species they die soon after egg laying, remaiss live longer. In some species they due soon after egg laying, but in other species they may live several years and copulate annually. To the former group belong the majority of spiders in temperate zones, to the latter the larger Lycosidae and the Theraphosidae. Some large tarantulae are known to have lived in capitivity as long

as 15 years.

Spiders have many enemies among vertebrates and invertebrates. Many lizards, some toads and various birds feeding on insects also eat spiders. The large Bufo maritima was observed greedily feeding on hairy translulae. Solitary wasps are perhaps the greatest enemies of spiders. Many of them depend entirely on spiders as food for their larvae. Collectors know that the easiest way of getting certain for finer larvae. Concerns know main me easiest way or getting certain species of splicers is by examining the nests of mud daubers. Species of the genus Pepsia among solitary digger wasps paralize Mygalomorph spiders, bury them and lay a single egg on the abdomen of each victim. Some Hymenoptera and Diptera spend their larval life as external parasites of spiders. Nematodes of the family Mermithidae external parasites of spiders. Nematodes of the family Mermithidae are not uncommon parasites in the body cavity of spiders. Protozoan and helminth intestinal parasites have not as yet been found, perhaps because infection is impossible on account of predigestion and filtering

More than 50,000 species of spiders are known, distributed among more than 3500 genera and many new species are discovered every year. The spider fauna of Europe is known fairly completely, that of the United States much less so.

Palaeontology.-Fossil spiders have already been found in the

of the United States much less so.

Palaeontology.—Fossil spiders have already been found in the red sandstone of the Devonian. Many species have been described from the Carboniferous of Europe and America. A single species has been reported from the Mesozoic, but the Tertiary of Europe and America and particularly the Oligocene Amber of the Baltic are rich in fossil species the great majority of which are now extinct.

Bibliography —The following short list of books may be of help to the uninitiated. More or less complete bibliography published yearly will be found in the Zoological Record. L. Berland, "Les Arachnides," Encyclopédie Entomologique XVI (Paris, 1932); W. S. Bristowe, The Comisty of Spiders, 2 vols. (London, 1939-41); J. H. Comstock, The Spider Book, Revised by W. J. Gertsch (1940); Sukh Dyal, "Spiders of Lahore," Bull. Depth. Zool. Panjab Univ. (1935); U. Gerhardt und A. Kästner, "Araneaa," Kükenthal's Handbuch der Spinningwork, 3 vols., Philadelphia (1289-93); K. C. McKoown, Spider Wonders of Australia (Sydney, 1936); E. Nielsen, The Biology of Spiders, 2 vols. (Copenhagen, 1932); A. Petrunkevitch, Systema Aranearum, Trans. Conn. Acad., Vol. 29 (1928); C. Fr. Roewer, "Araneae," Die Tiervelle Mitteleuropas (Leipzig, 1928); Th. Savory, The Biology of Spiders (1934); E. Simon, Les Arachnides de France, 7 vols. (Paris, 1892-1903).

SPIELHAGEN, FRIEDRICH VON (1829-1917), German novelist, was born at Magdeburg on Feb. 24, 1829. He was

man novelist, was born at Magdeburg on Feb. 24, 1829. He was brought up at Stralsund, studying also at Berlin, Bonn and Greifswald. He became a master in a gymnasium at Leipzig, but upon his father's death in 1854 devoted himself entirely to writing. After publishing Klara Vere (1857) and Auf der Düne (1858), he obtained a striking success with Problematische Naturen (1860-1861). His powerful Sturmflut appeared in 1876. He died

Feb. 25, 1911.

Spielhagen's Sömtliche Werke were published in 1871 in sixteen volumes, in 1878 in fourteen volumes; his Sömtliche Romane in 1898 (22 vols.), and these were followed by a new series in 1902. See his

SPIKENARD or NARD, a celebrated perfume which seems to have formed one of the most durable aromatic ingredients in the costly unguents used by the Romans and Eastern nations. The ointment prepared from it is mentioned in the New Testament (Mark xiv. 3-5; John xii. 3-5) as being "very costly," a pound of it being valued at more than 300 denarii (over £10). This appears to represent the prices then current for the best quality of nard, since Pliny (H.N. xii. 26) mentions that nard spikes reached as much as 100 denarii per lb. The source of the true or Indian nard is now identified as Nardostachys jatamansi, a plant of the family Valerianaceae, the fibrous root-stocks or "spikes" of which are still collected in Bhotan and Nepal.

The great spikenard of the United States is Aralia racemosa, and another species of the same genus, A. nudicaulis, or wild sarsaparilla, is known as "wild spikenard." In the West Indies Hyptis suaveolens is called "spikenard," and in Great Britain the name "ploughman's spikenard" is given to Inula squarrosa (I.

SPILITE, in petrology, a rock of basaltic character, but possessing in place of the normal labradorite, a felspar of the composition of albite. The ferromagnesian mineral is an augite of pale brown colour; spilites are, however, usually very completely decomposed, augite being represented by chlorite and calcite. They are commonly vesicular or variolitic and show wonderfuly preserved pillow structure, a feature in most cases indicative of a submarine origin of the lavas. The individual pillows are filled with concentric zones of vesicles filled with chlorite and calcite. The formation of pillow structure in volcanic rocks has been directly observed by Dr. Tempest Anderson in the case of the lava poured into the sea from the volcano Matavanu, in Samoa. On the surface of the lava, buds form and expand, giving rise to "pillows" with a glassy crust. The interspaces between the pillows are frequently filled with sediment representing the soft ooze of the sea floor. Not all pillow lavas are spilitic in character.

Some spilites showing pillow structure are not strictly lavas but shallow intrusions into unconsolidated submarine ooze. Excellent examples of such intrusive spilites are provided by the Devonian spilites of Nundle, New South Wales. Though the term spilite was first used by Brongniart for altered basic lavas free from phenocrysts and possessing well marked vesicular textures, a new significance was given to the term by Dewey and Flett, who urged that a special group of rocks-the spilitic suite-should be recognized. According to these authors, a large suite of igneous rocks is genetically associated with the spilites. Their composition varies widely, but they all have some characters in common. They possess a high percentage of soda and are usually extensively altered. These rocks are albite-dolerites, minverites, picrites, keratophyres, soda-felsites and soda-granites. The spilitic suite was originally given a status comparable with that of the alkaline and calc-alkaline suites. The spilitic series is regarded as peculiar to districts that have undergone a long continued and gentle subsidence with few or slight upward movements and no important faulting. The lavas are poured out on the margins of geosynclines while their common sedimentary associates are black shales, limestones and radiolarian cherts. As geosynclines are the centres of subsequent fold movements many ancient spilites have become extensively folded and metamorphosed with production of new minerals, including albite of metamorphic origin. Eruptions having the spilitic facies have occurred repeatedly over a wide area and on a large scale. The analyses of average basalt and spilite are as follows:

	SiO <sub>2</sub>	A12O2	Fe <sub>2</sub> O <sub>3</sub>	FeO	MgO	CaO	Na <sub>2</sub> O	K20	H2O(+)	TiO	co <sub>z</sub>
Average basalt Average spilite	49·06 46·01	15·70 15·21	5·38	6·37 8·69	6-17 4-18	8-95 8-64	3·11 4·97	1.52	1.62 2.48	1.36	 4·98
									(C	E	r.)

SPINA, an ancient city of Gallia Cispadana, Italy, between Ravenna and the mouths of the Po. In Etruscan times it was the principal port of Felsina. (See Bononia.) Near Comacchio, in the draining of the lagoon of Valle Tiebba, a very extensive necropolis has been found and some 450 tombs have been excavated, ranging from the 6th to the 3rd century B.C. They contained fine

Greek, Italic and Etruscan vases.

SPINACH (Spinacia oleracea) (family Chenopodiaceae), a hardy annual of Asiatic origin, long cultivated for its succulent leaves for use as a pot-herb. When sown in the fall at the proper time it will survive winter temperatures occasionally near oo F; when so grown it behaves as a biennial. The prolific rosette of leaves that first develops is harvested in entirety before the appearance of the seed stalks which develop rapidly to 1 to 3 ft. during warm, long days. The plant is sensitive to day length, and temperature; cool weather or short days are conducive to luxurous rosette development and retardation of seed stalk formation; hot weather or long days induce seed stalk formation. Male and female flowers are generally separate plants, the male flowers in terminal spikes and the female flowers (and fruits) in the axils of the branches and leaves. The so-called "seed" is a fruit consisting of a compressed seed together with the surrounding calyx lobes that may be either smooth or prickly.

Spinach can be grown as a summer cuop only in distinctly cool climates. It requires very rich, well-watered, well limed soil. In the United States it is grown very extensively as a fall, winter, or sping crop with plantings to coincide with suitable temperatures. In gardens it is sown thinly in rows 8 to 18 in. apart and the plants thinned to stand 3 to 4 in. apart. In many large fields it is sown in rows 8 in. apart, or even broadcast, and given no thinning or cultivation. Arti-

ficial protection is rately given duting winter.

Spinach culture in the United States received an enormous impetus about 1920 when attention was called to its relatively high content about 1930 when attention was taned to its featively high content of calcium and iron, and further impetus when its relatively high content of vitamins A and C were emphasized. The later discovery of large quantities of oxalates in the plant has cast some doubt upon its true dietary value, but it continues to be a most popular pot-herb. Its culture increased from about 6,000 ac. in 1918 to over 107,000 ac.

in 1937, after which it gradually declined to about 75,000 ac. in 1941.

New Zealand Spinach (Tetragonia expansa) (family Mesembry-accae), a tender annual, native to New Zealand, produces "greens" similar to spinach, when cooked. It is a much-branched, spreading plant I to 2 ft. high, with fleshy, triangular leaves and inconspicuous, yellow-green, axillary flowers. The "seed" is a nut-like fruit containing one to two seeds that often germinate very slowly. The plant is frosttender and heat tolerant, furnishing "greens" at a season when other pot-herbs do not thrive in warm regions. It is sown in rows 2 to 3 ft. apart, with the plants about 1 it, apart in the rows. The leafy tips of the branches are harvested repeatedly as new growth develops.

Mountain Spinach or Orach (Atriplex hortensis) (family

Chenopodiaceae), of Asiatic origin, is a coarse, hardy annual growing to a height of 6 ft. The leaves are large, triangular-ovate or arrow-shaped, with toothed or wavy margins and colour varying from pale yellow-green to dark red. The leaves are used as a pot-herb, but the plant is of little interest to European or American gardeners except in regions not suited to the culture of the commoner leafy vegetables, as the Great Plains of the United States.

SPINAL COLUMN, SURGERY OF. Most operations on the vertebral column are designed to relieve some condition of the enclosed spinal cord. The essentially degenerative diseases (tabes dorsalis, disseminated sclerosis, etc.) offer little scope for surgery, which finds its richest field in cases of cord compression. Spina bifida, a congenital defect in development, calls for operation in se-lected cases only, for most sufferers from this condition die during the first weeks or months of life. There is one fundamental fact which we must grasp if we wish to understand the possibilities of spinal surgery: that regeneration is impossible, so that once the cord, and the long conduction tracts of which it is composed, suffers actual anatomical

conduction tracts of which it is composed, states actual ammoniacal damage, that damage is permanent and cannot be undone.

Spinal Injuries.—These are generally due to indirect violence, the fracture occurring at a point distant from that at which the force was applied. Thus most injuries of the cervical spine (neck) are due to injuries applied to the head, while forcible flexion of the trunk by a weight failing on the shoulders (the common mechanism in pit accidents from a fall of "roof" or "dirt") causes a fracture at the first lumbar vertebra. The 24 bones which make up the cervical, thoracic and lumbar spine are not equally prone to injury; the three predominant sites where fractures or dislocations occur are at the points where the qualities and range of movement change—at the second cervical, where the compound movements of the head change over into the where the compound movements of the head change over into the ordinary movements of the neck, at the disc between the fifth and sixth cervical where the cervical mobility changes into the relative fixity of the chest, and at the first lumbar where the latter joins the rod-like lumbar portion. The bodies of the vertebrae can be compressed or broken without failury to the spinal cord (so-called "Kümmells' disease") provided there is no sliding of the broken parts on one another. A fact which colours our whole attitude towards spinal injury to-day is that when the cord is damaged the lesion is inflicted at the moment of injury. The old teaching was that the cord was being compressed by bone fragments and hence early operation was

advised. To-day we treat these cases with conservatism, reduce fracadvised. To-day we treat these cases with conservatism, reduce hac-tures by manupulation, and operate only when deterioration is setting in or pain is severe. But operation is never done as an immediate urgency. X-Rays are of the greatest help. In summary, the cord-lesion associated with most impures is central haemorrhage or actual laceration, and operation will not often be of service in the worst cases.

Spinal Tumours.—Once the diagnosis is reasonably certain it is best to operate early, for these growths are commonly (Elsberg gives \$2%) outside the cord and can be dislodged by laminectomy. An incision is made over the spinous processes, the laminae are exposed by clearing the muscles with a rongeur and some three of them are removed. The dura mater is incised, if the tumour has not already been found outside. The results in many cases are dramatic and the palsied may indeed be made to walk upright. When the tumour hes in the therapy is the only hope for such conditions, but only a few successes have so far been recorded. Little noticeable weakness follows a laminectomy per se.

Spinal Caries .- Tuberculosis of the vertebral column is commonest in the very young, and gives good results by fixation on fiames or in plaster jackets. Long periods of recumbency (1-3 years) are generally required. In order to render sufferers ambulant at an earlier time, bone-grafting operations have been devised. Albee advised this so-called "internal spinting" and recommended that a long thick graft should be taken from the tibia and inserted into a bed prepared grant should be taken from the thola and inserted into a beg prepared for it over the bared spinous processes and laminae at the region affected, including two healthy vertebrae above and below. Hibbs later introduced the operation of "spinal fusion"; in this no new bone is implanted but the spinous processes and laminae are split and turned up and down to produce a mass of bone which will lock the turned up and down to produce a mass of bone which will lock the bones together. The operations are most useful in persons of less tender years than are the majority of sufferers from Pott's disease. In Great Britain and Europe generally, excellent results are obtained by less drastic means, but in those who cannot afford a long con-valescence these operations should be considered. Sometimes a tuberculous abscess forms within the neural canal,

extends backwards from the diseased vertebrae, and presses on the cord. Happily most of these patients recover the function of their limbs when perfectly immobilized; laminectomy does not give the good results which one might theoretically expect from it.

Pain .- Much can be done for sufferers from agonizing pain by judicious spinal surgery. The chief indications for operation are neuralgia of the body or limbs, often the sequelae of amputations or of herpes zoster, the agonizing pains of spinal syphilis, and hopeless malignant growths. The usual operation heretofore has been section of posterior nerve roots just before they enter the spinal cord. The exposure is the same as for spinal tumours. The results of root sections have been inconsistent, and the operation is being replaced by section of the pain-carrying fibres in the cord itself (Spiller). This tract is the anterior spino-thalamic and lies just sufficiently far away from the motor pathway to the limbs (pyramidal tract) for its division to be effected without inflicting paralysis on the sufferer. As the sion to be enected without minicting paralysis on the suiterer. As the pain fibres cross in the cord, the tract of the opposite side to that on which the pain is felt is the one to be cut, and of course at a point cephalad to the site of the pain. A cut 2,5 to 3,0 mm. deep is made into the anterolateral aspect of the cord. A very fine and sharp knife is required and the operation must be most delicately and precisely performed. Brilliant results have generally followed, but it is too early to say what the late effects are.

Spinal Puncture.—No account of modern spinal surgery can omit some reference to the extended usefulness which is being made of lumbar puncture (puncture into the subarachnoid space and withdrawal of a specimen of cerebrospinal fluid). Our knowledge of the changing chemistry of that fluid in disease conditions is still growing. When a tumour or the like grows in relation to the spinal cord it causes a block in the subarachnoid space, either by its own bulk or causes a block in the subarachnoid space, either by its own bulk or by compressing the membranes against one another should it be extradural. The cerebrospinal fluid distal (caudal) to the obstruction is dammed back, for it is chiefly absorbed within the skull and thither it can not now return. A rise in albuminous content and a yellow tinge, xanthochromatosis (Froin's syndrome), are the results. This is of great diagnostic importance. Queckenstedt's test also makes use of of great magnostic importance. Queekensteers test also makes use of the block, for when a normal person's jugular veins are compressed the consequent rise of intracranial venous pressure is transmitted to the cerebrospinal fluid as a whole and can be measured by a manometer attached to a lumbar-puncture needle. If a tumour blocks the spinal canal the manometer records no change or modified changes only. This is most valuable in differentiating between the degenerative and compression groups of paralysis of the lower limbs Lastly, Lipidol, a heavy, opaque substance which when introduced into the cerebrospinal fluid above the tumour sinks down through it to rest on the tumour, is proving most useful. It is a 40% solution of inert iodine in poppy-seed oil and is quite opaque to X-Rays so that the precise position and often the shape of the upper end of the tumour becomes definitely recognizable.

BIBLIOGRAPHY.—Almour, "The Surgery of the Spinal Cord and its Membranes," Lancet. 1927, I. 423; Ayer, "Spinal subarachnoid block as determined by combined cistern and lumbar puncture," Arch. Neurol. Psychiat 1922, vii. 38; Elsberg, Tumours of Spinal Cord

(London, 1925); Frazier, "Section of the antero-lateral columns of the spinal coud for the relief of pain," Arch. Neurol, Psychat, 1920, iv., 137; Foerster, Due Leitungsbahnen des Schmerzgefishs und die Chirungische Behandlung der Schmerzsustande (Berlin, 1927); [Grson, "Spinal Injuries," Proc. Roy. Soc. Med., 1928, xxi., 21. [G. J.)

SPINAL CORD, in anatomy, that part of the central nervous system in man which lies in the spinal canal formed by the vertebrae, and reaches from the foramen magnum to the lower

margin of the first lumbar vertebra. It is about 18in. long, and only occupies the upper twothirds of the spinal canal The cord is protected by the same three membranes which surround the brain. Outside is the dura mater, which differs from that of the brain in not forming a periosteum to the bones, in sending no processes inward, and in having no blood sinuses enclosed within its walls; it is the continuation of only the inner layer of the dura mater of the skull. Inside the dura mater is the arachnoid, which is delicate and transparent, while between the two lies the subdural space, which reaches down to the second or third sacral vertebra. The pia mater is the s innermost covering, and is closely Fig. 1-SPINAL CORD, SHOWING applied to the surface of the cord TRACINGS OF ANTAGONISTIC REinto the substance of which it FLEXES



sends processes. Between it and the arachnoid is the sub-arachnoid space, which contains the cerebro-spinal fluid. Across this space, on each side of the cord, run a series of processes of the pia mater arranged like the teeth of a saw; by their apices they are attached to the dura mater, while their bases are continuous with the pia mater surrounding the cord. These ligaments, each consisting of twenty-one teeth, are the ligamenta denticulata, and by them the spinal cord is moored in the middle of the cerebro-spinal fluid.

The spinal cord itself is a cylinder slightly flattened from before backward. In the cervical region it is enlarged where the nerves forming the brachial plexus come off, while opposite the lower thoracic vertebrae the lumbar enlargement marks the region whence the lumbo-sacral nerves are derived. (See fig. 2.) Opposite the second lumbar vertebra the cylindrical cord becomes pointed and forms the conus medullaris, from the apex of which a glistening membranous thread runs down among the nerves which form the cauda equina, and, after blending with the termination of the dural sheath, is attached to the back of the coccyx.

Details of Structure.-In a transverse section of the cord (see fig. 3) two median fissures are seen; the antero-median is wide, and reaches about a third of the way along the anteroposterior diameter of the cord; it is lined by the pia mater and, in front, lies the single anterior spinal artery.

The postero-median fissure is much deeper and narrower, and has no reflection of the pia mater into it. Where the posterior nerve roots emerge is a depression which is called the posterolateral fissure, while between this and the postero-median a slight groove is seen in the cervical region, the paramedian fissure (see also fig. 2). The anterior nerve roots do not emerge from a definite fissure.

The spinal cord, like the brain, consists of grey and white matter, but, as there is here no representative of the cortical grey matter of the brain, the white matter entirely surrounds the grey. In section the grey matter has the form of an H, the cross bar forming the grey commissure. In the middle of this the central canal can just be made out by the naked eye (see fig. 4). The anterior limbs of the H form the anterior or ventral cornua, while the posterior, which in the greater part of the cord are longer and thinner, are the posterior or dorsal cornua. At the tips of the latter is a lighter-coloured cap known as the substantia gelatinosa Rolandi. On each side of the H is a slighter projection, the lateral cornu, best marked in the thoracic region (see fig. 4).

The grey matter has different appearances in different regions of the cord, and in the cervical and lumbar enlargements, where the nerves to the limbs come off, the anterior horns are broadened

Histologically the grey matter is made up of neuroglia, medullated and non-medullated nerve fibres, and nerve cells (see Nervous System). The nerve cells are arranged in three main columns, ventral, intermedio-lateral and posterior vesicular The ventral cell column has the longest cells, and these are again subdivided into antero-mesial, antero-lateral, postero-lateral and central groups. The intermedio-lateral cell column is found in

the lateral horn of the thoracic region.

The posterior vesicular or Clarke's column is also largely confined to the thoracic region, and lies in the mesial part of the posterior cornu. It is the place to which the sensory fibres of the sympathetic system (visceral afferents) run. The white matter, as has been shown, surrounds the grey and passes across the middle line to form the white commissure, which lies in front of the grey. It is composed of neuroglia and medullated nerve fibres, which are arranged in definite tracts, although in a section of a healthy cord these tracts cannot be distinguished even with the microscope. They have been and are still being gradually mapped out by pathologists, physiologists and embryologists.

A sensory nerve on passing into the cord (fig. 3) through the posterior nerve root lies close to the mesial side of the posterior horn of grey matter, where most of it runs upward. The next root higher up takes the same position and pushes the former one toward the middle line, so that the lower nerve fibres occupy an Fig. 2.—DIAGRAM OF DORSAL AS-

12TH DORSAL VERTERR 2ND LUNASD VERTERS

area close to the postero-median PECT OF SPINAL CORD, SHOWING fissure known as the tract of CERVICAL AND LUMBAR SWELLINGS

Goll, while the higher lie more externally in the tract of Burdach. The greater part of each nerve sooner or later enters the grey matter and comes into close relation with the cells of Clarke's column. but some fibres run right up to the nucleus gracilis and cuneatus in the medulla (see Brain), while a few turn down and form a descending tract, which, in the upper part of the cord, is situated in the inner part of the tract of Burdach and is known as the comma tract, but lower down gradually shifts quite close to the postero-median fissure and forms the oval area of Flechsig. It will be obvious that both these tracts could not be seen in the same section, and that fig. 3 is only a diagrammatic outline of their position.

A few fibres of each sensory nerve ascend in a small area known as Lissauer's tract on the outer side of the posterior nerve roots, and eventually enter the substantia gelatinosa.

To the outer side of Lissauer's tract and lying close to the lateral surface of the cord is the direct cerebellar tract, the fibres of which ascend from the cells of Clarke's column to the cerebellum. As Clarke's column is only well developed in the thoracic region this tract obviously cannot go much lower.

In front of the last and also close to the lateral surface of the cord is another ascending tract, the tract of Gowers, or, as it is sometimes called, the lateral sensory fasciculus. It probably begins in the cells of the posterior horn, and runs up to join the fillet and also to reach the cerebellum through the superior cerebellar peduncle. The crossed pyramidal tract lies internal to the direct cerebellar tract, between it and the posterior cornu. It is the great motor tract by which the fibres coming from the Rolandic area of the cerebral cortex are brought into touch with the motor cells in

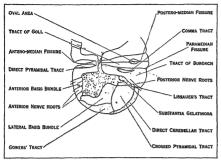


FIG. 3.—TRANSVERSE SECTION OF CORD SHOWING TWO MEDIAN FIS-SURES AND SCHEMATIC ARRANGEMENT OF COLUMNS OF FIBRES IN THE WHITE MATTER OF ONE HALF

the anterior cornu of the opposite side. This tract extends right down to the fourth sacral nerve.

In front of the crossed pyramidal tract is the lateral basis bundle, which probably consists of association fibres linking up different segments of the cord.

The anterior basis bundle lies in front and on the mesial side of the anterior cornu, and through it pass the anterior nerve roots. Like the lateral bundle it consists chiefly of association fibres, but it is continued up into the medulla as the posterior longitudinal bundle to the optic nuclei.

The direct pyramidal tract is a small bundle of the motor fibres from the Rolandic area, which, instead of crossing to the other side at the decussation of the pyramids in the medulla, runs down by the side of the antero-median fissure. Its fibres, however, keep on gradually crossing to the opposite side through the anterior white commissure of the cord, and by the time the mid-thoracic region is reached it has usually disappeared.

The roots of the spinal nerves in the upper part of the canal rise from the cord nearly opposite the points at which they emerge between the vertebrae, but the farther one passes down the higher the origin of each root becomes above its point of emergence. Consequently the lumbar and sacral nerves run a long way down from the lumbar enlargement to their spinal foramina and are enclosed in the dural and arachnoid sheaths to form a mass like a horse's tall, which is therefore known as the cauda equina.

Embryology.—The early development of the neural tube from the ectoderm is outlined in the article on the Brain. When the neural groove becomes a tube it is oval in section with a very large laterally compressed central canal (see fig. 5). The original ectodermal cells elongate and, radiating outward from the canal, are now known as spongioblasts, while the inner ends of some of them bear cilia and so the canal becomes ciliated. A number of round cells, known as germinal cells, now appear close to the central canal, except at the thin mid-dorsal and mid-ventral laminae (roofplate and floor-plate). From the division of these the primitive nerve cells or neuroblasts are formed and these later on migrate from the region of the canal and shoot out long processes—the axons. The permanent central canal of the cord was formerly said only to represent the ventral end of the large embryonic canal, the dorsal part being converted into a slit by the gradual closing in of its lateral walls, thus forming the postero-median fissure. A. Robinson, however, does not believe that the posterior fissure is any remnant of the central canal (Studies in Anatomy,

Owens College, 1891). Probably the fissure is formed partly by an infolding and partly from the original central canal. The antero-median fissure is caused by the ventral part of the cord growing on each side, but not in the mid-line where no germinal cells are

The anterior nerve roots are formed by the axons of the neuroblasts in the developing anterior cornua, but the posterior grow

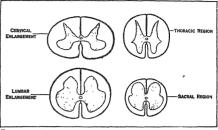
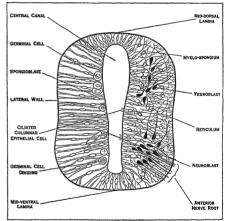


FIG. 4.—SECTIONS OF SPINAL CORD AT DIFFERENT LEVELS (2 X NAT SIZE)

into the cord from the posterior root ganglia (see Nerve: Spinal), and, as they grow, form the columns of Goll and Burdach.

In the embryo up to the fifth month there is little difference in the appearance of the grey and white matter of the cord, but at that time the fibres in the columns of Burdach acquire their medullary sheaths or white substance of Schwann, the fatty matter of which is probably abstracted from the blood. Very soon after these the basis bundles myelenate and then, in the sixth month, the columns of Goll. Next follow the direct cerebellar



FROM CUNNINGHAM, "TEXT BOOK OF AMATOMY" (OXFORD MEDICAL PUBLICATIONS)
FIG. 5.—SCHEMATIC REPRESENTATION OF TRANSVERSE SECTION
THROUGH EARLY NEURAL TUBE (YOUNG), SHOWING AN EARLIER STAGE
ON THE LEFT SIDE THAN ON THE RIGHT

tracts and, in the latter half of the eighth month the tracts of Gowers, while the fibres of the pyramidal and Lissauer's tracts do not gain their medullary sheaths until just before or after birth. At first the spinal cord extends as far as the last mesodermal somite, but neuroblasts are only formed as far as the first coccygeal somite, so that behind that the cord is non-nervous and degenerates later into the filum terminale. After the fourth month the nervous portion grows more slowly than the rest of the body

and so the long cauda equina and filum terminale are produced. At birth the lower limit of the cord is opposite the third lumbar vertebra, but in post-natal development it recedes still farther to the lower level of the first.

For further details see standard text books, e.g., Quain's Anatomy and J. P. McMurrich, Development of the Human Body

Comparative Anatomy.—In the Amphioxus there is little difference between spinal cord and brain; the former reaches the whole length of the body and is of uniform calibre. It encloses a central canal from which a dorsal fissure extends to the surface of the cord and it is composed of nerve fibres and nerve cells; most of the latter being grouped round the central canal or neurocoele, as they are in the human embryo. Some very large multipolar ganglion cells are present, and there are also large fibres known as giant fibres, the function of which is not clear.

When the reptiles are reached the cord shows slight enlargements in the regions of the limbs and these become more marked in birds and mammals.

In the lumbar region of birds the dorsal columns diverge and open up the central canal, converting it into a diamond-shaped space which is only roofed over by the membranes of the cord, and is known as the *sinus rhomboidalis*.

In all these lower vertebrates except the Anura (frogs and toads), the cord fills the whole length of the spinal canal, but in the higher mammals (Primates, Chiroptera and Insectivora) it grows less rapidly, and so the posterior part of the canal contains the cauda equina within its sheath of dura mater. In mammals below the anthropoid apes there are no direct pyramidal tracts in the cord, since the decussation of the pyramids in the medulla is complete. Moreover, the crossed tracts vary very much in their proportional size to the rest of the cord in different animals. In man, for example, they form IT-87% of the total cross area of the cord, in the mouse IT-47%. In the frog no pyramidal tract is found. It is obvious, therefore, that in the lower vertebrates the motor fibres of the cord are not so completely gathered into definite tracts as they are in man.

A good deal of interest has lately been taken in a nerve bundle which in the lower vertebrates runs through the centre of the central canal of the cord, and takes its origin in the optic reflex cells in close relation to the posterior commissure of the brain. More posteriorly (caudad) it probably acquires a connection with the most or cells of the cord and is looked upon as a means by which the muscles can be made to respond to the stimulus of light. It is known as Reissner's fibre, and its morphology and physiology have been studied most carefully in cyclostomes and fishes. It is said to be present in the mouse, but hitherto no trace of it has been found in man. It was discovered in 1860, but for forty years was looked upon as an artifact.

See P. E. Sargent, "Optic Reflex Apparatus of Vertebrates," Bull. Mus. Comp. Zool. Harvard, vol. xlv. No. 3 (July, 1904); also for general details R. Wiedersheim, Comparative Anatomy of Vertebrates (London, 1907); Lenhossek, Bau des Nervensystems (1895).

(F. G. P.)

## PHYSIOLOGY

The spinal cord is but a part of the nervous organ which throughout the length of the body forms the meeting-place of the nerve-paths arriving from and issuing to all regions with which nerve fibres communicate. To gain a true point of view for understanding the working of the spinal cord one must refer to the general function of the nervous system in the bodily economy.

Relation to General Nervous System.—An animal of microscopic size may continue throughout its life to be constituted entirely by one single cell. Animals of larger bulk, although each begins its existence as a single cell, attain their development by the multiplication of the original single cell, so that from it there comes to be formed a coherent mass of cells very many millions in number. In these multicellular animals each of the constituent cells is a minute self-centred organism, individually born, leading its own life and destined for individual death. The corporate power of the complex animal is the sum of the powers of those

manifold individual existences, its cells. Of the agencies which integrate the complex animal, one of the most potent is nervous action A certain number of the unit cells composing the animal are specially differentiated from the rest to bind the whole together by nervous action. These specially differentiated cells are called "neurones." They constitute living threads along which waves of physico-chemical disturbance are transmitted to act as releasing forces for the energy in distant cells.

It is characteristic of this nervous system, the system of neurones, that, although ramifying far and wide through the body, it is a continuum from end to end. The peripheral nerves are formed of bundles of neurones lying side by side, but these, although packed close together, are strictly isolated one from another as conductors and remain isolated throughout the whole length of the nerve The points of functional nexus of the neurones one with another are confined to one region only of the whole system. All their conductive connections one with another take place solely in the central nervous mass which constitute the so-called central nervous system, a nervous organ extending axially along the length of the body midway between the body's lateral halves. Thither the neurones converge in vast numbers, those of each body segment converging to that fraction of the central organ which belongs to their body segment. The central nervous organ thus receiving these neurones is, where it lies in the head, called the brain, the rest of it is called in vertebrates the "spinal cord," in worms and arthropods the "nerve-cord." The central organ not only receives neurones which converge to it from outside, but many of its own neurones thrust out their conductive arms from it as nerve fibres carrying nervous influence outwards to regulate the activity of glands and muscles. In the vertebrates the ingoing neurones for each segment and similarly the outgoing neurone fibres are collected into a segmental nerve To the spinal cord these are each attached by two roots, one dorsal, consisting of the afferent fibres, the other ventral, consisting of the efferent fibres.

The Reflex .- The simplest complete reaction of the system is a reflex. There are many reflexes which are extremely complex, being built up of a number of simpler reflexes combined. A reflex is a reaction started by the environment acting as a stimulus upon some nerve which communicates the excitement to other nerves by connections with them in the central nervous organ. The excitement so generated and transmitted finally travels outward from the central organ by one or more of the efferent nerves and through these reaches muscles or glands producing in them its final effect. The muscles and glands are from this point of view termed effector organs. The reaction is therefore "reflected" from the central organ. The nerve structures which include its tra-jectory are spoken of as a nervous arc. The whole purpose of the central nervous organ is to bring afferent neurones into touch with efferent neurones. The whole purpose of reflex arcs is to bind one part of the organism to another part in such a way that what the environment is doing to the organism at one place may appropriately call forth or restrain movement or secretion in the muscles or glands wherever situated in the organism.

Receptor Cells .- There is one condition for the due performance of these reactions which is not provided by the nervous system itself. The afferent neurones are not in most cases so constituted as to be excitable themselves directly by the environment-for instance, they cannot be stimulated by light. Their amenability to the environment, their sensitization to environmental agencies, is effected by special cells adjunct to their peripheral ends. These cells form organs called receptors. They are delicately adapted to be stimulated by this or that particular agent and are classifiable into various species, so that each species is easily excited by a particular agent which is "adequate" for it, and is inexcitable or excitable only with difficulty by agencies of other kinds. Thus in the skin some receptors are adapted for mechanical stimuli (touch) and not for thermal stimuli, while others (cold spots, warm spots) are adapted for thermal stimuli and not for mechanical. As far as it is known each afferent neurone is connected with receptors of one species only. receptors thus confer upon the reflex arcs selective excitability

Each arc is thus tuned to respond to certain stimuli, while other arcs not having that kind of receptor do not respond. The receptors, therefore, while increasing the responsiveness of the organism to the environment, prevent confusion of reactions (incoordination) by limiting to particular stimuli a particular reaction

Proprioceptors.—The system of neurones is thus made accessible to the play of the external world acting on the body. And in addition to those receptors which are stimulated directly by the external world, are others lying within the mass of the organism itself, which are excitable by actions occurring in the organism itself. These are called proprioceptors. They are distributed preponderantly in the muscles and structures functionally adjunct to muscle, such as joints, ligaments, fasciae, etc. The reactions both passive and active induced in such motor structures, reflexly by environmental stimuli, tend therefore secondarily to be followed and accompanied by reflex reactions initiated from proprioceptors.

Conduction.-The process by which the excitement generated in the afferent neurone travels along the reflex arc is known as conduction. Conduction along afferent and efferent nerves differs in some important respects from that obtaining in the nerve centre, i e., in the piece of the central nervous system connecting the afferent nerve with the efferent nerve. In a nerve-trunk the excited state set up in it by a stimulus travels along its fibres as wave-like disturbance at a speed of about 100 metres per second, and does not alter in intensity or speed in its travel. A nerve-trunk when excited at some point along its length transmits the "impulse," i.e., the wave-like excited state in both directions. ie, both up and down each fibre, from the point stimulated. This is true whether the fibre is afferent or efferent. The speed of travel of the nervous impulse along the nerve-trunk is the same whether the nervous impulse is weak or intense. The nerve-trunk shows practically no delay in its response to an effective, even though weak, stimulus and its response ceases practically at once on cessation of the exciting stimulus. When excited by repeated brief stimuli the rhythm of the response corresponds closely with that of the stimuli, even when the frequency of the latter is as high as 500 per second. With momentary stimuli a response even so brief as 20 can be given by the nerve-trunk. Finally, nerve-trunk conduction is singularly resistant to fatigue, to impoverished blood supply, and to many drugs which powerfully affect reflex actions.

Through the central nervous organ the travel of the impulse exhibits departure from these features. Its intensity is liable to be altered in transit. Its time of transit is much longer than for a similar length of nerve-trunk. Its direction of transmission becomes polarized, that is, confined to one direction along the nervous path. To a strong stimulus the central reaction instead of being as brief as an impulse, may endure for a whole second or more. A stimulus not capable of evoking a response from a centre when applied once may by simple repetition become effective (temporal summation). It is in the grey matter that conduction differs in these respects from conduction in nerve-trunks. In the grey matter each afferent fibre breaks up into branching threadlets which ramify in various directions and terminate in close apposition with other neurones. The point of nexus of one neurone with another is termed the synapse. If synapsis occurs by contiguity and not homogeneous continuity, it is fair to suppose that at it the transmission of nervous impulses must be different from that observable in the homogeneous conducting threads of nerve fibres. The conduction must traverse something of the nature of a membrane.

Reflex Reactions.—When the spinal cord is severed at any point the reflex arcs of the portion of the body behind the transection are quite cut off from the rest of the nervous system in front, including the brain. The reflex reactions elicited from the thus isolated region cannot therefore be modified by the action of the higher nervous centres. In the head the local centres are overlaid by higher centres which cannot by any simple severance be separated from them. By studying, therefore, the powers of the cord behind a complete spinal transection we can obtain information as to the powers of the purely local or segmental reflex mechanisms.

The so-called "flexion-reflex" of the limb is one of the most accessible of the local reflex reactions which can thus be studied with an isolated portion of the spinal cord as its centre.

Let it be supposed that the limb observed is the hind limb. The three main joints of the limb are the hip, the knee and the ankle Each of these joints is provided with muscles which flex or bend it, and others which extend or straighten it. It is found that the reflex throws into contraction the flexor muscles of each of these joints. It matters little which of all the various afterent nerves of the limb is stimulated, whichever of these the afferent nerve may be, the centrifugal discharge goes to practically the same muscles, namely, always to the flexors of the joints.

Not only does the reflex action not discharge motor impulses into the nerves of the extensor muscles, but if the spinal cord happens to be discharging impulses into these nerves when the reflex is evoked this discharge is suppressed or diminished (inhibited). In this way the latter muscles are prevented from impeding the action of the contracting flexors. This inhibition prevents other reflexes from upsetting for the time being the due action of the flexion-reflex, for it renders the muscles opposing that reflex less accessible to motor discharge through the spinal cord whatever the quarter whence incitation to that discharge may come.

A feature of this reflex is its graded intensity A weak stimulus evokes in the flexor muscles a contraction which is weak and in the extensor muscles a relaxation which is slight. In the case of the muscle-fibre any strength of stimulus if sufficient to excite it at all excites the fibre totally and evokes its full contraction (Keith-Lucas) and this latter remains the same in amount so long as the mechanical and nutritive conditions of the fibre remain constant. Each muscle-fibre reacting on this "all-or-none" principle and each nerve-fibre similarly responding on that same principle (Kato), different amounts of contraction yielded by the muscle under different strengths of stimulation of its nerve signify differences simply in the number of muscle-fibres which the stimulus excites. In other words the weaker stimuli excite fewer of the nerve-fibres innervating the muscle. When the tension developed by the muscle, e.g., against a stiff spring, reaches the maximal obtainable from it, that fact tells us that all the muscle-fibres are then in contraction; when the tension development is less than maximal some of the muscle-fibres are not in action. A stimulus to the nerve which evokes maximal tension from the muscle is one which succeeds in exciting all the nerve-fibres innervating the muscle, and any stimulus which evokes less than maximal tension is leaving some of the nerve-fibres "idle."

The tension developed by a muscle under reflex excitation falls short of its maximal tension, even when the afferent nerve is stimulated maximally. The reflex activates a proportion only of the total aggregate of the muscle's fibres, and therefore a proportion only of the spinal motor neurones innervating the muscle. But within the range of the limit imposed by the maximal number of muscle-fibres which it can activate, the grading of the number activated in accordance with the grading of the strength of stimulation of the afferent nerve is very delicate, much more so than in the case of the motor nerve itself. The actual fractional proportion of the muscle's total aggregate of motor units which an afferent nerve, maximally stimulated, can activate, differs from one afferent nerve to another, and for the same afferent nerve in different experiments. A subconvulsive dose of strychnine raises the size of the fraction. The threshold value of stimulus for the reflex is usually higher than for the contraction of the muscle from the motor nerve. Spinal reflex action no more regards 'muscles" than does a motor centre of the cerebral cortex. Both ignore muscles as entities and have in view movements purely. A weak flexion-reflex activates a few fibres of each of the several flexor muscles of the limb. The reflex treats a complex composed from some (i.e., those of similar threshold for the particular afferent nerve) motor-units of hip-flexor, of knee-flexor and of ankle-flexor as functionally more homogeneous than is the total group of fibres composing any one of these muscles alone.

Reflex inhibition has its seat in the grey matter of the spinal centre. It acts at some point in the reflex arc up-stream from

the all-or-none motor unit (motor nerve-fibre with its group of hind limbs of the "spinal" frog assume an attitude which is reflex, muscle-fibres). The inhibitory reflex is like the excitatory capable of very delicate grading; its effect in diminishing or precluding this or that amount of an excitatory reflex is effected entirely by regulating the number of the motor units thrown out of action or kept out of action. Intensity of contraction or of relaxation is thus in both cases a question simply of number of motor-units reacting. The reflex centre continues discharging impulses for a certain time after its exciting stimulus has ceased. This afterdischarge succeeding a strong stimulus may persist even for several seconds.

Refractory Phase.-Besides characters common to all or many spinal reflexes certain spinal reflexes have features peculiar to themselves or exhibited by them in degrees not obvious in other reflexes One of these features is refractory phase. The scratchreflex exemplifies this. In the dog, cat and many other animals the hind limb often performs a rapid scratching movement, the foot being applied to the skin of the shoulder or neck as if to groom the hairy coat in that region. This movement is in the intact animal under control of the brain, and can be executed or desisted from at will. When certain of the higher centres in the brain have been destroyed, this scratching action occurs very readily and in an uncontrolled way. When the spinal cord has been severed in the neck this scratching movement of the hind limb can be elicited with regularity as a spinal reflex by merely rubbing the skin of the side of the neck or shoulder, or applying there a weak electric current to the skin. In this reflex the stimulus excites afferent nerves connected with the hairs in the skin and these convey impulses to the spinal centres in the neck or shoulder segments, and these in turn discharge impulses into nerve fibres entirely intraspinal passing backward along the cord to reach motor centres in the hind limb region. These motor centres in turn discharge centrifugal impulses into the muscles of the hind limb of the same side of the body as the shoulder which is the seat of irritation. The motor discharge is peculiar in that it causes the muscles of the hind limb to contract rhythmically at a rate of about four contractions per second, and the discharge is peculiar further in that it excites the flexor and extensor muscles of the joints alternately so that at the hip for instance the limb is alternately flexed and extended, each single phase of the movement lasting about an eighth of a second. Now this rhythmic discharge remains the same in rate whether the exciting stimulus applied to the skin be continuous or one of many various rates of repetition. Evidently at some point in the reflex arc there is a mechanism which after reacting to the impulses reaching it remains for a certain brief part of a second unresponsive, and then becomes once more for a brief period responsive, and so on. And this phasic alternation of excitability and inexcitability repeats itself throughout the continuance of the reflex. The phase of inexcitability is termed the refractory phase. Its seat lies in the spinal centre. A similar element almost certainly forms part of the co-ordinating mechanism for many other cyclic reflexes, including those of the stepping of the limbs, the movement of the jaw in mastication, the action of the eyelids in blinking, and perhaps the respiratory movements of the chest and larynx.

Fatigue.-Nerve trunks do not easily tire out under stimulation even most prolonged. Reflex actions on the other hand relatively soon tire. Some are more resistant, however, than are others. The flexion-reflex may be continued for ten minutes at a time. As a reflex tires, the muscular contraction which it causes tends to become less intense and less steady. The relatively rapid onset of fatigue in reflexes is counterbalanced by speedy recovery in repose. A long flexion-reflex, when from fatigue it has become weak, tremulous and irregular, will recommence after 30 seconds' repose with almost the same vigour and steadiness as if it had not recently been tired out.

The natural movements to which the artificially provoked reflexes seem to correspond do not demand prolonged motor activity, or when they do, demand it in rhythmic repetition with intervening pauses which allow repose.

Reflex Postures.-But there are certain reflexes which do persist for long periods at a time. These are reflex postures. The

for it ceases on severance of the afferent spinal roots. This attitude is one of flexion at hip, knee and ankle, resembling the wellknown natural posture of the frog as it squats when quiet in the tank. Similarly in the "decerebrate" dog or cat certain muscles, e.g., the limb extensors, exhibit a persistent contraction. These tonic reflexes are related to attitudes. In the dog and cat they are exhibited by those muscles whose action antagonizes gravity in postures which are usual in the animal, thus the extensors of the knee and hip and shoulder and elbow are in tonic contraction during standing. The postural contraction is accompanied by electrical "action currents" like those of other contraction, though weak and indicative of self-smothering from the rhythms being asynchronous in the contributory fibre-groups. The postural contraction of the extensor muscles in the maintenance of the erect posture is traceable to a reflex, called the stretch-reflex. A stretch, e.g., by a pull upon the tendon, lengthening the muscle by even so little as 1%, excites reflex contraction of some of its fibres. The passive stretch is a mechanical stimulus to some of the proprioceptive organs (perhaps the muscle-spindles) in the muscle. The reflex is therefore unobtainable when the afferent nerve-fibres of the muscle itself have been severed. The essential centre for the stretch-reflex is spinal, but mid-brain and cerebellar centres much reinforce it. In the erect posture the head, neck, tail and jaw would droop and the limbs fold up under their own weight and that of superincumbent parts, were not the "antigravity muscles checked from yielding by the stretch-reflex which their own passive yield induces in themselves. Hence the reflexly maintained "standing" is a multiple stretch-reflex. Considerable latitude of actual pose is allowed to the individual parts because each muscle involved acts for itself and develops and regulates its own stretch-reflex.

Characteristic of reflex postural contraction is its continuance for long spells at a time without obvious fatigue. Attempts are uniformly unsuccessful to reproduce this feature by electrical stimulation of afferent nerves or of the muscle's motor nerve. The suggestion has therefore been made that the postural contraction of muscle is due to a different process in the muscle-fibre from that of the ordinary contraction executing movements and so easily and often studied under electrical stimulation in the laboratory. Forbes, however, has offered the satisfactory explanation that the postural contraction while the same process as that of ordinary reflex and other contraction involves usually relatively few motor units at a time and these as they fatigue, are replaced by others. The stretch which is the essential stimulus is automatically shifted to fresh motor-units so soon as those already in operation begin to yield and give out. Grafted, as it were, upon the reflex maintenance of the erect-posture are reflexes of locomotion which are also certainly spinal in essence, and essentially proprioceptive. The hind-limbs of the dog, after severance of the cord in the thoracic region, begin to step when released from the ground. Their stepping will go on sometimes quicker and sometimes slower for long periods at a time. Kinematograph analysis of this spinal stepping shows that it is identical with normal stepping except for a slight flexional yield when the limb is vertically on the ground in the normal step. Passively supported mid-flexion of knee and hip even of one hind limb alone at once causes the spinal reflex stepping to cease, in both limbs usually. The proprioceptive stimulus of the spinal stepping may therefore be the passive stretching of the hip and knee-flexor. From observations on stepping under narcosis Graham Brown regards the essential factor in "spinal" stepping to be the intrinsic activity of a "spinal stepping" centre or "centres." Certainly it is not uncommon for an extensor muscle of the limb in isolated attachment to the myograph and after its own afferent nerve fibres have been wholly destroyed and after all the other muscles of the limb have been put out of play by excision of nerve-section to start stepping on its own accord in the bulbospinal preparation. Skin stimuli, for instance, the contact of the sole with the ground. are not necessary for the reflex stepping. On the other hand the ground pressure against the toe pads and plantar cushion seems an important factor in the gallop-indeed the sudden brief though strong and almost simultaneous extension of all four limbs in the gallop can in the spinal animal be evoked by pressure simulating the ground pressure, and when applied even to one hind foot only.

The eyeballs are eminently organs which, the gaze being a posture, employ active postures throughout the waking day. The proprioception of the neck-muscles excites from the cervical spinal cord reflex influences acting on the nerves of the eyeball muscles. An instance is: turning of the neck toward one side. Or again, a clockwise partial rotation of the neck round its long axis excites from the neck proprioceptor a compensatory anti-clockwise rotation of the eyeballs. These reflex postures of the eyeballs are sometimes called compensatory, because they tend to keep truly vertical the vertical of the retina despite displacements of the head by the movements of the neck.

It may be mentioned here that the spinal and the bulbospinal animal (cat) although its composite stretch-reflex enables it when placed in the erect posture to maintain that attitude, even for hours at a time, is yet not capable of assuming that posture when laid, for instance, on its side. But when the mid-brain is retained in addition to hind-brain and cord the animal has that power of righting itself. These righting reflexes are likewise postural and largely evoked by the otolith organs. Although not truly spinal reflexes their field of nervous operation overruns into the spinal cord.

The Spinal Reflex Arcs of the Hind Limb.—When the skin of the limb is stimulated the flexion-reflex already described is evoked. The reflex is excited by nocuous stimuli such as a prick or squeeze applied to the skin anywhere in the limb, but most easily when applied to the foot. The reflex flexion of the ipsilateral hind limb is commonly accompanied by reflex extension of the opposite hind limb.

In the dog and cat extension of the ipsilateral hind limb can, however, be excited by stimulation of the skin in three limited regions. One of these is the sole of the foot; smooth pressure between the pads excites a strong brief extension. This is called the extensor thrust. It is accompanied by a similar sudden brief extension of all three other limbs. This reflex may be related to the action of galloping, and the pressure which excites resembles that which the weight of the body bears on the pads against the ground

The two other regions are the skin of the front of the groin supplied by the crural branch of the genito-crural nerve, and the skin just below and mesial to the buttock. These always excite the extensor muscles, not the flexors. They may be concerned with sexual acts.

Reflexes of the Fore Limb.—The ipsilateral reflex is flexion at shoulder, elbow and wrist. The contralateral fore limb at the same time is extended at shoulder, elbow and wrist.

The Scratch Reflex.—The area from which it can be excited extends from the ear to the loin. Each of these reflexes is a coordinate reaction. It is seen, therefore, that through the medium of the spinal cord the body behind the head has at command a certain number of reflexes and that each of these manages the skeletal musculature in a co-ordinate way. The muscles worked by these several reflexes are to a large extent common to them all. Some resemble one another in regard to their action upon a particular muscle. Some act in opposite ways upon a particular nuscle. In order to follow the co-ordination effected by the spinal cord we have to turn to a certain feature in the scheme of construction of the nervous system. This feature embodies what is termed the principle of the common path.

Interaction Between Reflexes.—At the commencement of every reflex-arc is a receptive neurone extending from the receptive surface to the central nervous organ. This neurone forms the sole avenue which impulses generated at its receptive point can use whithersoever be their destination. This neurone is therefore a path exclusive to the impulses generated at its own receptive point, and other receptive points than its own cannot employ it. A single receptive point may play reflexly upon quite a number of different effector organs. It may be connected

through its reflex path with many muscles and glands in many different regions. Yet all its reflex arcs spring from the one single shank or stem, i.e., from the one afferent neurone which conducts from the receptive point at the periphery into the central nervous organ.

But at the termination of every reflex arc we find a final neurone, the ultimate conductive link to an effector organ (muscle or gland). This last link in the chain, e.g., the motor neurone, differs obviously in one important respect from the first link of the chain. It does not subserve exclusively impulses generated at one single receptive source, but receives impulses from many receptive sources situate in many and various regions of the body. It is the sole path which all impulses, no matter whence they come, must travel if they are to act on the muscle fibres to which it leads.

Therefore, while the receptive neurone forms a private path exclusively serving impulses of one source only, the final or efferent neurone is, so to say, a public path common to impulses arising at any of many sources of reception. A receptive field, e.g., an area of skin, is analysable into receptive points. One and the same effector organ stands in reflex connection not only with many individual points, but even with many various receptive fields. Reflexes generated in manifold sense-organs can pour their influence into one and the same muscle. Thus a limb muscle is the terminus ad quem of many reflex arcs arising in many various parts of the body. Its motor nerve is a path common to all the reflex arcs which reach that muscle.

Reflex arcs show, therefore, the general features that the initial neurone of each is a private path exclusively belonging to a single receptive point (or small group of points); and that finally the arcs embouch into a path leading to an effector organ; and that their final path is common to all receptive points wheresoever they may lie in the body, so long as they have connection with the effector organ in question. Before finally converging upon the motor neurone the arcs converge to some degree. Their private paths embouch upon internuncial paths common in various degrees to groups of private paths. The terminal path may, to distinguish it from internuncial common paths, be called the final common path. The motor nerve to a muscle is a collection of final common paths.

Certain consequences result from this arrangement. One of these is the preclusion of essential qualitative difference between nerve-impulses arising in different afferent nerves. If two conductors have a tract in common there can hardly be essential qualitative difference between their modes of conduction.

A second consequence is that each receptor being dependent for final communication with its effector organ upon a path not exclusively its own but common to it with certain other receptors, such nexus necessitates successive and not simultaneous use of the common path by various receptors using it to different or opposed effect.

In the simultaneous correlation of reflexes some reflexes combine harmoniously, being reactions that mutually reinforce. These may be termed allied reflexes, and the neutral arcs which they employ allied arcs. On the other hand, some reflexes, as mentioned above, are antagonistic one to another and incompatible. These do not mutually reinforce, but stand to each other in inhibitory relation. One of them inhibits the other.

Allied Reflexes.—What happens when trains of impulses, travelling by convergent afferent arcs, meet at the same "common path?" With convergent reflexes which are "allied" in the above sense, this case must be one of extremely frequent occurrence and the management of the interaction between the convergent streams of impulses must be a fundamental factor in nervous co-ordination. The afferent path A embouches upon the intraspinal motor neurones of the knee-flexor and can activate 75% of them. The afferent path B embouches also upon the motor neurones of the same muscle and can activate 75% of them. When the muscle is reflexly contracting to A with a tension 75% of that of the muscle's maximal contraction, stimulation of B is added. The contraction tension in result rises to 85% of the maximal. The inference is that for 65% of the total motor units

of the muscle the excitation from A acts upon the same motor units as would that from B. In other words 65% of the total aggregate of the motor units of the muscle are common to A and to B. The stream of impulses arriving at these common motor-units from B when A's stream is already activating them leaves their activity unchanged, failing either to increase or to diminish it. A's stream, which is engaging them, precludes B's stream from engaging them. This is termed occlusion. We may turn from the case of the group to that of the single individual unit. Suppose a to be a train of impulses reaching a central terminal of path A and impinging upon a motor-unit  $\mu$  and activating it. Suppose  $\beta$  similarly a train impinging by one of path B's terminals upon the same motor unit µ already activated by a It has been argued that the resultant response of  $\mu$  to the double series of impulses impinging on it will show interference and interruption and unsteadiness from "inhibition," the impulses generated by the one train interfering with those generated by the other owing to the refractory phase following in the wake of each impulse. Experiment fails to substantiate such unsteadiness or other evidence of "interference inhibition" even when the impulse trains are each of them at 180 p. sec. Experiment in fact finds the reverse; the resultant contraction being steadier and more durable under the concurrent excitation of A and B than under either alone. An important kind of observation is the following, since it shows clearly that, against the interference view above, "occlusion" is not inhibition. An afferent A activates 50% of a given muscle's motor units. An afferent B activates a still larger percentage of the muscle's motor units. When afferent B is already activating the muscle the stimulation of A causes no outward result on the muscle, but if B's stimulus be then withdrawn A's continuing, the contraction at once falls to and remains at 50% of maximal. A's activation was occluded by B's already existent one, but there was no inhibition. A's activation was occluded throughout the large field amounting to 50% of the total aggregate of the motor units. Yet that not a single motor unit was inhibited, has been experimentally established by taking for B one of the relatively rare afferents which activate 100% of the muscle. Since B is then activating every motor unit it cannot be supposed that lack of A's effect when A is concurrently stimulated is due to inhibition of A's 50% of the motor units; for that would suppose those motor units to be at one and the same time both active and inhibited. The mutual support that the two trains yield each other in the actually observed result argues the immediate replacement of B's effect by A's when B's lapses or intermits: and vice versa. That this would be so is borne out by other observations. Where, during the concurrence of A and B, A's effect has been occluding B from activating, on abruptly ceasing to stimulate A, so that B remains under stimulation alone, B which has till then been ineffective owing to occlusion, at once appears as effective and without hesitation or pause replaces that of A step for step as A's after-discharge subsides. The final common path under this competition of allied arcs is comparable with a telephone line already "busy" for one subscriber and for that time "engaged" and non-available to other subscribers. The action of the principle of the final common path may be instanced in regard to "allied arcs" in the scratch-reflex as follows. If, while the scratch-reflex is being elicited from a skin point at the shoulder, a second point distant romm, from the other point but also in the receptive field of skin, be stimulated, the stimulation at this second point favours the reaction from the first point. This is well seen when the stimulus at each point is of subminimal intensity. The two stimuli, though each unable separately to invoke the reflex, yet do so when applied both at the same time. The "receptive field" of a reflex is really the common area of commencement of a number of allied arcs.

Antagonistic Reflexes.—But not all reflexes connected to one and the same common final path stand to one another in the relation of "allied reflexes." Suppose during the scratch-reflex a stimulus be applied to the foot not of the scratching side, but of the opposite side. The left leg, which is executing the scratch-reflex in response to stimulation of the left shoulder skin is cut short in its movement by the stimulation of the right foot. al-

though the stimulus at the shoulder to provoke the scratch movement is maintained unaltered all the time. The stimulus to the right foot will temporarily interrupt a scratch-reflex, or will cut it short or will delay its onset; which it does of these depends on the time-relations of the stimuli. The inhibition of the scratchreflex occurs sometimes when the contraction of the muscles innervated by the reflex conflicting with it is very slight. There is interference between the two reflexes and the one is inhibited by the other.

The reflex from the right foot evokes at the opposite (left) knee extension; in doing this it causes steady excitation of extensor neurones of that knee and steadily inhibits the flexor neurones. But the scratch-reflex causes rhythmic excitation of the flexor neurones. Therefore these flexor neurones in this conflict lie as a final common path under the influence of two antagonistic reflexes, one of which would excite them to rhythmical discharge four times a second, while the other would continually repress all discharge in them.

In all these forms of interference there is a competition, as it were, between the excitatory stimulus used for the one reflex and the excitatory stimulus for the other. Both stimuli are in progress together, and the one in taking effect precludes the other's taking effect as far as the final common path is concerned.

Again, if, while stimulation of the skin of the shoulder is evoking the scratch-reflex, the skin of the hind foot of the same side is stimulated, the scratching may be arrested. Stimulation of the skin of the hind foot by any of various stimuli that have the character of threatening the part with damage causes the leg to be flexed, drawing the foot up by steady maintained contraction of the flexors of the ankle, knee and hip. Here, therefore, there is an arc which embouches into a final path, common to it and to the scratch-reflex arc; both these arcs employ the same effector organ, namely, the knee-flexor, and employ it by the common medium of the final path FC. But though the channels for both reflexes embouch upon the same final common path, the excitatory flexor effect specific to each differs strikingly in the two cases. In the scratch-reflex the flexor effect is an intermittent effect; in the noci-ceptive flexion-reflex the flexor effect is steady and maintained. The scratch-reflex is set aside by that of the noci-ceptive arc from the homonymous foot.

The stimulation which previously sufficed to provoke the scratch-reflex is no longer effective, though it is continued all time. But when the stimulation of the foot is discontinued the scratch-reflex returns. In that respect, although there is no enforced inactivity, there is an interference which is tantamount to, if not the same thing as, inhibition. Though there is no cessation of activity in the motor neurone one form of activity that was being impressed upon it is cut short and another takes its place. A stimulation of the foot too weak to cause more than a minimal reflex will often completely suffice to interrupt, or cut short, or prevent onset of, the scratch-reflex

The kernel of the interference between the homonymous flexion-reflex and the scratch-reflex is that both employ the same final common path FC to different effect—just as in the interference between the crossed extension-reflex and the scratch-reflex. Evidently, the homonymous flexion-reflex and the crossed extension-reflex both use the same final common path FC. And they use it to different effect. The motor neurone to the flexor of the knee being taken as a representative of the final common path, the homonymous flexion-reflex inhibits it from discharging. Hence if, while the direct flexion-reflex is in progress, the crossed foot is stimulated, the reflex of the knee-flexor is inhibited. The crossed extension reflex therefore inhibits not only the scratch-reflex, but also the homonymous flexion-reflex.

Further, in all these interferences between reflexes the direction taken by the inhibition is reversible. Thus, the scratch-reflex is not only liable to be inhibited by, but is itself able to inhibit either the homonymous flexion-reflex or the crossed extension-reflex; the homonymous flexion-reflex is not only capable of being inhibited by the crossed extension-reflex, but conversely in its turn can inhibit the crossed extension-reflex. These interferences are therefore reversible in direction. Certain conditions

determine which reflex among two or more competing ones shall mere repose of the reflex centre, the repose so recruiting the obtain mastery over the final common path and thus obtain centre as to strengthen its subsequent action. But a similar expression.

Here of the reflex centre, the repose so recruiting the centre as to strengthen its subsequent action. But a similar of the reflex centre, the repose so recruiting the obtain mastery over the final common path and thus obtain centre as to strengthen its subsequent action. But a similar centre as to strengthen its subsequent action.

As to the intimate nature of the mechanism which thus, by summation or by interference, gives co-ordination where neurones converge upon a common path, it is difficult to surmise. In the central nervous system of vertebrates, afferent neurones A and B in their convergence toward and impingement upon another neurone Z, towards which they conduct, do not make any lateral connection directly one with the other—at least, there seems no clear evidence that they do. It seems, then, that the only structural link between A and B is neurone Z itself. Z itself should therefore be the field of coalition of A and B if they transmit "allied" reflexes.

Factors Determining the Sequence.—The formation of a common path from tributary converging afferent arcs is important because it gives a co-ordinate mechanism. There the dominant action of one afferent arc, or set of allied arcs in condominium, is subject to supersession by another afferent arc, or set of allied arcs, and the supersession normally occurs with-

out intercurrent confusion.

Whatever be the nature of the physiological process occurring between the competing reflexes for dominance over the common path, the issue of their competition, namely, the determination of which one of the competing arcs shall for the time being reign over the common path, is largely conditioned by four factors. These are spinal induction, relative fatigue, relative intensity of stimulus, and the functional species of the reflex.

r. Induction occurs in two forms, one of which has been named immediate induction. The stimulus which excites a reflex tends by central spread to facilitate and lower the threshold for reflexes allied to that which it particularly excites. A constellation of reflexes thus tends to be formed which reinforce each other, so that a reflex figure results. If the prepotent stimulus shifts, allied arcs are by the induction particularly prepared to be responsive to it or to a similar stimulus.

Immediate induction only occurs between allied reflexes. Its tendency in the competition between afferent arcs is to fortify the reflex just established, or, if transition occur, to favour transition to an allied reflex. Immediate induction seems to obtain with highest intensity at the outset of a reflex, or at least near its commencement.

The other form of spinal induction is successive induction. It is in several ways the reverse of the preceding. If the crossed-extension reflex of the limb of the "spinal" dog be elicited at regular intervals, say once a minute, by a carefully adjusted electrical stimulus of defined duration and intensity, the resulting reflex movements are repeated each time with much constancy of character, amplitude and duration. If in one of the intervals a strong prolonged (e.g., 30") flexion-reflex is reduced from the limb yielding the extensor-reflex movement, the latter reflex is found intensified after the intercurrent flexionreflex. The intercalated flexion-reflex lowers the threshold for the aftercoming extension-reflexes, and especially increases their after-discharge. This effect may endure, progressively diminishing, through four or five minutes, as tested by the extensor reflexes at successive intervals. Now, as we have seen, during the flexion-reflex the extensor arcs were inhibited: after the flexionreflex these arcs are in this case evidently in a phase of exalted excitability. The phenomenon presents obvious analogy to visual contrast. The exaltation after-effect may ensue with such intensity that simple discontinuance of the stimulus maintaining one reflex is immediately followed by "spontaneous" appearance of the antagonistic reflex.

The so-called "mark-time" reflex of the "spinal" dog is an alternating stepping movement of the hind limbs which occurs on holding the animal up so that its limbs hang pendent. It can be inhibited by stimulating the skin of the tail. On cessation of that stimulus the stepping movement sets in more vigorously and at quicker rate than before. This after-increase might be explicable in either of two ways. It might be due to the

mere repose of the reflex centre, the repose so recruiting the centre as to strengthen its subsequent action. But a similar period of repose obtained by simply supporting one limb—which causes cessation of the reflex in both limbs, the stimulus being stretch of the hip-flexors under gravity—is not followed by after-increase of the reflex, or the after-increase might result from the inhibition being followed by a rebound to super-activity. This latter seems to be the case. The after-increase occurs even when both hind limbs are passively lifted from below during the whole duration of the inhibitory stimulus applied to the tail. And the reflex inhibition of the knee-extensor by stimulation of the central end of its own nerve is followed by marked rebound to superactivity of the extensor itself Again, the knee jerk, after being inhibited by stimulation of the hamstring nerve, is more brisk than before the inhibition.

By virtue of this spinal contrast, therefore, the extensionreflex predisposes to and may actually induce a flexion-reflex, and conversely the flexion-reflex predisposes to and may actually induce an extension-reflex. This process is qualified to play a part in linking reflexes together in alternating sequence

Much of the reflex action of the limb that can be studied in the "spinal" dog bears the character of locomotion. This has been shown recently with particular clearness by the observations of Phillipson. In the stepping of the limb the flexion that raises the foot and carries it clear of the ground prepares the antagonistic arcs of extension, and, so to say, sensitizes them to respond later in their turn by the supporting and propulsive extension of the limb necessary for progression. The reflex "stepping" of the "spinal" dog proceeds without an external skin stimulus: it will continue when the dog is held in the air. The cat walks well when all four feet are anæsthetized.

A reflex movement must generate in its progress a number of further stimuli and throw up a shower of centripetal impulses from the moving muscles and joints into the spinal cord. Squeezing of muscles and stimulation of their afferent nerves and those of joints, etc., elicit reflexes. The primary reflex movement might be expected, therefore, of itself to initiate further reflex movement, and that secondarily to initiate further still, and so on Yet on cessation of the external stimulus to the foot in the flexion-reflex the whole reflex comes usually at once to an end. The scratch-reflex, even when violently provoked, ceases usually within two seconds of the discontinuance of the external stimulus that provoked it. We have as yet no satisfactory explanation of this

2. Another condition influencing the issue of competition between reflexes of different sources for possession of one and the same final common path is fatigue. A spinal reflex under continuous excitation or frequent repetition becomes weaker, and may cease altogether. This decline is progressive, and takes place earlier in some kinds of reflexes than it does in others. In the "spinal" dog the scratch-reflex under ordinary circumstances tires much more rapidly than does the flexion-reflex.

A reflex as it tires shows other changes besides decline in amplitude of contraction. Thus in the flexion-reflex, the original steadiness of the contraction decreases; it becomes tremulous, and the tremor becomes progressively more marked and more irregular. Finally, an irregular phasic tremor of the muscles is all that remains. It is not the flexor muscles themselves which tire out, for these, when under fatigue of the flexion-reflex contract no longer for that reflex, contract in response to the scratch-reflex which also employs them.

Similar results are furnished by the scratch-reflex, with certain differences in accord with the peculiar character of its individual charge. One of these latter is the feature that the individual beats of the scratch-reflex usually become slower and follow each other at slower frequency. Also the beats, instead of remaining fairly regular in amplitude and frequency, tend to succeed in somewhat regular groups. The beats may disappear altogether for a short time, and then for a short time reappear.

When the scratch-reflex elicited from a spot of skin is fatigued, the fatigue holds for that spot, but does not implicate the reflex as obtained from the surrounding skin. The reflex is, when tired out to stimuli at that spot, easily obtainable by stimulation two or

more centimetres away.

The local fatigue of a spinal reflex seems to be recovered from with remarkable speed. A few seconds' remission of the stimulus suffices for marked though incomplete restoration of the reaction. Fatigue seems a process elaborated and preserved in the selective evolution of the neural machinery. One obvious use attaching to it is the prevention of the too prolonged continuous use of a common path by any one receptor It precludes one receptor from occupying for long periods an effector organ to the exclusion of all other receptors. It prevents long continuous possession of a common path by any one reflex of considerable intensity. It favours the receptors taking turn about It helps to ensure serial variety of reaction. The organism, to be successful in a million-sided environment, must in its reaction be many sided Were it not for such socalled fatigue, an organism might, in regard to its receptivity, develop an eye, or an ear, or a mouth, or a hand or leg, but it would hardly develop the marvellous congeries of all those various senseorgans which it is actually found to possess.

The final efferent-root neurone forms the instrument for many different reflex arcs and acts. It is responsive to them in various rhythms and in various grades of intensity. In accordance with this, it seems from experimental evidence to be relatively inde-

fatigable.

3 In the transition from one reflex to another a final common path changes hands and passes from one master to another. A fresh set of afferent arcs becomes dominant on the supersession of one reflex by the next. Of all the conditions determining which one of competing reflexes shall for the time being reign over a final common path, the intensity of reaction of the afferent arc itself relatively to that of its rivals is probably the most powerful. An afferent arc that strongly stimulates is caeteris paribus more likely to capture the common path than is one excited feebly. A stimulus can only establish its reflex and inhibit an opposed one if it have intensity. This explains why, in order to produce examples of spinal inhibition, recourse has so frequently been made in past times to strong stimuli. A strong stimulus will inhibit a reflex in progress although a weak one will fail. Thus in inhibition of micturition in the "spinal" dog a forcible squeeze of the tail will do it, but not a weak squeeze. So, likewise, any condition which raises the excitability and responsiveness of a nervous arc will give it power to inhibit other reflexes, just as it would if it were excited by a strong stimulus.

Crossed reflexes are usually less easy to provoke, less reliable of obtainment, and less intense than are direct reflexes. Consequently we find crossed reflexes usually more easily inhibited and replaced by direct reflexes than are these latter by those former. Thus the crossed stepping-reflex is easily replaced by the scratch-reflex, though its stimulus be continued all the time, and though the scratch-reflex itself is not a very potent reflex. But the reverse can occur with suitably adjusted intensity of stimuli.

Again, the flexion-reflex of the dog's leg is, when fully developed, accompanied by extension in the opposite leg. This crossed extensor movement, though often very vigorous, may be considered as an accessory and weaker part of the whole reflex, of which the prominent part is flexion of the homonymous limb. When the flexion-reflex is elicitable poorly, as, for instance, in spinal shock or under fatigue or weak excitation, the crossed extension does not appear. But, where the flexion-reflex is well developed, if not merely one but both feet be stimulated simultaneously with stimuli of fairly equal intensity, steady flexion at knee, hip and ankle results in both limbs, and extension occurs in neither limb. The contralateral part of each reflex is inhibited by the homolateral flexion of each reflex. In other words, the more intense part of each reflex obtains possession of the final common paths at the expense of the less intense portion of the reflex. But if the intensity of the stimuli applied to the right and left feet be not closely enough balanced, the crossed extension of the reflex excited by the stronger stimulus is found to exclude even the homonymous flexion that the weaker stimulus should and would otherwise evoke from the leg to which it is applied.

It was pointed out above that in a number of cases the transference of control of the final common path FC from one afferent

arc to another is reversible. The direction of the transference can caeteris paribus be easily governed by making the stimulation of this receptor or that receptor the more intense. A factor largely determining whether a reflex succeed another or not is therefore intensity of stimulus.

4. A fourth main determinant for the issue of the conflict between rival reflexes seems the functional species of the reflexes. Reflexes initiated from a species of receptor apparatus that may be termed noci-ceptive appear to dominate particularly the majority of the final common paths issuing from the spinal cord. In the simpler sensations we experience from various kinds of stimuli applied to our skin there can be distinguished those of touch, of cold, of warmth and of pain. The pain ending may be regarded as adapted to a whole group of excitants, a group of excitants which has in relation to the organism one feature common to all its components, namely, a nocuous character.

With its liability to various kinds of mechanical and other damage, in a world beset with dangers amid which the individual and species have to win their way in the struggle for existence, we may regard nocuous stimuli as part of a normal state of affairs. The skin has evolved a specific sense of its own injuries. As psychical adjunct to the reactions of that apparatus we find a strong displeasurable effective quality in the sensations they evoke. may be a means for branding upon memory, of however rudimentary a kind, a feeling from past events that have been perilously critical for the existence of the individuals of the species. In other words, if we admit that damage to such an exposed sentient organ as the skin must in the evolutionary history of animal life have been sufficiently frequent in relation to its importance, then the existence of a specific set of nerves for skin-pain seems to offer no genetic difficulty, any more than does the clotting of blood or innate immunity to certain diseases. That these nerve-endings constitute a distinct species is argued by their all evoking not only the same species of sensation, but the same species of reflex movement as regards "purpose," intensity, resistance to "shock," etc. And their evolution may well have been unaccompanied by evolution of any specialized end-organ, since the naked free nerveendings would better suit the wide and peculiar range of stimuli, reaction to which is in this case required. A low threshold was not required because the stimuli were all intense, intensity constituting their harmfulness; but response to a wide range of stimuli of different kinds was required, because harm might come in various forms. That responsive range is supplied by naked nerve itself, and would be cramped by the specialization of an end-organ. Hence these nerve-endings remained free.

It is those areas, stimulation of which, as judged by analogy, can excite pain most intensely, and it is those stimuli which, as judged by analogy, are most fitted to excite pain which, as a general rule, excite in the "spinal" animal-where pain is of course non-existent-the prepotent reflexes. The nervous arcs of pain-nerves, broadly speaking, dominate the spinal centres in peculiar degree. Pain is thus the psychical adjunct of an imperative protective reflex. It is preferable, however, since into the merely spinal and reflex aspect of the reaction of these nerves no sensation of any kind can be shown to enter, to avoid the term "pain-nerves." Remembering that the feature common to all this group of stimuli is that they threaten or actually commit damage to the tissue to which they are applied, a convenient term for application to them is nocuous. In that case what from the point of view of sense are cutaneous pain-nerves are from the point of view of reflex-action conveniently termed noci-ceptive nerves.

In the competition between reflexes the noci-ceptive as a rule dominate with peculiar certainty and facility. This explains why such stimuli have been so much used to evoke reflexes in the spinal frog, and why, judging from them, such "fatality" belongs to spinal reflexes.

One and the same skin surface will in the hind limb of the spinal dog evoke one or other of two diametrically different reflexes according as the mechanical stimulus applied be of noxious quality or not, a harmful insult or a harmless touch. A needle-prick to the planta causes invariably the drawing up of the limb—the flexion-reflex. A harmless smooth contact, on the other hand,

causes extension-the extensor-thrust above described This flexion is therefore a noci-ceptive reflex. But the scratch-reflex-which is so readily evoked by simple light irritation of the skin of the shoulder-is relatively mildly noci-ceptive. When the scratchreflex and the flexion-reflex are in competition for the final neurone common to them, the flexion-reflex more easily dispossesses the scratch-reflex from the final neurone than does the scratch-reflex the flexion-reflex. If both reflexes are fresh, and the stimuli used are such as, when employed separately, evoke their reflexes respectively with some intensity, in my experience it is the flexionreflex that is usually prepotent. Yet if, while the flexion-reflex is being moderately evoked by an appropriate stimulus of weak intensity, a strong stimulus suitable for producing the scratch-reflex is applied, the steady flexion due to the flexion-reflex is replaced by the rhythmic scratching movement of the scratch-reflex, and this occurs though the stimulus for the flexion-reflex is maintained unaltered. When the stimulus producing the scratch is discontinued the flexion-reflex reappears as before.

In decerebrate rigidity, where a tonic reflex is maintaining contraction in the extensor muscles of the knee, stimulation of the noci-ceptive arcs of the limb easily breaks down that reflex. The noci-ceptive reflex dominates the motor neurone previously held in activity by the postural reflex. And noci-ceptive reflexes are relatively little depressed by "spinal shock."

Besides those receptors attuned to react to direct noxa, the skin has others, concerned likewise with functions of vital importance to the species and colligate with sensations similarly of intense affective quality: for instance, those concerned with sexual functions. In the male frog the sexual clasp is a spinal reflex. The cord may be divided both in front and behind the brachial region without interrupting the reflex. Experiment shows that from the spinal male at the breeding season, and also at other times, this reflex is elicited by any object that stimulates the skin of the sternal and adjacent region. In the intact animal, on the contrary, other objects than the female are, when applied to that region, at once rejected, even though they be wrapped in the fresh skin of the female frog and in other ways made to resemble the female. The development of the reflex is not prevented by removal of the testes, but removal of the seminal reservoirs is said to depress it, and their distension, even by indifferent fluids, to exalt it. If the skin of the sternal region and arms is removed the reflex does not occur. Severe mutilation of the limbs and internal organs does not inhibit the reflex, neither does stimulation of the sciatic nerve central to its section. The reflex is, however, depressed or extinguished by strong chemical and pathic stimuli to the sternal skin, at least in many cases. The tortoise exhibits a similar sexual reflex of great spinal potency.

It would seem a general rule that reflexes arising in species of receptors which considered as sense-organs provoke strongly affective sensation caeteris paribus prevail over reflexes of other species when in competition with them for the use of the "final common bath."

Of all reflexes it is those of ordinary posture that are the most casily interrupted by other reflexes. Even a weak stimulation of the noci-ceptive arcs arising in the foot often suffices to lower or abolish the knee-jerk or the reflex extensor tonus of the elbow or knee. If various species of reflex are arranged, therefore, in their order of potency in regard to power to interrupt one another, the reflexes initiated in receptors which considered as sense-organs excite sensations of strong affective quality lie at the upper end of the scale, and the reflexes that are answerable for the postural tonus of skeletal muscles lie at the lower end of the scale. One great function of the tonic reflexes is to maintain habitual attitudes and postures. They form, therefore, a nervous background of active equilibrium. It is of obvious advantage that this equilibrium should be easily upset, so that the animal may respond agilely to the passing events that break upon it as intercurrent stimuli.

Results.—Intensity of stimulation, fatigue and freshness, spinal induction, functional species of reflex, are all, therefore, physiological factors influencing the result of the interaction of reflexarcs at a common path. It is noticeable that they all resolve them-

selves ultimately into intensity of reaction. Thus, intensity of reflex which are habitually prepotent in interaction with others are those which are habitually prepotent in interaction with others are those which are habitually intense; those specially impotent in competition are those habitually feeble in intensity, e.g., skeletal muscular tone. The tonic reflexes of attitude are of habitually low intensity, easily interfered with and temporarily suppressed by intercurrent reflexes, these latter having higher intensity.

The high variability of reflex reactions from experiment to experiment, and from observation to observation, is admittedly one of the difficulties that has retarded knowledge of them. Their variability, though often attributed to general conditions of nutrition, or to local blood-supply, etc., seems far more often due to changes produced in the central nervous organ by its own functional conductive activity apart from fatigue. This functional activity itself causes from moment to moment the temporary opening of some connections and the closure of others. The chains of neurones, the conductive lines, have been, especially in recent years, by the methods of Golgi, Ehrlich, Apathy, Cajal and others, richly revealed to the microscope. Anatomical tracing of these may be likened, though more difficult to accomplish, to tracing the distribution of blood vessels after Harvey's discovery had given them meaning, but before the vasomotor mechanism was discovered. The blood vessels of an organ may be turgid at one time, constricted almost to obliteration at another. With the conductive network of the nervous system the temporal variations are even greater, for they extend to absolute withdrawal of nervous influence. Under reflex inhibition a skeletal muscle is relaxed to its post-mortem length, i.e., there may then be no longer evidence of even a tonic influence on it by its motor neurone. The final common path is handed from some group of a plus class of afferent arcs to some group of a minus class, or of a rhythmic class, and then back to one of the previous groups again, and so on. The conductive web changes its functional pattern with certain limits to and fro. It changes its pattern at the entrances to common paths. The changes in its pattern occur there in virtue of interaction between rival reflexes: occlusion, substitution by equivalence, inhibition, immediate induction, successive induction, fatigue, are factors. As a tap to a kaleidoscope, so a new stimulus that strikes the receptive surfaces causes in the central organ a shift of functional pattern of the linkage. The central organ is a vast network whose lines of conduction follow a certain scheme of pattern, but within that pattern the details of connection are, at the entrance to each common path, mutable. The grey matter may be compared with a telephone exchange, where, from moment to moment, though the end-points of the system are fixed, the connections between starting-points and terminal points are changed to suit passing requirements, as the functional points are shifted at a great railway junction. In order to realize the exchange at work, one must add to its purely spatial plan the temporal datum that within certain limits the connections of the lines shift to and fro from minute to minute. An example is the "reciprocal innervation" of antagonistic muscles-when one muscle of the antagonistic couple is thrown into action the other is thrown out of action. This is only a widely spread case of the general rule that antagonistic reflexes interfere where they embouch upon the same final common paths. And that general rule is part of the general principle of the mutual interaction of reflexes that impinge upon the same common path. Unlike reflexes have successive but not simultaneous use of the common path; like reflexes mutually reinforce each other on their common path. Expressed teleologically, the common path, although economically subservient for many and various purposes, is adapted to serve but one purpose at a time. Hence it is a co-ordinating mechanism and prevents confusion by restricting the use of the organ, its minister, to but one action at a

In the case of simple antagonistic muscles, and in the instances of simple spinal reflexes, the shifts of conductive pattern due to interaction at the mouths of common paths are of but small extent. The co-ordination covers, for instance, one limb or a pair of limbs. But the same principle extended to the reaction of the great arcs arising in the projicient receptor organs of the head,

 $e\,g$ , the eye, which deal with wide tracts of musculature  $as\,a$  whole, operates with more multiplex shift and wider ambit. Releasing forces acting on the brain from moment to moment shut out from activity whole regions of the nervous system, as they conversely call vast other regions into play. The resultant singleness of action from moment to moment is a keystone in the construction of the individual whose unity it is the specific office of the nervous system to perfect. The interference of unlike reflexes and the alliance of like reflexes in their action upon their common paths seem to lie at the very root of the great psychical process of "attention."

The spinal cord is not only the seat of reflexes whose "centres" lie wholly within the cord itself; it supplies also conducting paths for nervous reactions initiated by impulses derived from afferent spinal nerve, but involving mechanisms situate altogether headward of the cord in the brain. Many of these reactions affect consciousness, occasioning sensations of various kinds.

Besides the paths followed by headward-running impulses the spinal cord contains paths for impulses passing along it backward from the brain. These paths lie almost entirely in the ventrolateral columns of the cord. The fibres of which they are composed cross but little in the cord. Their sources are various, some come from the hind brain and some from the mid-brain, and in the higher mammalia, especially in man and in the anthropoid apes, a large tract of fibres in the lateral column (the crossed pyramidal tract) comes from the cortex of the neopallium of the fore brain. This last tract is the main medium by which impulses initiated by electrical stimulation of the motor cortex reach the motoneurones of the cord and through them influence the activity of the skeletal muscles.

Of the function of the other tracts descending from the brain into the cord little is known except that mediately or immediately they excite or inhibit the spinal motoneurones by various levels. How they harmonize one with another in their action or what their purpose in normal life may be is at present little more than conjecture.

Such terms, therefore, as "paths for volition," etc., are at present too schematic in their basis to warrant their discussion here.

(C. S. S.)

Bibliography.—M. Philippson, Traw, d. Lab. d. Physiol. Institut Solvay (Bruxelles, 1905); H. Head and Theodore Thompson, Brain, vol. xxix, p. 537 (1906); C. S. Sherrington, Integrative Action of the Nervous System (1906); Graham T. Brown, "Studies," Quart. Journ. Exp. Physiol., vol. xxix-vol. lxxi (1911-13); A. Forbes (with others) Amer. Journ. of Physiol., vol. xxix-vol. lxxi (1912-7); J. S. Bertioff, Quart. Journ. of Exp. Physiol., ix, p. 199 (1913); G. Riddoch, Brain, xl, p. 26a (1918); L. H. Weed, Am. Journ. of Physiol., xilii, p. 131 (1917); Cornelius Winkler, Opera Omnia, tome vi (Hairlem, 1915); F. M. R. Walshe, Brain, Ixi, p. 1 (1919) and L'Encephale, xx, p. 73 (1925); G. Riddoch and F. Butzard, Brain, Ixiv, p. 397 (1921); E. D. Adrian and J. M. D. Olmsted, Journ. of Physiol., Ivi, p. 426 (1922); A. Charlam and W. G. Penfield, Brain, xlv, p. 185 (1922); A. Forbes, Physiol. Review, ii, pp. 361-414 (1922); F. Bremer, Arch. Intern. de Physiol., xi, p. 308 (1923); E. G. T. Liddell and C. S. Sherrington, Proc. Roy. Soc. B., vol. xcv-xcvii (1923-25); G. Rossi, Arch. di Fisiol., Proc. Roy. Soc. B., vol. xcv-xcvii (1923-25); G. Rossi, Arch. di Fisiol., vol. xci-xcii (Bruxelles, 1924-25); S. Cobb, Physiol., Rev. 5, p. 5, 58 (1924); R. Magnus, Proc. Roy. Soc., 98B, p. 339-353 (1924); L. Ballif, J. F. Fulton and E. G. T. Liddell, Proc. Roy. Soc., 98B, p. 586 (1925); J. F. Fulton and E. G. T. Liddell, Proc. Roy. Soc., 98B, p. 586 (1925); J. F. Fulton, Muscular Contraction of the Reflex Control of Movement (1926).

SPINDLE TREE (Evonymus europaeus), so-called from its tough wood being formerly used for spindles, a small tree of the family Celastraceae, native to Europe and sparingly naturalized in eastern North America. The wood furnishes good charcoal. (See EVONYMUS; WAHOO.)

SPINEL, in mineralogy, the name given to a group of minerals, of the general composition R"O.R<sub>2</sub>"O<sub>3</sub>, Where R"=Mg, Fe, Mn, Zn, and R"=Al, Fe", Cr". The typical member is MgO.Al<sub>2</sub>O<sub>3</sub>, a magnesium aluminate to which the name (Fr. spinelle, from the Latin "spina," perhaps in allusion to the sharp angles of the crystals) was originally restricted. All spinels crystallize in the cubic system, typically in octahedra. Twinning is common, the octahedral face being the twin plane, giving a characteristic form known as the spinel twin.

The group of spinel minerals includes the following members: Magnesioferrite MoFe.O. MgAl<sub>2</sub>O<sub>4</sub> Magnesia spinel . FeFe<sub>2</sub>O<sub>4</sub> . (Mg,Fe) Al<sub>2</sub>O<sub>4</sub> Magnetite Gahnite . ZnAl<sub>2</sub>O<sub>4</sub> Hercynite .FeAl<sub>2</sub>O<sub>1</sub> Franklinite (Zn,Mn) Fe2O4 . (Mg,Fe) (Al,Cr)2O4 Picotite Chromite FeCr.O.

Cleavage is typically absent in these minerals with the exception of the zinc spinel (cleavage on 111), but an octahedral parting is observable in magnetite and franklinite. The hardness is variable, in ordinary spinel 7.5–8, but magnetite H=6 and chromite H=5.5. The specific gravity varies with the composition, from 3.6 (magnesia-spinel) to 5.2 (magnetite). The light refraction shows a range from 1.718 (pure MgAlaO4), hercynite 1.80, to picotite 2.05, chromite 2.10 and magnetite 2 42.

Spinels vary much in colour. Magnesia spinels are pink, red and blue, and are used as gem stones. The pure magnesia spinel is colourless, hercynite is dark green in thin slices and picotite and chromite are brown in the thinnest sections. Spinels are readily produced artificially. Magnesia spinel melts at 2135° C. and between this compound and FeAl<sub>2</sub>O<sub>4</sub> there is complete miscibility as revealed in spinel analyses, but solid solution between (Mg, Fe) Al<sub>2</sub>O<sub>4</sub> and magnetite is very limited. The spinels used in jewellery are found mostly in gem gravels, the chief localities being Ceylon, Thailand and Upper Burma.

Spinels occur both in igneous and metamorphic rocks. The home of the magnesia spinel is in thermally altered dolomites where it arises by reaction of alumina with dolomite. There it is usually accompanied by calcite and forsterite. The iron-rich member, pleonaste, is common both in ultrabasic rocks such as dunites and in quartzless argillaceous hornfelses and gneisses. In these latter it is almost universally accompanied by cordierite and frequently by sillimanite, andalusite or corundum. Hercynite is characteristic of the granulites of Saxony in association with garnet, sillimanite, etc.

The chromiferous spinel, picotite, is relegated to the ultrabasic rocks, as dunite, therzolite and the serpentines derived from them Gahnite, the zinc spinel, occurs in schists associated with zinc ores, and in pegmatites in Finland and at Broken Hill, N.S.W., while franklinite is associated with zinc and manganese minerals in limestone at Franklin Furnace, N.J. (See also Chromite; Macnetics) (C. E. T.)

SPINELLO, ARETINO (c. 1330-1410), Italian painter, the son of a Florentine named Luca, who had taken refuge in Arezzo in 1310 when exiled with the rest of the Ghibelline party, was born at Arezzo about 1330. Spinello was a pupil of Jacopo di Casentino, a follower of Giotto, and his own style was a sort of link between the school of Giotto and that of Siena. In the early part of his life he worked in Florence painting frescoes, nearly all in terra verde in the churches, the Carmine, Sta. Maria Novella and elsewhere. These works are no longer extant. Between 1360 and 1384 he was occupied in painting many frescoes in and near Arezzo, almost all of which have perished. After the sack of Arezzo in 1384 Spinello returned to Florence, and in 1387-1388 with some assistants covered the walls and vault of the sacristy of S. Miniato near Florence with a series of frescoes, the chief of which represent scenes from the life of St. Benedict. Of his later works the chief are the very fine series of frescoes painted in 1407-1408 in the Salia di Balia in the Palazzo Pubblico at Siena; these are the finest of Spinello's existing frescoes. Spinello died at Arezzo on March 14, 1410.

See Sir Dominic Colnaghi, Dictionary of Florentine Painters (1928).

SPINET or SPINNET, names given in England to all small keyboard instruments irrespective of shape, having one string to a note, plucked by means of a quill or plectrum of leather. The earliest name recorded for this instrument is clavicymbalum, which occurs in the rules of the Minnesingers (1404). In the 20th century the term "spinet" was adopted in the U.S. to describe a small upright piano. (See HARPISCHOED.)

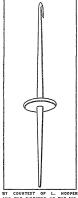
**SPINNING**, the forming of threads by drawing out and twisting various fibres. There is ample evidence of the great antiquity and wide diffusion of the art of spinning, for spinning necessarily precedes weaving (q.v.) whenever short fibrous materials

have to be made into threads, and weaving is one of the primal and most universal employments of mankind. No art which has been so long and widely practised remained so unprogressive as that of spinning. On the other hand, since about the middle of the 18th century, when human ingenuity bent itself in earnest to improve the art, there have not been developed in the whole range of mechanical industries machines of greater variety,

delicacy of action and capacity than those

now in use for spinning.

The primitive thread-making implement consisted of a wooden spindle, from 9 to 15in. long, which was rounded and tapered at both extremities, as in the accompanying figure. Near the top there was usually a notch in which the yarn was caught while undergoing the operation of twisting, and lower down a whorl, or wharve, composed of a perforated disk of clay, stone, wood, or other material was secured to give momentum and steadiness to a rotating spindle. Long fibres were commonly attached to a distaff of wood, which was held under the left arm of the operator, but short fibres were spun from carded rolls. After attaching some twisted fibres to the spindle, a rotatory motion was given to the latter either by rolling it by hand against one thigh, or by twirling it between the fingers and thumb of the right hand, after which the fibres were drawn out in a uniform strand by both hands and converted into BY COUNTEST OF L. HOOPER yarn. When the thread was of sufficient TORIA AND ALBERT MUSEUM strength, the spindle was suspended by it until a full stretch had been drawn and until a full stretch had been drawn and twisted, after which that portion was wood and was from 9in. to wound upon the body of the spindle, and 15in. long



AN EARLY SPINDLE

the operation continued until the spindle was filled. The quantity thus rolled up gives the name to a now definite measure of linen yarn, namely "the spindle," or 14,400 yards. Simple as was this primitive apparatus, a dexterous spinner could produce yarn of an evenness, strength and delicacy such as has scarcely been exceeded by elaborate modern appliances. The yarns for the gossamer-like Dacca muslins of India were so fine that r lb. weight of cotton was spun into a thread nearly 253m. long. This was accomplished with the aid of a bamboo spindle not much bigger than a darning needle, and which was lightly weighted with a pellet of clay. Since such a tender thread could not support even the weight of so slight a spindle, the apparatus was rotated upon a piece of hollow shell. The spindle as here described was, so far as is known, the sole apparatus with which yarn was spun until comparatively recent times.

Modern Spinning .- Modern changes have had for their obiect: (1) the providing of mechanical means to rotate the spindle, (2) an automatic method of drawing out the fibres, and (3) devices for working a large group of spindles together, at rapid speeds.

The first improvement consisted in cutting a ring groove in the wharve, mounting the spindle horizontally in a frame, and passing a band from a large wheel round the wharve. A rotatory motion was then given to the spindle by turning the wheel with the left hand. After attaching the filaments to the spindle they were attenuated with the right hand, and when fully twisted the thread was moved to form a right angle with the spindle and coiled upon it. Such a wheel has long been known in India, and from a drawing in a 14th-century manuscript in the British Museum it is obvious that it was not unknown, although far from being in general use, in Europe at that early date. It came ultimately to be known in England as the "bobbing wheel," and was in constant use down to the beginning of the 19th century for spinning coarse and fine yarns. But fine yarns received two spinnings; the first consisted in drawing out and slightly twisting the fibres into what is still known as a roving, and by the second spinning the roving was

fully attenuated and twisted In 1533, a citizen of Brunswick is said to have cranked the axis of the large wheel and added a treadle, by which the spinner was enabled to rotate her spindle with one foot and have both hands free to manipulate the fibres.

It is not possible accurately to fix the dates at which all improvements in spinning appliances were made; it is certain that many were known and used long before they were generally adopted Thus the flyer, which twists yarn before winding it upon a bobbin, is shown in a drawing by Leonardo da Vinci, together with a device for moving the bobbin up and down the spindle so as to effect an even distribution of the yarn. During the 16th century a machine of the foregoing type was widely used, and came to be known as the Saxony wheel. It changed spinning from an intermittent to a continuous operation The spindle had affixed upon its outer end a wooden flyer, whose forked legs were far enough apart to enclose a double-flanged spool, and at short intervals bent wires, known as the heck, were inserted in each leg for the purpose of guiding the thread evenly upon the spool. This spool was loosely threaded upon the spindle and one of its flanges was grooved to take a driving band from the large wheel, hence the spindle and the spool were separately driven, but the former at a higher speed than the latter. The twisted filaments were drawn through an eye in the flyer, led along one of its legs, and made fast to the spool. By operating the treadle the flyer twisted all the fibres about a common axis once for each revolution, and the spool wound up the length thus spun: the thread being slipped from tooth to tooth of the heck at regular intervals to direct it evenly across the spool.

The remaining part of the problem which lay before inventors was to draw out masses of parallel fibrous material, and twist them into uniform strands by mechanical means. The first stage in the evolution of mechanical spinning was effected by the invention of Lewis Paul, of Birmingham, who obtained a patent in 1738, and who was assisted by John Wyatt. The essential features of this invention consisted in passing carded slivers between pairs of parallel rollers, each succeeding pair of which moved faster than the preceding pair, to attenuate the sliver to the required extent. From Paul's specification it would appear that he attempted to turn the rollers about their horizontal and vertical axes simultaneously, in order to draw out the fibres and twist them at one operation. But he also mentions a plan for which he procured a patent 20 years later, namely, the use of only one pair of rollers working in conjunction with a bobbin which drew off the thread faster than the rollers delivered the sliver, and coiled the thread about itself. The bobbin, therefore, attenuated, twisted and wound the material. Neither plan proved a commercial success. Thomas Highs, of Leigh, and others, laboured upon the problem, but it was left to Richard Arkwright, a barber, of Preston and Bolton, to achieve what his predecessors vainly struggled for. He obtained patents, in 1769 and 1775, for a machine which was subsequently known as the water-twist frame by reason of water-power being applied to drive it. Arkwright's first machine did not contain any really new feature, for it consisted of Paul's drawing rollers, and the spindle, fiver and spool from the Saxony wheel, but the spindles and rollers were grouped in sets of four. Later the water-twist frame was changed into the "throstle" frame, which in turn has almost ceased to be used. In 1829 C. Danforth (1797-1876), an American spinner, invented a dead spindle, on the top of which he placed a hollow cap to serve as the winding point, and inside the cap he rotated a spool: a plan still used by worsted spinners. In 1828 Mr. Thorpe, also an American, invented the ring spinning frame, whose principal feature consisted in the substitution for the flyer of a flanged annular ring, and a light C-shaped traveller. By means of the traveller a thread was held in the best position for winding upon a spool, as well as put under the necessary tension. Later inventors have so altered the construction of the ring, traveller and spindle that a speed of upwards of 11,000 revolutions per minute can now be attained. This represents the highest development of continuous

Whilst endeavours were being made to perfect continuous spinning, attention was also directed to perfecting the intermittent

process as represented by the bobbing wheel. Between the years 1764 and 1767, James Hargreaves, of Standhill, invented the spinning jenny, by the aid of which 16, or more, threads could be spun simultaneously by one person. All the spindles were placed vertically and rotated from a drum, but the rovings were mounted in a movable carriage and passed between a clamp that opened and shut like a parallel ruler. After securely clamping the rovings and attaching them to the spindles, the carriage was drawn out slowly by one hand and the spindles revolved by the other. The rovings were thus stretched to the proper degree of tenuity, and sufficiently twisted. This was followed by the inward run of the carriage, when the stretch of spun threads was wound upon the spindles, and the operation repeated Hargreaves therefore returned to the first principles of spinning, viz., simultaneous drawing and twisting. But although the jenny gave a greatly increased output, it was ill adapted for fine spinning. During the years 1774 to 1779, Samuel Crompton, of Bolton, combined, in the mule, the drawing rollers of Paul with the stretching of Hargreaves. But his rollers did not fully attenuate the rovings before twisting them, as is the case with continuous spinning, neither was stretching alone relied upon. From its introduction this machine was able to spin finer and more elastic threads than any of its rivals, but for a time the preparation of suitable rovings was a source of great trouble. The immediate consequence of the decision of the court of king's bench, in 1785, to throw open to the public Arkwright's preparatory machinery, was an enormous increase in the usefulness of the mule. Since Crompton's time a host of inventors have laboured to render all parts of the mule thoroughly automatic; this has led to many changes and additions, but none of its essential features has been discarded. The inventions of Paul, Arkwright, Hargreaves and Crompton are at the foundation of all modern systems of spinning; for details regarding them see Cotton and the Cotton Industry. Cotton-Spinning and Manufacture. (T. W. F.)

SPINOLA, AMBROSE, Marquis de los Balbases (1569-1630), Spanish general, born in Genoa, then practically a protected state under the power of Spain. The family of Spinola was of great antiquity, wealth, and power, and a rival of the house of Doria for authority within the republic. Unsuccessful in a lawsuit against the Dorias, Spinola decided to advance the fortunes of his house by serving the Spanish monarchy in Flanders. In 1602, he and his brother Frederick entered into a contract with the Spanish government. It was a speculation in which Spinola risked the whole great fortune of his house. Frederick. who was to form a squadron of galleys for service on the coast, was killed in action with the Dutch (May 24, 1603). Spinola's first landing in Flanders resulted in nothing definite and he returned at the end of 1602 for more men. On Sept. 29, 1603, he laid siege to Ostend and took it on Sept. 22, 1604, winning thereby a high reputation among the soldiers of his time. A visit to the Spanish court at Valladolid, resulted in his being appointed commander-in-chief in Flanders. The wars of the Low Countries consisted at that time almost wholly of sieges, and Spinola made himself famous by the number of places he took in spite of the efforts of Maurice of Nassau to save them.

On the outbreak of the Thirty Years' War Spinola conducted a vigorous campaign in the lower Palatinate, and was rewarded by the grade of captain-general. The most renowned victory of his career-the capture of Breda after a long siege (Aug. 28, 1624-June 5, 1625)—is the subject of the great picture by Velazquez, known as "Las Lanzas"; the portrait of Spinola is from memory. The taking of Breda was the culmination of Spinola's career. The enmity of Olivares and the want of money paralysed his efforts. Appointed plenipotentiary and general in the war over the succession to the Duchy of Mantua, Spinola landed at Genoa on Sept. 19, 1629. In Italy, Olivares caused him to be deprived of his powers as plenipotentiary, and, broken down in health, he died on Sept. 25, 1630, at the siege of Casale.

n health, he died on Sept. 25, 205, h. See A. Rodríguez Villa, Ambrosio Spinola . . . (Madrid, 1905).
(D. H.)

forms: Espinoza, d'Espinoza, Despinoza, de Spinoza, and simply Spinoza. His first name was Baruch (Hebrew for "Blessed"); but, in accordance with the custom of the time, it was rendered into its Latin equivalent (Benedictus).

## THE LIFE AND WRITINGS OF SPINOZA

Early Years (1632-1654).-Spinoza was born in Amsterdam on November 24, 1632. The house in which he first saw the light, and in which he passed his early years, occupied the site of what is now No 41, Waterlooplein. His grandfather (Abraham) and his father (Michael) were Portuguese crypto-Jews, that is, descendants of Jews whom the Inquisition had compelled to embrace Christianity but who remained Jews at heart. When the Netherlands revolted against Spain and the Spanish Inquisition, in 1567, and the Union of Utrecht decreed, in 1579, that "every citizen shall remain free in his religion," many crypto-Jews in Spain and Portugal turned their eyes to Holland in the hope of finding refuge there from their common oppressors. The destruction of the Spanish Armada, in 1588, probably favoured schemes of escape. So in 1593 the first batch of Jewish refugees arrived in Amsterdam. Among these early arrivals were Spinoza's father and grandfather They hailed from Vidigueira, near Beja, in the South of Portugal, but appear to have stayed for a while in Nantes (France) before settling in Amsterdam. Spinoza's mother came from Lisbon. She died in 1638, when Spinoza was barely six years old.

The Spinozas were fairly well-to-do merchants. Spinoza's grandfather was regarded as the head of the Amsterdam Jewish community from about 1628 onwards, and Spinoza's father was Warden of his synagogue on many occasions, also Warden of the Jewish School, and President of a Jewish Charity which granted loans free of interest. Under the circumstances it may be assumed that Spinoza attended the school for Jewish boys, founded about 1638. The curriculum of this school is well known, so we have a sufficiently clear idea of Spinoza's early education The school hours were 8 till 11 A.M. and 2 till 5 P.M. The subjects were all Hebrew—the Old Testament, the Talmud, Hebrew Codes, and the works of Ibn Ezra, Maimonides, Crescas and others. Outside school hours the boys had private lessons in secular subjects. The vernacular used in the Jewish school and in Jewish homes was Spanish. Spinoza learned Latin from a German scholar, Jeremiah Felbinger, who may also have taught him German. Spanish and Portuguese Spinoza learned from his father, Dutch from his environment, and he also knew some French and Italian. When exactly he learned mathematics and physics is not known. There were plenty of Hebrew books dealing with these sciences, and the Jewish School had a good lending library, so that Spinoza may have commenced these studies during his school years. Hence probably his choice of the profession of a maker of lenses.

Of Spinoza's teachers at the Jewish School the most eminent were Saul Morteira and Manasseh ben Israel. Morteira was born in Venice in 1596, and studied medicine under Montalto, the crypto-Jewish Court physician of Maria de Medici. He came to Amsterdam in 1616, and in 1638 was elected presiding Rabbi of the Amsterdam synagogues. Manasseh ben Israel was born in Lisbon in 1604. His father was one of 150 Jews whom the Inquisition condemned to the flames in 1605. They managed to save their lives at the expense of their fortunes, and fled at the earliest opportunity. Manasseh's parents brought him to Amsterdam about 1606. In 1622 he became the youthful Rabbi of one of the Amsterdam synagogues (the "Habitation of Peace"). In 1627 he started a Hebrew printing press, and in 1640 he was appointed to one of the senior posts in the Jewish School.

In March 1654 Spinoza's father died. There was some litigation over the estate, as Spinoza's only surviving step-sister claimed it all. Spinoza won the lawsuit, but allowed her to retain nearly everything. Henceforth Spinoza had to fend for himself.

Critical Years (1654-1656).-Spinoza was in his twentysecond year when his father died. His studies so far had been mainly Jewish. But he was an independent thinker and he had SPINOZA, BENEDICTUS DE (1632-1677), Dutch philosopher and maker of lenses. The surname occurs in various orthodox theology. In the Biblical commentary by Abraham Ibn

Ezra (1092-1167) one meets with many "a word to the wise" directing attention to some inconsistency in Scripture, to the post-Mosaic authorship of parts at least of the so-called "Five Books of Moses," or to the different authorship of the two parts of Isaiah. In the Guide of the Perplexed of Moses Maimonides (1135-1204) attention is drawn to various crudities in Biblical theology, and to the provisional character of certain Biblical ordinances. In the writings of Gersonides (1288-1344) rationalism encroaches on miracles and prophecy in an attempt to eliminate the element of supernaturalism. Already Maimonides had insisted on interpreting Scripture in such a way as to harmonize it with reason. Gersonides went further than that. He faced the possibility of a conflict between Reason and Revelation, and maintained that, in such an event, the Bible "cannot prevent us from holding that to be true which our reason prompts us to believe." Again, the popular conception of the world's creation out of nothing was denied by both Ibn Ezra and Gersonides, who believed in the eternity of matter. Maimonides also repudiated the belief that man is the centre of creation, maintaining that each thing exists for its own, not for man's, sake; he also suggested the relativity of good and evil. The Jewish Mystics had taught that Nature is animated. Crescas (1340-1410) ascribed extension to God, denied the validity of the conception of final causes (or the explanation of objects and events by reference to their alleged purposes), and, like Ibn Ezra, maintained a thoroughgoing determinism. Here was food enough for thought. and incentive enough for heresy.

Moreover, the tendency to revolt against mere tradition and authority was very much in the air since the Renaissance, and it affected young Jews as others. There was the tragic figure of Gabriel da Costa, or Uriel Acosta (1585-1640). A crypto-Tewish refugee from Oporto, in Portugal, he settled in Amsterdam. He was opposed to the belief in immortality, and to various Jewish rites, on the ground that they were not Biblical. He was excommunicated by the Jewish authorities, recanted, then returned to the charge, was excommunicated again, recanted again under humiliating conditions, and shot himself. In his naturalistic outlook he was a forerunner of Spinoza. Especially interesting for the understanding of Spinoza is the case of another Jewish doctor of Amsterdam-Daniel de Prado (d. 1663). He too was opposed to supernaturalism and traditionalism, and appears to have influenced young people to adopt similar views. He was persuaded to recant in the synagogue in 1656, but there was no material change in his attitude. The synagogue authorities tried to bribe him to go abroad, but he declined, and was excommunicated in 1657. A contemporary poet, punster and protector of the faith (Isaac Orobio de Castro) wrote an invective in verse against de Prado as a philosophaster who led astray young students. Tewish and non-Tewish. Some of the allusions in this invective most probably refer to Spinoza, the record of whose excommunication faces the page in the communal minute book on which de Prado's recantation is recorded. Some of the writings of Jewish authors of the period (Samuel da Silva, Manasseh ben Israel, Orobio de Castro, etc.) in defence of immortality, revelation and tradition afford considerable evidence of the intellectual ferment in Amsterdam Jewry. And the religious leaders of the day were not particularly tactful or tolerant. They were alarmed by heresies which were at least as anti-Christian as anti-Jewish, and were afraid of giving offence in a country of which they were not yet regarded as citizens. This alarm shows itself in the attempt to bribe de Prado and Spinoza into silence. But they were also imbued with something of the intolerant spirit of the Inquisition, whose victims they had been. In 1640, they actually put the ban on Manasseh ben Israel for some trivial reason, though they rescinded it soon afterwards.

The views which brought Spinoza into collision with the synagogue authorities were essentially the same as those of Farrar, Acosta and de Prado. In conversation with other students he told them that there is nothing in the Bible to support the views that God has no body, that there really are angels (as distinguished from merely imaginative visions of them), and that the soul is immortal. He also expressed his belief that the author

of the Pentateuch was no wiser in matters pertaining to physics or even theology than they were. These utterances were reported to the Jewish authorities, who after vainly trying to silence him with bribes and threats excommunicated him in July 1656. The fact of his excommunication was formally reported to the civil authorities—a gesture intended to absolve the Jewish community from all responsibility for Spinoza's heresies. And Spinoza was banished from Amsterdam for a short period.

There is no evidence that Spinoza really wanted to break away from the Tewish community. Such evidence as there is rather points the other way. On December 5, 1655, he attended service in the synagogue and made an offering. In view of his impecuniosity, offerings must have been rare events for him, and it may be assumed that he also went to the synagogue after that date, certainly in March 1656, the anniversary of his father's death. Shortly before or after his excommunication he also addressed an Apology (or defence of his views) to the synagogue authorities. Apparently he was not entirely indifferent to their opinions of him. Possibly if Manasseh ben Israel had not been away in London at the critical time, the whole storm would have blown over. As it was, tactlessness, mischief making, alarm and intolerance were in the saddle and rode for a fall. In his 24th year Spinoza stood alone, but unafraid, and uplifted by his destiny to become one of the great lights of humanity.

Years of Re-Orientation (1656-1660).-Already before his estrangement from the synagogue Spinoza had become acquainted with a number of Christians. Among these was a certain Francis van den Enden, an ex-Jesuit and ex-bookseller, but an ardent classical scholar and something of a poet and dramatist, who opened a school in Amsterdam in 1652. For a time Spinoza stayed with Van den Enden, assisting with the teaching of the school children, and receiving help in his own further education. In this way Spinoza improved his knowledge of Latin, learned some Greek, was introduced to the Neo-Scholastic philosophy of such writers as Burgersdijck (d. 1632) and Heereboord (d. 1659), and possibly also to the works of Descartes. In any case Spinoza's other Christian acquaintances were mostly Collegiants who were especially interested in the "new philosophy" of Descartes. At the same time he was learning the science and art of making lenses, in which he became a great expert. After his excommunication Spinoza spent some weeks, or possibly months, at Ouwerkerk, a village south of Amsterdam, and then returned to his native city, where he stayed until 1660. He supported himself partly by grinding and polishing lenses for spectacles, telescopes and microscopes, and partly by helping various people with their private studies. Holland was a country of many religious sects whose friction with the predominant Calvinist clergy imparted considerable vitality to theological problems and connected philosophical questions. As all these reformation movements were, or professed to be, "back to the Bible," a knowledge of Hebrew was felt to be necessary, and Hebrew experts like Spinoza were in some demand. The same was true of philosophy as an aid to theology. Accordingly, a number of amateur theologians secured the services of Spinoza to help them with their studies, and through them he also came into contact with others. Of his friends and acquaintances during this period the most important were Pieter Balling, Jarig Jelles, Lodewijk Meyer, Simon Joosten de Vries, and Jan Rieuwertsz. The sincerity of Simon Joosten de Vries's admiration for Spinoza was shown in many ways. At one time he pressed Spinoza to accept a gift of 2,000 florins, at another time he wanted to make Spinoza his sole heir, but in vain. By his will he left Spinoza an annuity of 500 florins, but Spinoza would not accept more than 300. Some or all of these and certain others formed a kind of reading and discussion circle for the study of religious and philosophical problems under the guidance of Spinoza. At first, we may assume, Cartesian philosophy played an important part in these discussions. For at that time there was something like a coalition between the "new philosophy" and liberal, dissenting theology, for they were both opposed by the dominant Calvinists. Most of his Collegiant friends remained Cartesian to the end, though Spinoza himself never followed Descartes in anything

except his science.

To judge from the opening passage of his Treatise on the Improvement of the Understanding, which was written shortly afterwards, the years 1656 to 1660 must have been years of storm and stress in Spinoza's mental history. Cut off from kith and kin. and left stranded as the result of his honest attempt to think independently, worldly aims must have seemed at times more alluring than the beck of the spirit. But his higher self won through, partly perhaps with the help of the faith which his unsophisticated friends and disciples placed in knowledge and in him. His new orientation was accomplished by the end of this period. He had learned to view life and its problems from other angles than those of his native environment, and he had acquired a knowledge of a language and a system of concepts more suitable to serve as a vehicle for the great thoughts that were taking shape in his mind, and more suitable, too, for the wider influence which they were destined to exercise. What he needed now was peace and quiet in which to collect his thoughts and reduce them to system. He withdrew accordingly to Rijnsburg, a quiet unworldly village on the old Rhine, about six miles from Leyden.

Life at Rijnsburg (1660-1670).—Rijnsburg was the headquarters of the Collegiants. Arrangements for his stay there were no doubt made by his Collegiant friends. He lodged with a surgeon named Hermann Homan, whose humanitarianism is obvious from the inscription on the cottage wall:

Alas! if all men were but wise, And would be good as well, The Earth would be a Paradise, Where now 'tis mostly Hell.

(From Kamphuysen's May Morning). In this cottage (now Het Spinozahuis) Spinoza wrote his Short Treatise on God, Man and his Well-being, the Treatise on the Improvement of the Understanding, the greater part of his Geometric Version of Descartes' Principia with the appendix on Metaphysical Thoughts. and the first book of his Ethics. Part of the Short Treatise consists of notes which he had prepared in connection with the study circle in Amsterdam. This circle continued to meet after Spinoza's departure from Amsterdam, and periodically Spinoza sent them the various parts of his Short Treatise and other works for study and discussion. This is clear from Letters VIII. and IX. (The Correspondence of Spinoza, pp. 101 seq.) and from the closing sentences of the Short Treatise (pp. 149 seg. in A. Wolf's edition). The Short Treatise and the Treatise on the Improvement of the Understanding were ready in or before April 1662, and were originally intended to be one work, as is clear from Spinoza's third letter to Oldenburg (Correspondence, pp. 98 seq.). Already in these earlier writings Spinoza's attitude is anti-Cartesian.

During his stay in Rijnsburg Spinoza met various interesting people. Especially noteworthy are Steno, the founder of modern geology, and Oldenburg, one of the first two secretaries of the Royal Society of London, Steno subsequently turned Roman Catholic and tried to persuade Spinoza to do likewise (see Correspondence, pp. 324 seq.); but he has the merit of having recognized in Spinoza "the reformer of the new philosophy." Oldenburg is of special interest in a biography of Spinoza because the most important part of Spinoza's correspondence passed between him and Oldenburg. Oldenburg visited Leyden in 1661. His countryman Coccejus was professor there. Spinoza must have acquired a reputation somehow, for Oldenburg went out of his way to visit him in Rijnsburg. The deep impression which Spinoza made on Oldenburg (who was about 18 years older than Spinoza) is evident from his first letter to Spinoza (see Correspondence, pp. 73 seq.). In Rijnsburg also Spinoza first met the brothers Koerbagh whose subsequent tragic fate showed how little freedom of thought there really was even in Holland. Casearius, another student at the University of Leyden, came to spend a year or so in Rijnsburg, and stayed in the same cottage as Spinoza, who instructed him in the philosophy of Descartes. For this purpose Spinoza made a geometrical version of the second part of Descartes' Principia. While on a visit to Amsterdam, in 1663, Spinoza showed this to his Cartesian friends, who

persuaded him to do the same with the first part of the Principia. He did so in a fortnight. These two parts, together with an appendix called Metaphysical Thoughts, were accordingly published by his friends in 1663. L. Meyer wrote the introduction explaining that Spinoza did not really share the views expressed in the book; J. Rieuwertsz was the publisher; and J. Jelles defrayed the cost. This was the only book published in Spinoza's life-time with his name on the title-page. P. Balling prepared a Dutch translation of this book, and published it in 1664.

Early in 1662 Spinoza had completed the first draft of his philosophy in one work combining the Short Treatise and the Treatise on the Improvement of the Understanding. He was not satisfied with its style or with its method of exposition. He had tried the dialogue form without success, so he tried the geometrical method, in the manner of Euclid's Elements, which gave him more satisfaction. He therefore decided to lay aside his earlier attempts and make a new start. Thus originated his Ethics. the first book of which was finished, and in the hands of his friends, early in 1663. The title of the whole work was not yet intended to be Ethics, but "On God, the Rational Soul, and the Highest Happiness of Man," and the work was planned in three parts corresponding to the three parts of the title, instead of the five parts into which it eventually developed. The publication of his version of Descartes' Principia was intended to prepare the way for the publication of his own philosophy. For this purpose two things were necessary. He had to secure the patronage of influential men who could shield him and his book from the remorseless hostility of the Calvinist clergy and other fanatics, and he had to show to the more philosophically minded people, who were mostly Cartesians, that his rejection of Cartesianism was not due to ignorance (see Correspondence, pp. 123 seq., and The Oldest Biography of Spinoza, pp. 57 seq., 147 seq.). Spinoza appears to have succeeded so far as to win the interest of a few people belonging to the governing class. These afforded him some protection, but not sufficient to enable him to publish his philosophy in his life-time. Among these were J. Hudde (who subsequently became Sheriff and then Burgomaster of Amsterdam, and a member of the States of Holland), H. Boxel (Pensionary of Gorkum), C. Burgh (who became Treasurer General of the United Netherlands in 1666), possibly also C. van Beuningen (at one time Burgomaster of Amsterdam) and Jan de Witt (Grand Pensionary of Holland).

In June 1663 Spinoza moved from Rijnsburg to Voorburg, near The Hague. Here Spinoza got to know Vossius the philologist, who was subsequently appointed Canon of Windsor, and Christiaan Huygens, the discoverer of Saturn's rings, inventor of the pendulum clock, and originator of the undulatory theory of light.

Though busy with his Ethics and his lenses, Spinoza kept up his correspondence with various people, especially with Oldenburg. Oldenburg kept Spinoza informed of the doings of the Royal Society (which had obtained its charter in July 1662) and of the researches of Robert Boyle and others, and solicited news from Spinoza about Huygens and others, and solicited news from Spinoza about Huygens and others. But about 1665 the correspondence was interrupted. The Great Fire of London (1666) and the continuation of the war were no doubt responsible for this. In 1667 Oldenburg was suspected of espionage and clapped into the Tower of London for a time. He was released, but became nervous and cautious, so that his correspondence with Spinoza was not resumed until 1675.

From a letter written in June 1605 it appears that Spinoza was then nearing the completion of his Ethus (Correspondence, p. 202). In the following August or September, however, Spinoza informed Oldenburg that he was engaged on a theological treatise (see Correspondence, pp. 204, 206). During the next few years Spinoza was at work on his Tractatus Theologico-Politicus, which was published anonymously in 1670. Why did he put aside his Ethics in order to write a treatise on the Scriptures? The chief reason is stated on the very title-page of the Tractatus, which states that its object is "to show that not only is perfect liberty to philosophize compatible with devout piety and with the peace of the State, but that to take away such liberty is to destroy the public peace and even piety itself." Already in 1665 Spinoza

mentioned this object to Oldenburg. But he also mentioned another, namely, he wanted to clear himself of the charge of atheism which had been brought against him. It would appear that, with the completion of the Ethics in sight, Spinoza was considering the question of its publication, but found that such a step was impracticable in the then state of public opinon, which under the increasing influence of the clerics and monarchists became very intolerant and restive, as the troubles caused by the war multiplied. Spinoza consequently conceived the plan of vindicating the cause of freedom of thought in a manner that would at once serve the general interest of the Republic and also prepare the way for the publication of his own philosophy. The chief obstacle was the Calvinist clergy with their constant appeal to Scripture, which they interpreted in any manner that served their fanaticism. So Spinoza set himself the task of showing that the Bible, properly understood, gives no support to the intolerance of the clerics and their interference in civil and political affairs.

Last Years (1670-1677) .- In May 1670, shortly after the anonymous appearance of the Tractatus Theologico-Politicus, Spinoza moved into The Hague, possibly in order to be nearer some of his influential friends. He certainly needed protection. His book created a stir, and went through five editions in as many years. But it stirred a hornet's nest, and denunciations came fast and furious. At first Spinoza stayed on the Stille Veerkade, but in 1671 he went to stay with the Van der Spycks in the Paviljoensgracht near by, and remained in their house (now Domus Spinozana) to the end of his days. His work on the Tractatus involved the resumption of his earlier Hebrew studies, and it was about this time that he commenced his Hebrew Grammar. He did not, however, finish it, but returned to his Ethics, though the prospect of its publication became more and more remote. In 1672 the French invaded Holland, which was unprepared, and so suffered many disasters. The populace, fomented by the monarchists, sought a scapegoat, and murdered the brothers Jan and Cornelius de Witt. Spinoza was beside himself. He prepared a placard expressing his disgust with "the very lowest of barbarians," and was going to post it up on the scene of the crime. Fortunately Van der Spyck locked the door, and saved him from the fate of the De Witts. As it was, his Tractatus was denounced as an instrument "forged in hell by a renegade Jew and the devil, and issued with the knowledge of Mr. Jan de Witt." In 1673, while the French army was at Utrecht, Spinoza received an invitation to visit Prince Condé there. It was inspired by a Colonel Stoupe, who was in command of a Swiss regiment under Condé. Stoupe had been a Calvinist minister, and his service with Catholic France against Calvinist Holland evoked the severe censure of some of his countrymen. Stoupe was an unscrupulous adventurer, but was anxious to save appearances. So he conceived the idea of showing that the Dutch were really heretics, and for this purpose he wanted to use Spinoza as his cat's paw. He actually published later in that year a little book in which he denounced the Dutch for tolerating an atheist like Spinoza, and for making no attempt to answer his atheistical treatise. Spinoza only saw in the invitation a possible opportunity of initiating peace negotiations. So he consulted some people of authority, and, armed with the necessary safe-conducts, set out for Utrecht in May 1673. In the meantime Condé had been called away, and Spinoza after waiting for him several weeks in vain, returned to The Hague, where a suspicious rabble greeted him with scowls and stones, but did him no harm. Earlier in the same year another kind of invitation had reached Spinoza. It was an invitation from the Elector Palatine to the Chair of Philosophy in the University of Heidelburg. Spinoza declined the offer with many thanks. He had trouble enough with the clerics and theologians as a recluse, he would not court worse trouble by becoming a public character. So he stayed in The Hague, polishing his *Ethics* and his lenses, and generally practising the art of plain living and high thinking. The impression he made on the people about him may be gathered from the fact that one day his pious Lutheran hostess asked him whether he considered her religion the right way to salvation. Spinoza, of course, reassured her

In 1675 the Ethics was finished finally, and Spinoza went to Amsterdam to see whether it might be published. But rumour had preceded him. Not only the clerics and theologians but even the "stupid Cartesians" were up in arms and brewing mischief, Spinoza, accordingly, abandoned the idea of publishing it. But manuscript copies of it were in the hands of his intimate friends. Once more he turned his attention to political problems, and began his Political Treatise, which he did not live to finish.

In 1675 Tschirnhaus visited Spinoza, and also brought about the resumption of the correspondence between Oldenburg and Spinoza. In 1676 Leibniz was staying in The Hague Already in 1671 he had heard of Spinoza as an authority on optics and had sent him a copy of an optical tract. Since then he had read the Tractatus Theologico-Politicus, of which Spinoza then sent him a copy; and he had also learned from Tschirnhaus something about Spinoza's philosophy. He was evidently interested deeply. For, according to his own account, he visited Spinoza 'frequently and "conversed with him often and at great length."

The days of Spinoza were drawing to an end. The glass dust from the lenses had done its worst. He was in the last stage of consumption. About the middle of February 1677 he sent to Amsterdam for his medical friend Schuller. On Sunday, February 20, about 3 o'clock in the afternoon, Spinoza passed away in the presence of Schuller. Four days later he was buried in the New Church on the Spuy. He was only 44.

In accordance with his previous instructions his manuscripts were sent to Rieuwertsz in Amsterdam. Jelles, Meyer and Schuller prepared them secretly for the press. The Opera Poshhuma by B. D. S. (and the Dutch version, De Nagelate Schriften) were published before the end of 1677. They consisted of the Ethics, the Political Treatise, the Treatise on the Improvement of the Understanding, the Letters and the Hebrew Grammar. The Short Treatise had disappeared, but two copies of a Dutch version were recovered in 1852 and an edition was published in 1862. Two short essays on The Rainbow (1687) and The Calculation of Chances were also lost for a time, but were found and published. The Rainbow in 1862, and both essays in 1883.

For about a century Spinoza's name was anathema. His writings were indeed studied and his ideas were borrowed to a greater extent than is commonly supposed. But people dared not mention his name with respect, much less acknowledge their indebtedness to him. In time, however, things improved. Lessing, Goethe and Coleridge did most to rehabilitate his name, and others followed suit. The monument at The Hague, the Spinosahuis at Rijnsburg, and the Domus Spinosana in The Hague bear testimony to the reverence in which the memory of Spinoza is now held throughout the civilized world.

## THE PHILOSOPHY OF SPINOZA

General Account.—The pioneers of modern thought were inspired by a revulsion from the mediaeval reliance on authority, and the subordination of reason to it. The Humanists of the Renaissance attempted to vindicate the autonomy of reason as against the authority of books and institutions. This rationalist spirit affected some of the Jews of Amsterdam, and, as already remarked, brought them into conflict with established authority. It was the same spirit that brought about the crisis in the early life of Spinoza, who eventually became the prince of rationalists. He insisted that even the Scriptures must be submitted to the test of reason, and produced the most effective protest against the subordination of reason to their authority. This revolt against mere authoritarianism, however, only represented the negative side of rationalism. Important as this was, it was only preparatory to its positive aspect. The positive side of rationalism may be seen in the great classics of science in the 16th and 17th centuries-the works of Copernicus, Vesalius, Galileo, Gilbert, Kepler, Harvey, Boyle, Descartes, Huygens, Pascal, Leibniz and Newton, to mention only a round dozen of the most famous names of the period. Their discoveries were the positive results of reason, whose main function it is to trace the connections between things, to discover their laws, and to display the order which makes things intelligible. It may be said, without any disrespect for these famous men, that the positive side of rationalism also found its fullest expression in Spinoza. For he attempted a synthesis of the whole of reality. This attempt shocked some of the above-mentioned genuses, and would have shocked the rest, had they heard of it. For none of them dreamed of the possibility of bridging the chasm between the natural and the supernatural. Spinoza conceived of the whole of reality, including the human and the divine, as an organically interconnected cosmos, in which there is nothing capricious or contingent, but everything happens in an orderly manner according to law.

Spinoza arrived at his conception partly as follows. Whatever object or event be considered, it can only be explained by reference to innumerable others which condition it. Each of these is, in turn, dependent on innumerable others. Each finite thing seems to send out innumerable tendrils and derive support from all directions. Is it conceivable that reality should be composed entirely of such conditional, dependent things? Spinoza, like others, said No. There must be some self-existing, independent or absolute Being as the ground of all that is dependent. But what is the relation of this absolute Being to the world of dependent things and events? The common answer is that this absolute Being is God, an omnipotent supernatural Being who created the world out of nothing, maintains its existence, and occasionally interferes with it in miraculous ways. This conception was almost universal at that time. Newton subscribed to it. And Descartes made a special entry in his diary to record his belief in the three miracles, namely, the creation out of nothing, free-will, and the God-man. But Spinoza rejected the idea of an external Creator suddenly, and apparently capriciously, creating the world at one particular time rather than another, and creating it out of nothing. The solution appeared to him more perplexing than the problem, and rather unscientific in spirit as involving a break in continuity. He preferred to think of the entire system of reality as its own ground. This view was simpler; it avoided the impossible conception of creation out of nothing; and was religiously more satisfying by bringing God and man into closer relationship. Instead of Nature, on the one hand, and a supernatural God, on the other, he posited one world of reality, at once Nature and God, and leaving no room for the supernatural. This socalled Naturalism of Spinoza is only distorted if one starts with a crude materialistic idea of Nature and supposes that Spinoza degraded God. The truth is that he raised Nature to the rank of God by conceiving Nature as the fulness of reality, as the One and All. He rejected the specious simplicity obtainable by denying the reality of Matter, or of Mind, or of God. The cosmic system comprehends them all. In fact, God and Nature become identical when each is conceived as the Perfect Self-Existent. This constitutes Spinoza's Pantheism.

God or Nature consists of Attributes. God, as the complete system of Attributes, is absolutely infinite or complete; each Attribute is only infinite of its kind. By Attribute Spinoza means an ultimate or irreducible quality or energy. He names two such Attributes, namely, Extension and Thought, but he allows for the possibility of an infinity of Attributes. The Attributes do not belong to, but are identical with, Substance. Reality, moreover, is essentially dynamic, not static-to be is to be doing. Thus the Attribute Extension is really the whole of material energy, and the Attribute Thought is the whole of mind-energy. All material things and events are changing modes or states of Extension; and all mental events or experiences are similarly modifications or states of Thought. Each Attribute exhausts its kind of reality, is an ultimate character, activity or "world-line" of Nature, and gives rise to its entire series of objects and events in accordance with its own laws. These finite objects and events are real enough while they last, but as finite modes they change and pass; not, however, into mere nothingness, for the Attribute, of which they are states, abides. The cosmic process never stops

Spinoza's conception of Extension and Thought, or Matter and Consciousness, as concurrent Attributes or Energies of Reality cast a new light on the problem of the relation between body and soul. Indeed, it was this problem which led him to the conception of concurrent Attributes. Under the influence of Plato and of

Christianity, body and soul had come to be regarded as antagonistic to each other, and their apparently intimate relation caused much perplexity to Cartesians and others. Materialists tried to explain away the soul; idealists sought to explain away the body; the Cartesian Occasionalists fell back on the miraculous intervention of God to synchronize body and soul (that is, physical and mental processes) like the wire-puller in a Punch and Judy show. Spinoza realized the difference between the mental and the material, but rejected the Cartesian conception of their antagonism. So he did not hesitate to attribute to God both Extension and Thought. And man, a finite mode of God, is thus both physical and mental, and functions in both ways concurrently, even if each series of events is self-contained. This solution committed Spinoza to the view that all physical beings are animated, though in very different degrees; and Spinoza accepted this view.

Theory of Knowledge.-Spinoza commenced a treatise specially devoted to the problem of Knowledge. But this work, the Treatise on the Improvement of the Understanding, was never completed. In his other works epistemological discussions are intimately linked with the rest of his philosophy. Indeed, even in the Treatise on the Improvement of the Understanding epistemological views are almost inseparably connected with ethical and religious ones. That is the consequence of his characteristic conception of "Knowledge." For Spinoza "Knowledge" is "life," not in the sense that contemplation is the highest life, but in the sense that knowledge is the means of holding together the threads of life in a systematic unity that can fill its proper place in the cosmic system. In this sense the effort after the highest knowledge becomes part of the cosmic activities by which cosmic unity is maintained, and so part of the very life of God. There are two things which must be borne in mind in connection with Spinoza's conception of knowledge. The first is his insistence on the active character of knowledge. The ideas or concepts by means of which thought construes reality are not like "lifeless pictures on a panel"; they are activities by which reality is apprehended; they are part of reality, and reality is activity. The second point is that Spinoza does not divorce knowing from willing. Man always acts according to his lights. If a man's endeavours appear to fall short of his knowledge, that is only because his knowledge is not really what it is held to be, but is wanting in some respect. On the one hand, reason, for Spinoza, is essentially the "practical reason." On the other hand, the highest expression of willing is experienced in that striving for consistency and harmony which is so characteristic of reason. For Spinoza, then, as for Bacon and all the Renaissance thinkers, "Knowledge is power," but in a much deeper sense than Bacon intended.

Spinoza's account of knowledge is particularly interesting as a clue to the way in which he gradually built up his ontology. He distinguishes three ascending grades of knowledge, namely, opinion, reason and intuition. By "opinion" Spinoza means the lowest grade of knowledge in which one assents to what one hears, perceives or imagines. It is the pre-scientific stage of knowledge. Its main characteristic is that objects and events are apprehended as detached things, without any insight into their connections or laws. The second grade, or "reason," is that in which we have an insight into the connections of things and events, and their laws; it is the stage of scientific knowledge. This grade of knowledge is greatly superior to the first, inasmuch as a knowledge of their connections and laws makes things more intelligible. But even this stage is imperfect because rather abstract. It reveals the course of single threads in the fabric of reality, not the whole pattern; it traces "world-lines," but affords no synoptic vision of the cosmos as a whole. It is the function of the third grade of knowledge, "intuition," to complete the scheme. In intuitive knowledge the cosmic system is grasped as a whole. This highest stage is only possible for a mind that has been through the discipline of the rational stage. Unlike the mystics, Spinoza does not regard intuitive vision as a substitute for thought and entirely different from it, but rather as its highest fruit-it is "thoughtfulness matured to inspiration." The three stages of knowledge might be roughly compared with the three stages in the acquisition of the knowledge of a new language.

First come the separate letters of the alphabet; then combinations of letters into words and of words into sentences, etc., in accordance with the laws of grammar; lastly comes the stage when the significance of a whole sentence or paragraph is grasped at a glance. So it is with the great book of Nature. First comes the perception of apparently isolated facts and events; next comes the understanding of their interconnections and laws; finally comes the intuition of the structure and significance of the whole—the vision which sees all things in God, and God in all things.

Spinoza's theory of knowledge appears to make the ontological assumption that reality is an interconnected system. Spinoza himself regarded it as an ultimate intuition. And his theory of knowledge was in some ways a justification of that view. To realize this it is necessary to grasp the fundamental distinction which Spinoza draws between "opinion" and "reason," or perception and understanding. A percept or an image is, for Spinoza, something entirely different from an idea or concept. Conception or understanding is an activity which grasps interconnections, and has nothing to do with images as such. Perception and imagination, on the other hand, are concerned with images and not with connections. And the laws of these two kinds of activities are as different as are their objects. Perception, or imagination, is concerned with images and follows the laws of association; conception or understanding is concerned with connections and follows the laws of logic. Hence Spinoza's insistence that "we can not imagine God, but we can conceive Him" (Correspondence, p. 289). Hence also Spinoza's rejection of Baconian empiricism. From observations of particulars as such it would be impossible, according to Spinoza, to derive laws or necessary connections. The laws or general truths of science rest, in the last resort, not on their correspondence with objects of perception, but on their harmonious interconnection in a system of truths. Spinoza, accordingly, dispenses with an external criterion of truth. "The true," he maintains, "reveals itself and the false." The ultimate test of truth is more truth or more knowledge, or the coherence of all that is known. The false or untrue betrays itself by its incoherence with what is already known. In fact, Spinoza for the most part regards ideas or concepts from the point of view of their adequacy rather than their truth, in order to avoid the suggestion of a merely external correspondence such as is usually associated with the term "truth." Concepts (or "ideas" in this sense) are acts of thought by which the laws and interconnections of things and events are apprehended. They are adequate in so far as they really enable us to systematize a certain range of facts. In that case they are also true, for they agree with the facts. The primacy, however, is with the adequacy of the concept, because until we have the adequate concept we can not apprehend the facts in such a way that it can be said to agree with them, or to be true.

In the history of philosophy Spinoza was the first to elaborate the coherence theory of truth. In his time mathematics was the only science that could serve as a model of such a coherent system. Hence his addiction to the method of geometry. The significance of his use of this method has been misinterpreted. His sole aim was to express his philosophy in as coherent and objective a manner as possible. Two points should be noted in particular. In the first place, Spinoza did not suppose that science or philosophy can dispense with observation or experience. He fully realized the importance of experience in the very setting of the problems which science and philosophy seek to solve; and it is known from his letters that he carried out many chemical and physical experiments. All that he insisted upon was that science involves much more than mere observation, that it needs concepts not derived from experience. It was his intention to write about scientific method, and to show that Bacon's ideas about it were inadequate; but this was one of several plans which he did not live long enough to carry out. The second point is that Spinoza had no delusions about the conclusiveness of the geometrical method. He himself had expounded the philosophy of Descartes in that method, although he thoroughly disagreed with it.

Above all it is important to note that, for Spinoza, the highest knowledge ("intuitive" or "clear" knowledge) is something much fuller and richer than the abstract assertions usually associated with the term knowledge. In the Short Treatise (p. 69 ed. Wolf) he describes it as "feeling and enjoying the thing itself." One must try to realize his meaning by thinking of what happens when a train of thought interests a thinker so deeply as to master him completely, and he gets so absorbed in the object of his thought as to identify himself with it. If we can conjure up all this vividly and warmly, then we may realize how Spinoza came to identify the highest "knowledge" with that "intellectual love of God" in which the individual realizes himself as part of the living Universe. In this state he does not merely picture reality in an external manner, but feels its very heart throb, and feels himself as part of it. But here we are on the verge of the mystical where all but the greatest poets cease to be articulate.

Substance, Attributes, Modes .- Spinoza's ideas relating to the character and structure of reality are expressed by him in terms of substance, attributes, and modes. These terms are very old and familiar; but not in the sense in which Spinoza employs them. To understand Spinoza, it is necessary to lay aside all preconceptions about them, and follow Spinoza closely. Spinoza, as already explained, found it impossible to understand the finite, dependent, transient objects and events of experience without assuming some reality not dependent on anything else but selfexistent, not produced by anything else but eternal, not restricted or limited by anything else but infinite. Such an uncaused, self-sustaining reality he called *substance*. So, e.g., he could not understand the reality of material objects and physical events without assuming the reality of a self-existing, infinite and eternal physical force which expresses itself in all the movements and changes which occur, as we say, in space. This physical force he called Extension, and described it, at first, as a substance, in the sense just explained. Similarly, he could not understand the various dependent, transient mental experiences with which we are familiar without assuming the reality of a self-existing, infinite and eternal consciousness, mental force, or mind-energy, which expresses itself in all these finite experiences of perceiving and understanding, of feeling and striving. This consciousness or mind-energy he called Thought, and described it also, at first, as a substance. Each of these "substances" he regarded as infinite of its kind (that is, as exhaustive of all the events of its own kind), and as irreducible to the other, or any other, substance. But in view of the intimate way in which Extension and Thought express themselves conjointly in the life of man, Spinoza considered it necessary to conceive of Extension and Thought not as detached realities, but as constituting one organic whole or system. And in order to express this idea, he then described Extension and Thought as Attributes, reserving the term Substance for the system which they constitute between them. This change of description was not intended to deny that Extension and Thought are substances in the sense of being self-existent, etc. It was only intended to express their coherence in one system. The system of course would be more than any one attribute. For each attribute is only infinite of its kind; the system of all the attributes is absolutely infinite, that is, exhausts the whole of reality. Spinoza, accordingly, now restricted the term "substance" to the complete system, though he occasionally continued to use the phrase "substance or attribute," or described Extension as a substance. As commonly used, especially since the time of Locke, the term substance is contrasted with its attributes or qualities as their substratum or bearer. But this meaning must not be read into Spinoza. For Spinoza, Substance is not the support or bearer of the Attributes, but the system of Attributes—he actually uses the expression "Substance or the Attributes." If there is any difference at all between "Substance" and "the Attributes," as Spinoza uses these terms, it is only the difference between the Attributes conceived as an organic system and the Attributes conceived (but not by Spinoza) as a mere sum of detached forces. Something is still necessary to complete the account of Spinoza's conception of Substance. We have so far only considered the two Attributes, namely, Extension and

Substance or cosmic system. And using the term "infinite" in the sense of "complete" or "exhaustive," he ascribed to Substance an infinity of Attributes, that is, all the Attributes there are. whether known to man or not.

Now reality, for Spinoza, is activity. Substance is incessantly active, each Attribute exercising its kind of energy in all possible ways. Thus the various objects and events of the material world come into being as modes (modifications or states) of the attribute Extension; and the various minds and mental experiences come into being as modes of the attribute Thought (or Consciousness). These modes are not external creations of the Attributes, but immanent results—they are not "thrown off" by the Attributes. but are states (or modifications) of them, as air-wayes are states of the air. Each Attribute, however, expresses itself in its finite modes not immediately (or directly) but mediately (or indirectly), at least in the sense to be explained now. Galilean physics tended to regard the whole world of physical phenomena as the result of differences of motion or momentum. And, though erroneously conceived, the Cartesian conception of a constant quantity of motion in the world led Spinoza to conceive of all physical phenomena as so many varying expressions of that store of motion (or motion and rest). Spinoza might, of course, have identified Extension with energy of motion. But, with his usual caution, he appears to have suspected that motion may be only one of several types of physical energy. So he described motion simply as a mode of Extension, but as an infinite mode (because complete or exhaustive of all finite modes of motion) and as an immediate mode (as a direct expression of Extension). Again, the physical world (or "the face of the world as a whole," as Spinoza calls it) retains a certain sameness in spite of the innumerable changes in detail that are going on. Accordingly, Spinoza described also the physical world as a whole as an infinite mode of Extension ("infinite" because exhaustive of all facts and events that can be reduced to motion), but as a mediate (or indirect) mode, because he regarded it as the outcome of the conservation of motion (itself a mode, though an immediate mode). The physical things and events of ordinary experience are finite modes. In essence each of them is part of the Attribute Extension, which is active in each of them. But the finiteness of each of them is due to the fact that it is restrained or hedged in, so to say, by other finite modes. This limitation or determination is negation in the sense that each finite mode is not the whole attribute Extension, it is not the other finite modes. But each mode is positively real and ultimate as part of the Attribute.

In the same kind of way the Attribute Thought exercises its activity in various mental processes, and in such systems of mental process as are called minds or souls. But in this case. as in the case of Extension, Spinoza conceives of the finite modes of Thought as mediated by infinite modes. The immediate infinite mode of Thought he describes as "the idea of God"; the mediate infinite mode he calls "the infinite idea" or "the idea of all things." The other Attributes (if any) must be conceived in an analogous manner. And the whole Universe or Substance is conceived as one dynamic system of which the various Attributes are the several world-lines along which it expresses itself in all the infinite variety of events.

Having regard to the persistent misinterpretation of Spinozism it may be as well to emphasize the dynamic character of reality as Spinoza conceived it. The cosmic system is certainly a logical or rational system, according to Spinoza, for Thought is a constitutive part of it; but it is not merely a logical system-it is dynamic as well as logical. His frequent use of geometrical illustrations affords no evidence at all in support of a purely logico-mathematical interpretation of his philosophy; for Spinoza regarded geometrical figures, not in a Platonic or static manner, but as things traced out by moving particles or lines, etc., that is, dynamically.

Emergence.—A few words may be added here to indicate the merits of Spinoza's conception of the Universe in relation to the doctrine of emergent evolution as maintained by C. Lloyd Morgan

Thought. Spinoza, however, realized that there may be other and S. Alexander. (See EMERGENCE and PHILOSOPHY, HISTORY Attributes, unknown to man. If so, they are all part of the one or.) If reality is considered from the point of view of the finite modes (or Natura naturata, in Spinoza's terminology) instead of from that of Substance or the Attributes (or Natura naturans), then beginning with the simplest kinds of modes and passing on to more and more complex combinations of them, each such combination will always be something more than the mere sum of its components. To this extent something new emerges at every stage where a system is formed out of simple constituents. At a certain stage we reach the various infinite modes, then the several Attributes, and finally God. For Spinoza, however, God or the Attributes and the Infinite Modes are eternal, so that the process of evolution can only concern the world of finite modes. This kind of emergent evolution Spinoza can be said to recognize when he identifies moral progress with ever widening synthesis-"the more perfection (i.e., reality) anything has, the more does it participate also in Deity" (Correspondence, p. 151). But Spinoza's conception has an advantage over the new conception of "emergence" (including the emergence of Deity). For the new doctrine involves the conception of the emergence of something out of nothing, inasmuch as the "emergent" is not contained in the sum of its conditions, but is something new. For Spinoza, on the other hand, the fulness of reality in all its essentials is always there, and the emergence of higher modes with the increasing synthesis or "holism" (q.v.) of lower modes does not involve a miraculous emergence of something out of nothing, but merely a rearrangement of what is already real.

Moral Philosophy,-For Spinoza, reality means activity, and the reality of anything expresses itself in a tendency to selfpreservation-to exist is to persist. In the lowest kinds of things, in so-called inanimate matter, this tendency shows itself as inertia; in living organisms, it shows itself as a "will to live." Regarded physiologically this effort is called appetite; when we are conscious of it, it is called desire. The moral categories. good and evil, are intimately connected with desire, though not in the way commonly supposed. Man does not desire a thing because he thinks it is good, or shun it because he considers it bad; rather he considers anything good if he desires it, and regards it as bad if he has an aversion for it. Now whatever is felt to heighten vital activity gives pleasure; whatever is felt to lower such activity causes pain. Pleasure coupled with a consciousness of its external cause is called love, and pain coupled with a consciousness of its external cause is called hate-"love" and "hate" being used in the wide sense of "like" and "dislike." All human feelings are derived from pleasure, pain and desire. Their great variety is due to the differences in the kinds of external objects which give rise to them, and to the differences in the inner conditions of the individual experiencing them. Spinoza gives a detailed analysis of the whole gamut of human feelings, and his account is one of the classics of psychology. For the present purpose the most important distinction is that between "active" feelings and "passive" feelings (or "passions"). Man, according to Spinoza, is active or free in so far as any experience is the outcome solely of his own nature; he is passive, or a bondsman, in so far as any experience is due to other causes besides his own nature. The active feelings are all of them forms of self-realization, of heightened activity, of strength of mind, and are therefore always pleasurable. It is the passive feelings (or "passions") which are responsible for all the ills of life, for they are induced largely by things outside us and frequently cause that lowered vitality which means pain. Spinoza next links up his ethics with his theory of knowledge, and correlates the moral progress of man with his intellectual progress. At the lowest stage of knowledge, that of "opinion," man is under the dominant influence of things outside himself, and so is in the bondage of the passions. At the next stage, the stage of "reason," the characteristic feature of the human mind, its intelligence, asserts itself, and helps to emancipate him from his bondage to the senses and external allurements. The insight gained into the nature of the passions helps to free man from their domination. A better understanding of his own place in the cosmic system and of the place of all the objects of his likes and dislikes, and his insight into the necessity which rules all things, tend to cure him of his resentments, regrets and disappointments. He grows reconciled to things, and wins peace of mind. In this way reason teaches acquiescence in the universal order, and elevates the mind above the turmoil of passton. At the highest stage of knowledge, that of "intuitive knowledge," the mind apprehends all things as expressions of the eternal cosmos. It sees all things in God, and God in all things. It feels itself as part of the eternal order, identifying its thoughts with cosmic thought and its interests with cosmic interests. Thereby it becomes eternal as one of the eternal ideas in which the Attribute Thought expresses itself, and attains to that "blessedness" which "is not the reward of virtue, but virtue itself," that is, the perfect joy which characterises perfect self-activity. This is not an easy or a common achievement. "But," says Spinoza, "everything excellent is as difficult as it is rare."

Two things at least must be added to prevent a misunderstanding of this slight sketch of Spinoza's ethics. The first is that he did not teach asceticism. Circumstances compelled him to be extremely flugal and live on a few pence a day; but he affected no contempt for the joys of life. On the contrary, he urged that "it is the part of a wise man to use the world and delight himself in it as best he may, though not to satiety, for that is no delight." The second point is that Spinoza, though compelled by circumstances to live the life of a recluse more or less, laid great stress on the social character of the moral life. "Men," he says, "will find that their needs are best satisfied by mutual help, and that only by uniting their strength can they escape the dangers that beset them everywhere." He insists further that the good pursued by reasonable men is a good that may be enjoyed by all, and that the virtuous man wants no special privileges, but desires also for his fellow men whatever he desires for himself. The third point is that Spinoza's contention that the conception of goodness, like that of purpose, is inapplicable to the cosmic system as a whole does not mean that he denied the validity of the distinction between good and evil in the realm of human conduct. The notions "good" and "evil" involve the conception of an ideal that is desired but not yet realized, and the realization of which is helped by some things, hindered by others. Now the cosmic system, or God, is completely real or perfect, and therefore "beyond good and evil." But with finite modes like men it is quite different. Much can be done that really heightens or lowers human life. Whatever enriches it really is good; whatever impoverishes it really is bad, even if its badness is something negative, a defect, rather than something positive.

Political Philosophy.-Spinoza agreed with Hobbes that if each man had to fend for himself, with nothing but his own right arm to rely upon, then the life of man would be "nasty, brutish and short." The truly human life is only possible in an organized community, that is, a state or commonwealth. The state ensures security of life, limb and property; it brings within reach of every individual many necessaries of life which he could not produce by himself; and it sets free sufficient time and energy for the higher development of human powers. Now the existence of a state depends upon a kind of implicit agreement on the part of its members or citizens to obey the sovereign authority which governs it. In a state no one can be allowed to do just as he pleases. Every citizen is obliged to obey its laws; and he is not free even to interpret the laws in a special manner. This looks at first like a loss of freedom on the part of the individuals, and the establishment of an absolute power over them. Yet that is not really so. In the first place, without the advantages of an organized state the average individual would be so subject to dangers and hardships of all kinds and to his own passions that he could not be called free in any real sense of the term, least of all in the sense in which Spinoza used it. Man needs the state not only to save him from others but also from his own lower impulses and to enable him to live a life of reason, which alone is truly human. In the second place, state sovereignty is never really absolute. It is true that almost any kind of government is better than none, so that it is worth while bearing much that is irksome rather than disturb the peace. But a reasonably wise government will even in its own interests endeavour to secure

the good will and co-operation of its citizens by refraining from unreasonable measures, and will permit or even encourage its citizens to advocate reforms, provided they employ peaceable means. In this way the state really rests, in the last resort, on the united will of the citizens, on what Rousseau, who read Spinoza, subsequently called the "general will." Spinoza sometimes writes as if he upheld absolute sovereignty. But that is due mainly to his determined opposition to every kind of ecclesiastical control over the state. Though he is prepared to support what may be called a state religion, as a kind of spiritual cement, yet his account of this religion is such as to make it acceptable to the adherents of any one of the historic creeds, to deists, pantheists and all others, provided they are not fanatical believers or unbelievers. It is really in the interests of freedom of thought and speech that Spinoza would entrust the civil government with something approaching absolute sovereignty in order to effectively resist the tyranny of the militant churches.

One of the most striking features in Spinoza's political theory is his basic principle that Right is Might. This principle he applied systematically to the whole problem of government, and seemed rather pleased with his achievement, inasmuch as it enabled him to treat political theory in a scientific spirit, as if he were dealing with applied mathematics. The identification or correlation of right with power has caused much misunderstanding. People supposed tnat Spinoza reduced justice to brute force. But Spinoza was very far from approving Realpolitik. In the philosophy of Spinoza the term "power" (as should be clear from the above account of his moral philosophy) means a great deal more than physical force. In a passage near the end of his Political Treatise he states explicitly that "human power chiefly consists in strength of mind and intellect"-it consists in fact, of all the human capacities and aptitudes, especially the highest of them. Conceived correctly, Spinoza's whole philosophy leaves ample scope for ideal motives in the life of the individual and of the community.

Spinoza discusses the principal kinds of states, or the main types of government, namely, Monarchy, Aristocracy and Democracy. Each has its own peculiarities and needs special safeguards, if it is to realize the primary function of a state. Monarchy may degenerate into Tyranny unless it is subjected to various constitutional checks which will prevent any attempt at autocracy. Similarly, Aristocracy may degenerate into Oligarchy, and needs analogous checks. On the whole, Spinoza favours Democracy, by which he meant any kind of representative government. In the case of Democracy the community and the government are more nearly identical than in the case of Monarchy or Aristocracy; consequently a democracy is least likely to experience frequent collisions between the people and the government, and so is best adapted to secure and maintain that peace which it is the business of the state to secure.

Bible Criticism .- Spinoza was not only the real father of modern metaphysics and moral and political philosophy, but also of the so-called higher criticism of the Bible. This part of his work was incidental to his plea for freedom of thought and speech. His Tractatus Theologico-Politicus undertook to show that the Scriptures properly understood gave no authority for the militant intolerance of the clergy who sought to stifle all dissent by the use of force. To achieve his object, Spinoza had to show what is meant by a proper understanding of the Bible. And this gave him occasion to apply criticism to the Bible. To appreciate his services in this connection it must be remembered that his age was remarkably lacking in historical sense, especially in matters relating to religion. Saintly contemporaries like John Bunyan and Manasseh ben Israel made the most fantastic use of Scripture texts; while militant clerics, relying on the ignorant bibliolatry of the masses, misapplied Bible texts to gain their ends. Spinoza, who permitted no supernatural rival to Nature and no rival authority to the civil government of the state, rejected also all claims that Biblical literature should be treated in a manner entirely different from that in which any other document is treated that claims to be historical. His contention that the Bible "is in parts imperfect, corrupt, erroneous, and inconsistent with itself, and that we possess but fragments of it" roused a great storm at the time, and was mainly responsible for his evil repute for a century at least. Nevertheless, the intelligent world has gradually come round to his views, and has learned to agree with him that the real "word of God," or true religion, is not something written in books but "inscribed on the heart and mind of man." And many ministers of religion now praise Spinoza's services in the correct interpretation of Scripture as a document of first rate importance in the progressive development of human thought and conduct.

Bibliography:—Biographies: (M. Lucas) The Oldest Biography of Spinoza, edited, translated and annotated by A. Wolf (1927); A. Wolf, Spinoza, edited, translated and annotated by A. Wolf (1927); A. Wolf, Spinoza, this Life and Treatise on God and Man (1920); J. Freudenthal, Das Leben Spinozas (1904, 1921), and Die Lebensgeschichte Spinozas (1920). Works: The best edition is Spinoza Opera (1921). Translations: An English translation of the complete works of Spinoza (1921). Translations: An English translation by A. Wolf is in course of preparation; the volume containing the complete Correspondence of Spinoza was published in 1928. Of other English translations the following are the most important: Spinoza's Chief Works translated by R. H. Elwes (2 vols., 1823-84, etc.); Ethics translated by Hale White and A. H. Stilling (1899); A Short Treatise on God, Man and his Well-being translated by A. Wolf (1910). The best French translations are those by E. Saisset (3 vols., 1861) and Ch. Appuhn (4 vols., 1904, etc.). The best German translations are those by B. Auerbach (2 vols., 1871), and by O. Baensch, C. Gebhardt and others (3 vols., 1904, etc.). Books on Spinoza's Philosophy, etc. The following are the most important: F. Pollock, Spinoza, His Life and Philosophy (1880, 1890, 1911); Martineau, A Study of Spinoza (1883, 1895); J. Caird, Spinoza (1888, 1901); H. H. Joachim, A Study of the Ethics of Spinoza (1907); R. A. Duff, Spinoza's Ethical and Political Philosophy (1903); L. Roth, Spinoza, Descartes, and Maimondies (1924); J. A. Gunn, Benedict Spinoza (1925); contains a bibliography; R. McKeon, The Philosophy of Spinoza (1928); L. Roth, Spinoza (1900); J. Freudenthal, Spinoza (1900); C. Problem mortal active to Camera, Delic Lehre Spinozas (1901); J. J. Freudenthal, Spinoza (1902). Of German Books the most important are: D. Camera, Die Lehre Spinozas (1932) and Leben und

SPINY SQUIRREL, a group of African ground squirrels, characterized by the spiny nature of the fur. They form the genera Xerus, Euserus, Allantoserus and Geosciurus, being characterized by the small size or absence of the ears, and the long, nearly straight, claws. Typical spiny squirrels live in clefts or holes of rocks, or in burrows. (See RODENIA.)

SPION KOP, a mountain in Natal on the N. Tugela river, and 24 mi. W.S.W. of Ladysmith. It was the scene of a battle in the Transvaal War (see South African War and Ladysmith).

SPIRAEA, a much cultivated genus of shrubs of the rose family (Rosaceae, q.v.), comprising about 80 species, natives mostly of the northern hemisphere. They are slender shrubs, 2 to 8 ft. high, usually with simple leaves and small white, pink or reddish flowers arranged in dense showy clusters. S. salicifolia (queen of the meadow) occurs in England and Scotland. S. latifolia (meadow-sweet), S. alba (white meadow-sweet) and S. tonentosa (hardnack, q.v.) are representative species of E. North America. S. douglasi (western meadow-sweet) occurs on the Pacific coast. Among the best-known cultivated forms are S. prunifolia (bridal-wreath) and the popular hybrid S. vanhouttei. There are dozens of named forms, commonly called spiraeas, and some are forced for early spring bloom.

A few of the so-called spiraeas belong to the genus Astilbe of the family Saxifragaceae.

SPIRE, in architecture, a steep, pyramidal form, crowning a tower. The origin of the form was the simple, four-sided, pyramidal roof frequently erected over Romanesque towers, as in many crude 11th century examples in Normandy, some of the Italian campaniles of the 11th and 12th centuries, and many German Romanesque towers, mostly of the 12th century. This form is abrupt and stunted and may easily be ungraceful, and various experimental attempts were made to soften the line. Thus the late 11th century tower at Le Puy en Velay has the successive stages of the tower receding and broken up by projecting bays on the sides. Furthermore, the pyramidal roof itself is

A. ....

decorated with corner finials and small, round-headed dormers. In Germany the form was varied by ending each face of the square tower in a gable, the plane determined by adjacent gable slopes establishing the slope of the pyramid, as in the square tower of the abbey church of Laach (c. 1156). The pleasanter effect of the octagonal spires over octagonal towers, like another of the towers at Laach, or the older of the two towers at Mainz (late 12th century), led to attempts to combine an octagonal spire with a square tower. This was accomplished in various ways, one of the simplest being the so-called broach spire, in which small, triangular planes of a less steep pitch than that of the spire proper occur at the bottom of the corner spire faces, with their lower points coinciding with the corners of the towers, as seen in the 12th century church of S. Columba at Cologne.

A more developed form of broach spire lies in the substitution of a small pyramid at the bottom of the corner faces, instead of the triangular plane. This is a type which became common in English Gothic spires. It may be described geometrically as the intersection of a four-sided pyramid of low slope by an eight-sided pyramid of steep slope, as in the 14th century spire of St. Mary's at Stamford. A more elaborate method of softening the junction between square and octagon was to carry the corner faces down unbroken to the top of the tower and fill the triangular corners thus left with decorative finials. An early example is the crossing tower of the church of S. Ours, at Loches, France (12th century).

In the south-west tower of Chartres cathedral (end of the rath century) a further advance is made in connecting tower and spire, by adding high, gabled dormers on the faces of the spire, over the centres of the tower faces, as well as richly developing the conner pinnacles. In the spire at Senlis cathedral (13th century) a vertical, octagonal stage, or lantern, is placed between the square tower and the octagonal spire. The corners of the square tower are occupied by pinnacles and eight slim dormers surround the spire base. The edges of the Chartres and Senlis spires are decorated with projecting roll mouldings, and those at Senlis are further enriched by crockets which form an admirable fretting of the silhouette. It is probable that similar crocketed spires were almost universally intended over the great towers of most of the French cathedrals. The towers at Laon, for instance, were once so crowned and spires at Reims and Amiens were begun.

Gothie CHmax.—It was in Normandy, England and Germany that Gothic spire design reached its climax. Particularly famous are the spires of S. Sauveur at Caen (14th century); S. Fierre at Caen (1308) and the magnificent group of spires at Coutances cathedral (13th century), in which the spire dormers and the corner pinnacles are treated with the utmost richness and the sense of height and slimness emphasized in every possible manner. The customary lavishness of the French Flamboyant style is magnificently illustrated in its pierced and intricately traceried spires. The two most remarkable examples are the northern spire of Chartres cathedral (1506–13), by Jehan Texier, and the so-called Tour de Beurre (c. 1520) of the cathedral at Rouen.

Spires of a simple type crown many of the Italian campaniles, and during the 13th, 14th and 15th centuries, spires and lanterns were frequently added to earlier towers. In neither Italy nor Spain, however, was the highly developed spire a native form, and Italian spires were simple, slate, tile or metal covered, pyramidal or conical roofs of timber. Burgos cathedral is unique in Spain in possessing two western spires of intricate, open-work masonry, which date from the 15th century. These, however, are known to have been designed by a German architect.

German luxuriance, which had already appeared in the numerous varieties of timber spires used on the Rhenish Romanesque churches, found equally congenial expression in the stone spires of the Gothic period. The early, simple type is seen in the solid spires of S. Elizabeth at Marburg (not completed until the middle of the 14th century but probably from a 15th century design). The cathedral at Freiburg has a spire (1270–88) which is of a new and infinitely richer type. The low, square tower carries a high, octagonal lantern, each side of which is capped by a slim gable and filled with delicate tracery, the corners of the square being filled with rich, triangular pinnacles, one of which is con-

tinued up as an open, spiral staircase, giving access to the upper portion. The spire rises above the lantern, a mere cage of open-work tracery, with crocketted edges, amazingly light and delicate in effect. Somewhat similar, although even more intricate in their pierced stone-work are the western spires of Regensburg cathedral (late 15th century), by Roritzer. These open-work spires became the rule in Germany, as illustrated in the intricate cage of Strasbourg cathedral (spire, 1435); the west towers of Cologne cathedral, hullt in the 19th century from mediaeval drawings; the overcomplicated lace-work of the cathedral at Vienna (1433) and the spire at Ulm, over 500 ft. high, built in the last years of the 19th century, from Isth century drawings.

The spire of Oxford cathedral (1220) is a perfect example of the Early English spire type: it is octagonal, has a marked entasis or convex curve, and is decorated with dormers on each face and corner pinnacles. The great spire of Salisbury cathedral (1250), 406 ft. high, shows the tremendous aesthetic advantage of the greater steepness there present, which became the rule in the later English spires. During the Decorated period it became customary to finish the top of the tower with a parapet, either battlemented or of pierced tracery, and to set back the base of the spire behind the face of the wall. With this change the use of broaches disappeared and tall, corner pinnacles, sometimes supported on corner buttresses, filled the tower corners. An early example of the parapeted tower with a spire, in which broaches remain and the corner pinnacles are raised up to the top of the broach, is that of Ashbourne church, Derbyshire (14th century). Among the loveliest of Decorated spires are the two western spires of Lichfield cathedral, with heavy but effective, corner pinnacles. The highly developed type of spire with corner pinnacles and a parapet below can be seen in St. Peter's, Kettering, and Sts. Peter and Paul, Oundle (both in Northamptonshire), both of the Perpendicular period. In other examples a little flying buttress connects the corner pinnacles with the face of the spire, as in the exquisite Perpendicular spire of Louth church, Lincolnshire. Many Perpendicular spires are often ornamented with crockets up the angles.

Renaissance.-The spire was a form never thoroughly absorbed by the Renaissance, which preferred domed lanterns crowning towers. Nevertheless, during the 17th century in Germany, most effective, fantastic, spire-like forms were developed. These, based partly on Italian Baroque prototypes, usually had profiles of broken concave and convex lines, crowned at the top with a sort of onion dome, the whole rising to a considerable height, and, in imaginative quality, far surpassing any of the Italian examples. It is such fantastic spires crowning the simple towers of village churches, which give much of their character to the little towns of south Germany and Austria. At the same time, in England, the spire idea was receiving a much simpler and more straightforward, and equally effective, Renaissance expression, through the efforts of Sir Christopher Wren and his followers, particularly in the churches built after the Great Fire of London in 1666, such as St. Martin's, Ludgate hill, St. Mary-le-Bow and St. Bride's, Fleet street, all by Wren. St. Mary-le-Strand (early 18th century) and St. Martin's-in-the-Fields (1721-1726) both by Tames Gibbs, which simplified and refined upon their Wren prototypes, are very successful.

Even more effective are many American colonial spires, which, although originally based upon the work of Wren and Gibbs. achieved a fresh beauty through still further simplification. Particularly noteworthy is the type in which a small, octagonal, arcaded lantern crowns a simple, square tower and carries, usually above an attic, a simple, slim, white spire, as in the Old South Meeting House, Boston (1729) and the extremely delicate, white, wooden steeple of the church at Farmington, Conn. (c. middle 18th century). Such steeples as that of S. Paul's chapel, New York (c. 1767), Christ church, Philadelphia (1754) and S. Michael's, Charleston, S.C. (1742, occasionally attributed to James Gibbs himself), although more monumental in treatment and more English in effect, still retain the characteristic American delicacy. This trend toward the more slender and attenuated proportions reached its climax in the exquisitely light spire of Park street church, Boston (1819), by Peter Banner. (For

bibliography see Gothic Architecture.) (T. F. H.)

SPIRE LIGHT, the term given to the windows in a spire which are found in all periods of English Gothic architecture and are an important feature in French spires. They are not glazed, and, if of large size, sometimes have transoms to strengthen the mullions.

SPIRES: see Speyer.
SPIRITS. The word spirits is most frequently used as a designation for alcoholic beverages, more particularly of the ardent type which owe their strength to distillation. This process is one commonly used to separate the more volatile from the less volatile components of solutions, simultaneously concentrating the former in the distillate and leaving the latter also in a more concentrated form as a residual solution. In the preparation of spirituous beverages, the distillate is the portion of greater value, and the residue is often a waste product rather than a material of commercial utility: this is not invariably the case with products of distillation, for, apart from alcoholic beverages, there are instances where the residue is the substance of greater interest, while the distillate may or may not be of sufficient value to warrant the precautions taken in its recovery. Again, the volatiles might be nuisances or even dangerous if they were simply boiled off without any precautions being taken to condense them into a liquid form, which may be more convenient for disposal, if not for reutilization.

The major components of distilled spirituous beverages are alcohol, the active intoxicating principle, and water, the diluent. Mixtures of these two substances in their purer forms would not, however, afford drinks of any appreciable attraction, and it is from small quantities of substances having more complex nature that the beverages derive their individual characters. The effectiveness of the minor constituents, which include higher alcohols, aldehydes, ethers, esters, volatile acids and other organic compounds, is in most cases out of all proportion to their quantities, and these subsidiaries can, accordingly as they may be excessive or otherwise in amount, invest the liquors with coarser or feebler flavours than may be desired. The aim of the manufacturer has been from time immemorial to produce a spirit of satisfactory strength with just sufficient of the flavouring agents to yield a palatable product. This is usually attained with a pot still.

Distilling in Antiquity.—The evaporation of the alcohol out of the various beers, wines and such liquors and its reclamation in liquid form gave rise to interesting developments in the forms of distilling apparatus. Originally a cool surface was held in the hot vapours from the boiling liquor and periodically cleared of the fluid which collected upon it. Pliny mentions the hanging of fleeces over boiling resin to collect turpentine, and Alexander of Aphrodisias records that sailors boiled sea water and collected sweet water by hanging sponges in the steam. This expedient seemed to have been superseded, for the sake of more efficient collection, by the use of a bowl filled with cold water, from the outer surface of which the condensate dripped into a vessel within the still pot (Tibetan and Bhutan style) or, according to Peruvian practice, into a tube which transferred it to an external receiver. By leading the vapours from the still pot through a pipe into a receiving vessel, where they condensed naturally, the Kalmuck Tatars made another evolutionary step, while the Sinhalese in their warmer climate augmented the effectiveness of this arrange-



FIG. 1.-ANCIENT FORM OF STILL, USED IN TIBET

ment by immersing the receiver in cold water. The natives of Tahiti sought to chill the vapours before they reached the receiver by cooling the connecting pipe and so invented the precursor of the Dariot or Liebig condenser, which has in modern times been modified into many ingenious forms. The Alexandrians elaborated the primitive cold surface into a more complex still head or alembic with an annular gutter by which the distillate was led

SPIRITS 241

to an external receiver; the addition of supplementary water cooling to this head exemplifies the form of the Mysore still which was reinvented in later years in the guise of Kodak and Sheldon condensers.

Modern Types of Still.—Simple pot stills constructed on the lines of the Tahiti model are used even now in France for brandy



FIG. 2 .-- ANCIENT FORM OF STILL USED IN PERU

and in Scotland and Ireland for whisky, but the pot is usually surmounted by a bulbous head or capital for the purpose of freeing the rising vapours from spray, which would contaminate the distillate, and of avoiding the risk of priming or blowing liquid over with the vapour. In some Irish installations, however, the still is connected to the condenser through a cooled lyne arm which partially condenses the less volatile components of the vapour, these being returned to the still pot while the more volatile substances pass on to the condenser. This is a primitive type of fractionator or rectifier. Some of the French brandy stills have a two-compartment bulbous vessel between the still and the condenser: one compartment contains the next charge to be transferred to the still, while in the other the less volatile substances are partially condensed, as in the lyne arm of the Irish still, but the heat lost by the vapour in becoming liquid is gained by the wine about to be run into the pot. This heat interchanger is an economizer of fuel. The pot stills used in the whisky distilleries of Scotland become more complicated, with two or more vessels between pot and condenser; they are retorts (the "eggs" of Eduard Adam's patent of 1801, inspired by the Woulf's bottle), or rectifiers, which return less volatile components to the pot and pass on the lighter fractions toward the condenser. These operate by virtue of the latent heat liberated by the steam during its condensation, evaporating spirit out of liquid which has already condensed. Wash heaters or heat interchangers are also incorporated.

In 1944 there were designed types of pot stills suggested by the admiralty for use in lifeboats and for other purposes, including the recovery of spirit which has become diluted in the performing of technical operations. In these models no attempt is made to fractionate the distillate, but heat is economized as much as possible by heat interchangers between boilers and condensers and in the boiler drainage tubes, a constant flow of waste liquor from the pot being maintained in order to keep the boiler clean.

The idea of the charge heater of the French brandy still is not modern, for a similar design appears in a publication by H. Braunschwick in 1512, the arrangement being shown as surmounting the boiler; it thus appears as the precursor of the modern refluxing fractionating column or still head which, in all its complicated modifications, is designed to give the maximum separation of volatile components in the course of a single operation. These improvements have been so effective that fractionating columns have become quite useful instruments in an analyst's equipment.

It is by an easy progression from the fractionating column, via

Charles Louis Derosne's, J. H. L. Pistorius' and J. J. Saint-Marc's designs, that Aeneas Coffey's and other patent stills were developed; these offer an efficiency in industrial operations which is unattainable on the laboratory scale so far as economical operation is concerned. The subject of Coffey's patent of 1832 consists of two towers which are essentially large-scale fractionating columns and heat interchangers. The first tower, called the analyzer, may or may not surmount a boiler and is a fractionating column into which steam is blown at the bottom and the alcoholic liquor or wash injected near the top. The tower is packed with perforated plates through which the steam blows, preventing the wash from passing from one plate to the next below through the perforations; when any upper plate carries sufficient liquor, the excess flows through a short pipe standing in a cup which rests on the plate below. This serves both as weir and as an obstruction to the steam which can then only rise through the tower by bubbling through successive layers of liquid. The heat evolved in the condensation of some of this steam evaporates or strips the alcohol out of the wash, and the mixed vapours pass to the base of the next tower or rectifier, which contains a similar arrangement of plates to that of the analyzer and a pipe lying in sinuous coils between each pair of plates. This pipe serves two purposes: it acts both as a heat interchanger, by warming the wash which passes through on its way to the top of the analyzer and as a cooler, by causing partial condensation of the vapours passing through the column. The condensate loads up the plates and fractionating is taken a stage further by removing the less volatile constituents, which are collected as fusel oil and water from the base of the tower. Finally, the vapour issuing from the top of the column is condensed as high strength spirit containing few impurities and known as plain, neutral, silent, velvet or Cologne spirit. Being almost flavourless and strong, plain spirit alone is of no value as a beverage, but some of it is used to dilute other alcoholic drinks which are too highly flavoured, to prepare compounded spirits and to fortify weak wines; the rest of it finds an outlet in industry.

Much industrial equipment has an important peculiarity: a refrigerator, which usually has the form of a simple worm condenser, is interposed between the condenser proper and the receiver; its purpose is to complete condensation and to chill the distillate, so reducing the vapour pressure of the latter that loss by evaporation is minimized.

Application of Distillation in Industry.—It should be noted in passing that the perfecting of the distillation plant, though closely connected through the ages with the production of spirituous beverages, has been in the 20th century a considerable asset to coal tar, oil and other industries; developments in these fields have continued at an amazing pace, so that mixtures of volatile substances can easily be analyzed into fractions whose condition approaches a state of purity.



FIG. 3,-STILL OF ANCIENT TYPE AS USED IN TAHITI

An interesting application of distillation equipment is exemplified in the apparatus used to fractionate liquid air at low pressures in order to obtain oxygen in such large quantities that the needs of industry can be economically satisfied. Another case is the provision of fractional distillation in the arrangements of certain

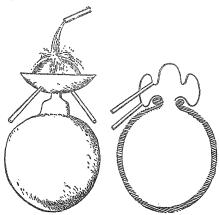


FIG. 4.--ANCIENT STILL USED IN SOUTHERN INDIA (MYSORE STILL)

refrigerators claimed to possess no moving parts; operation is possible by evaporation of a volatile liquid into a circulating gas stream, absorption from this into a less volatile liquid and fractionation of the resultant solution to separate the volatile liquid again, the operations being concurrent and continuous.

In the British Isles, where the revenue duties on potable spirits are high, the board of customs and excise have a lively interest in the existence of stills and none are allowed to be established unless a license has been issued or unless permission has been granted to possess or use a still without license. All such installations are subject to inspection at any time by excise officers in order that the clandestine distillation of potable spirits may be prevented. Illicit stills are therefore not common.

The distilled beverages which may properly be designated as spirits are, among English-speaking peoples, brandies, gins, rums and whiskies, but there are others known to other nationalities. The history of these substances is obscure, but a brief tabulation of some of them with their origins may be of interest.

B.C.	Country	Raw material	liquor	Distillate
*****	China	Rice and millet	Tchoo	Sautchoo
800	Ceylon and India	Rice and palm sap	Toddy	Arrack
-	Asiatic Tatary	Mare's milk	Koumis	Arika
	Caucasia	" "	Kephir	Skhou
	Japan	Rice	Saké	Sochu
A.D.				
500	Britain	Honey	Mead	"Mead" distilled
1000	Italy	Grapes	Wine	Brandy
IIOO	Ireland	Oats and barley malt		Uisgebeatha
1200	Spain	Grapes	Wine	Aqua vini
1300	France	a	и	Cognac
1500	Scotland	Malted barley	"Beer"	Aqua vitae Whisky

In general, the raw material is a sugar such as is to be found in honey, ripe fruit, sugar cane, beetroot, milk, or a substance of an amylaceous nature which may be easily converted into a sugar. Fortunately this change is simply effected, for some of the active agent is already present in ccreals containing the necessary starch, or is easily developed in them; where it is absent, as in potato starch, a suitable cereal can be added.

Action of Enzymes.—The active agents which break downstarches into sugars and sugars into alcohol are known as enzymes and are generally water-soluble nitrogenous compounds having something of the nature of albuminoids. They behave rather like catalysts in that a very little of them will cause a fundamental change in large quantities of the material being processed; they are easily poisoned by certain substances such as hydrocyanic

acid, mercury salts and formalin, are sensitive to temperature variations (being rendered inactive in certain conditions) and are specific in action in that each is effective for certain classes of substance only. They convert complex insoluble material into simpler assimilable substances: the enzyme amylase, for instance, will reduce starch to dextrin and then to the sugar maltose; the enzyme maltase will reduce maltose to the simpler sugar dextrose, and finally the enzyme zymase will ferment the dextrose to alcohol and carbon dioxide; all of these changes take place easily in aqueous solution. The presence of amylase and maltase in cereals, particularly if germination has begun, and the presence of zymase in yeast ensure that all the necessary materials for the manufacture of spirit are readily and economically available. There are, of course, other enzymes-sucrase, present in yeast and malt, will break down cane sugar to invert sugar; lactase will hydrolyse milk sugar to simpler fermentable sugars; cytase will disintegrate cellulose; lipase will degrade fats, and so on.

Processing.—In the case of cereals, processing is begun by grinding the grain and heating it with water to gelatinize the starch and so form the mash. This is cooled to a temperature between 50° and 60° C. and saccharified by adding ground malt, a preparation obtained from a cereal such as barley which has been moistened, allowed to germinate, dried, kilned (over peat fires for Scotch whisky) and ground; in this powder there are sufficient amylase and maltase to break down not only the start of the malted cereal but also that of the other amylaceous material. The liquid, now known as wort, is cooled to about 20° C. and pitched with yeast to initiate fermentation, a process which produces a wash ready for the stills.

Saccharine materials do not need the assistance of malt to prepare them for fermentation and the simpler ones, such as honey and grape sugar, can be fermented without any preparation other than solution in water, but the more complex sugars, such as cane sugar (molasses), beet sugar and many fruit sugars, need to be simplified or inverted before the yeast can attack them; the enzyme effecting this change, invertase or sucrase, is fortunately present in yeast and malt, and its action can proceed simultaneously with fermentation.

Yeast, the fermenting agent, is a budding fungus or unicellular vegetable organism without chlorophyll belonging to the genus Saccharomyces; of its many kinds, those of interest to brewers and distillers are of the species cerevisiae. In this species there are many varieties not always containing the same enzymes, and behaving differently toward various sugars. Charles Simmonds gives an interesting synopsis in his book Aicohol,

Yeast.—The whole story of yeasts and moulds, their active principles and the manner of utilizing them is a long and fascinating one which has occupied the attention of many investigators since the publication of the researches of Louis Pasteur, the real pioneer of the science of modern brewing; those who have more

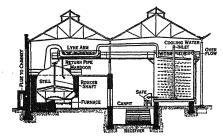


FIG. 5.—DIAGRAM OF SINGLE TYPE OF IRISH POT-STILL PLANT (JOHN JAMESON'S DISTILLERY, DUBLIN)

than a passing interest will find the records of Pasteur's work a good foundation for serious study.

The wash or the wine is conducted to the stills where, in the

case of the pot stills, two or more successive distillations are performed to produce a spirit of the desired strength; in the case of patent stills the process is completed in one operation. The resultant liquid is colourless and, in all products other than those from the plain spirit patent stills, rather harsh or raw in flavour: it should be matured. To this end the distillate is stored for at least four years in oak casks which may previously have contained sherry or which may have been charred internally, if there are none available that have already been used for the maturing process. Old casks, particularly those which have contained good vintages of choice blends and which have been well used, are esteemed of high value; Limousin oak is thought to be the best wood for their construction. During the storage period, considerable changes among the secondary constituents occur. While the concentration of the alcohol itself decreases, the proportions of volatile acids, aldehydes, higher alcohols and esters increase. but it should be remembered that some of the increase may be only relative in consequence of the evaporation of alcohol. The liquid also absorbs colouring matter and flavoursome ingredients, such as tannin, from the wood of the casks. After four years the change is not so rapid, although the mellowing tendency is still marked. Cask storage is extremely important, because only by this means can the finest maturing be achieved. In other containers, such as bottles, there is scarcely any noticeable change.

Potable Spirits.-Of the main classes of potable spirits there are many varieties. Commercially, the most important brandy is cognac made from the grape wines of the Charente and Charente Inférieure; this is the only brandy which in France can legally be named cognac, and the convention is generally respected elsewhere. Incidentally it is rather curious that this best brandy is obtained from a wine which to the palate appears to be of poor quality. Other French grape brandies are designated eaux de vie, with either the name of the district of origin or the name of the raw material from which they are made; for example, eaux de vie de marc is made in Burgundy from pomace or marc, the grape residues which are rejected in the manufacture of wine. United States brandy is made from Californian wines, and other grape brandies of good quality have their origin in Africa and Australia. Apple brandy or apple jack is distilled from hard cider in the eastern U.S., while peach brandy from fermented peach juice solves a problem of unmarketable peach crops in the southern states; blackberry brandy is also fairly common in the U.S. Huckleberries and raspberries are the raw materials for their respective brandies in the Black Forest district and gentian root serves a similar purpose in south Germany and Switzerland. In these same districts and in the south of France wild cherries provide the saccharine material from which real cherry brandy, arrack, or kirschwasser, is prepared. In Britain and elsewhere a maraschino cherry brandy and a blackberry brandy are extensively marketed; these are not true brandies but rather compounded spirits, liqueurs or bounces containing fruit juices, sugar and neutral spirit or mild brandy. (See BRANDY; LIQUEURS.)

Gins are generally patent still spirits, doubly rectified, sweetened or unsweetened and flavoured with the volatile constituents of juniper berries, angelica, almonds, calamus, cardamons, cassia, coriander, fennel, grains of paradise, licorice, orris and turpentine; the flavouring is usually added to the liquid before final distillation. Geneva (corrupted from "jenever," meaning juniper), Hollands and schnapps are Dutch gins, pot-stilled from maltwine, rectified and flavoured. Old Tom is a sweetened gin containing 1% to 6% of sugar. Plymouth gin contains a little ether, because a small quantity of sulphuric acid is added to the purch before distillation. (See Gray.)

wash before distillation. (See Gin.)

There are not many varieties of rum, but they are characteristic. (See Rum.) Demerara rum is prepared from a rapidly fermented dilute solution (sp.g. 1.060) of molasses, slightly acidified with sulphuric acid to liberate organic acids and inhibit bacterial action. Jamaica rum is distilled from a slowly fermented wash (sp.g. 1.078-1.096) made from molasses, soured skimmings from sugar pans and dunder or the residues in the still pots from previous operations; a certain bacterial action is encouraged in the fermenting liquor and the resulting spirit has a high content

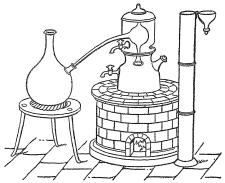


Fig. 6.—DESIGN FOR DISTILLING APPARATUS FROM BRAUNSCHWICK'S DAS BUCH ZU DISTILLIEREN (1512)

of volatile acids and esters. German rum is the result of a special fermentation to provide large quantities of esters and secondary constituents with a strong flavour in consequence; it is intended for mixing with neutral spirit to provide imitation rum. Pot stills are used in rum distillation to retain as high a proportion as possible of the secondaries, but patent stills are also employed to produce a so-called white rum, which is really a neutral spirit, and from this large quantities of gin are manufactured.

Whiskies are obtainable in many varieties. In the U.S. corn whisky is made from maize alone, part of the cereal being sprouted to develop the amylase necessary for the saccharification of the starch. Malt whisky is similarly derived from malted barley only, and rye whisky is, as its name implies, produced from rye. Bourbon whisky is prepared from mixed cereals such as maize 65%, rye 20% and barley malt 15%. Apart from variants in the raw materials, there are two methods of mashing which can yield products of diverse flavours. In sour mash some of the residues from a previous fermentation, and sometimes spent lees from the stills, are added to the new mash, giving rise to acidic conditions under which fermentation is allowed to proceed for some 48 hours. Sweet mash is prepared from fresh cereals and malt only and the succeeding fermentation is extended up to 72 hours. Irish whisky is usually a pot-still product and is derived entirely from malted barley or from a mixture such as 50% malt and 50% cereals, four-fifths of the latter being barley and the remainder oats, wheat and rye. Scotch whiskies are obtainable in half a dozen types, of which there are many blends; cambus or grain whisky is a patent-still product; i.e., neutral spirit; the other types are pot-still goods and derive their characters from the malts used in their preparation: a malt which has not been kilned in peat smoke yields a grain and malt whisky; Campbell town whisky is derived from a malt which is mildly peat-smoked, while Lowland, Highland and Islay are successively stronger in peat smoke flavour. The peat necessary for this kilning of the malt is carefully selected and generally subjected to a routine of controlled fermentation and drying to develop the properties most desirable in it. (See Whisky.)

Compounded Spirits.—Another class of well-known alcoholic beverages is that of the compounded spirits. These are extracts, infusions and mixtures concocted from one or more of the potable spirits or diluted plain spirits with flavourings derived from fruits, herbs and spices. They are sometimes sweetened and often coloured, and include liqueurs (foreign goods) such as absinthe, anisette, bénédictine, chartreuse, crème de menthe, curaçao, künnel, maraschino, noyeau and vermouth; cordials (British products) such as cherry brandy, cherry whisky, clove cordial, ginger cordial, orange bitters, peach bitters, peppermint cordial and sloe gin; ratafias, which are fruit extracts not subjected to distillation; and also gin and imitation rum.

General Properties of Spirits .-- Apart from aroma, which is usually caused by small quantities, even traces, of strongly flavoured secondaries, essences or extracts, the general properties of spirits are those of aqueous solutions of ethyl alcohol, a colourless mobile liquid with a slightly higher viscosity but a lower surface tension and a much lower electrical conductivity than water. It is neutral in character, but can act either as a base, by combining with acids to form esters or ethereal salts, or as an acid, by combining with strongly basic metals to produce ethylates. It can burn in air with a blue nonluminous flame and is decomposable in the absence of air at high temperature, particularly in the presence of catalysts such as powdered aluminum, zinc dust, reduced nickel, thoria or alumina, releasing hydrocarbons and other simple compounds. On the other hand, contact with strong oxidants will result in the formation of aldehyde. acetic acid and even of carbon dioxide and water. Absolute alcohol is hygroscopic and miscible with water in all proportions, with an accompanying evolution of heat and a contraction in total volume which is most noticeable when 52 volumes of alcohol are mixed with 48 volumes of water at 20° C., to yield 96.3 volumes when temperature is restored to 20° again. Specific heat is about twothirds and thermal expansibility is five and a half times that of water at 20° C.; these characteristics, coupled with the possession of a low freezing point (-130° C.), render the liquid a suitable filling for certain ranges of thermometers. The boiling point of alcohol is 78.3° C., heat of vaporization is only about 2/11 of that of water, vapour pressure at ordinary temperatures is about 21/2 times as great; these facts are reflected in the relatively easy separation of alcohol from water by fractional distillation-up to a certain limit-and in the lesser known data of flash points, which are of great importance in connection with fire risks during storage and transport. According to von Schwartz, the following temperatures may be taken as a guide to the flash points of various alcoholic liquors:

Ethyl alcohol 100% 51° F.
Ethyl alcohol 95% 57° F.
Rum, arrack and cognac 77° F.
Whisky 82° F.
Hollands gin 89° F.
Sherry and port wine 120° F.

These temperatures must be regarded with a certain amount of reserve, since they are dependent upon spirit strength, which has a considerable range of variation in each type of beverage. Aqueous mixtures at any given pressure boil at various temperatures, according to the alcohol content, but the lowest boiling point is that of a solution containing 4.43% of water, the mixture of constant boiling point; i.e., 79.15° C. at 760 mm. as against 78.35° C. for pure alcohol. This is an azeotropic mixture-one which distils at a constant temperature lower than the boiling points of its components, without change of composition, when the pressure is kept constant. Constitution varies with pressure, and at pressures below 70 mm, of mercury the alcohol-water azeotrope does not exist; it is therefore possible to obtain absolute alcohol by vacuum fractional distillation, although in practice the separation is not easily effected because of the small difference between the boiling points of the absolute and aqueous alcohols. The spirit produced from wash by any simple distillation process at ordinary atmospheric pressures can never be pure alcohol, but the latter may be obtained by drying out the water with powerful dehydrating agents before a final distillation, by vacuum fractional distillation or by adding to the aqueous alcohol sufficient of another liquid, such as benzene, or a chlorohydrocarbon to form a triple azeotrope boiling at a still lower temperature and fractionating: in this instance, first the triple azeotrope containing the undesired water and then a double azeotrope containing the excess of the added substances are eliminated, leaving absolute alcohol as a residue or final distillate.

Mixtures of alcohol and water have values intermediate between those of the pure components for some of their physical characteristics, such as viscosity, heat of vaporization, specific heat, thermal expansion, vapour pressure, electrical conductivity, boil-

ing point, refractive index and specific gravity. Although the variations may not be strictly proportional to the amount of alcohol present, they are nevertheless generally progressive for certain ranges, if not right through the scale of concentrations. This fact has provided some convenient physical means of determining spirit strength and it is common practice to derive such

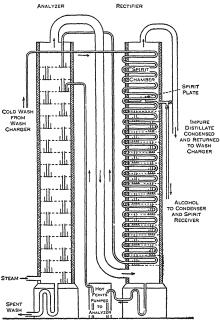


FIG. 7 .-- DIAGRAM OF COFFEY STILL

information from the specific gravity. Provided that the liquid is free, or has been freed by distillation, from saccharine and other matter which would interfere, the specific gravity is determined by immersing in it a hydrometer which may be graduated: (1) in terms of specific gravity; (2) with arbitrary scales (Great Britain, U.S.S.R.); (3) in percentages by volume of alcohol (Belgium, France, Italy, Norway, Spain, Sweden); (4) in percentages by weight of alcohol (Germany); (5) in percentages by volume of proof spirit (U.S.); (6) with a scale based upon fractions of the volume of the instrument (Netherlands). In all cases these instruments are calibrated at standard temperatures, and when the liquid to be tested is cooler or warmer (as it usually is), reference is made to tables to ascertain the true value for the spirit at the standard temperature.

Yet another way of ascertaining the specific gravity of the liquid is by the use of the pyknometer, or specific gravity bottle, which is calibrated by being weighed, filled with pure cold water, adjusted to standard temperature and weighed again. A similar procedure with the bottle filled with the spirit to be tested will provide a value which, when compared with the weight of water which can fill the bottle, indicates the specific gravity, and this in turn is found in appropriate tables to correspond with a spirit strength which is that of the solution under examination.

Spirit strength may be designated in several ways—percentage by weight, weight per gallon, gallons per hundredweight or percentage by volume, all these having reference to absolute alcohol and water. But there are other standards in common use; e.g., U.S. proof spirit, which is 50% by volume of alcohol and water, and British proof spirit, which is of such a strength that at 51° F. its weight is  $\frac{1}{8}$  of an equal volume of water; this solution contains 49.28% by weight or 57.10% by volume of alcohol at 60° F. The subject of alcohometry is comprehensively described in Simmonds' Alcohol. (See also ALCOHOL).

monds' Alcohol. (See also Alcohol.).

Binliodarphy.—P. Duplais and M. McKennie, Manufacture and Distillation of Alcoholic Liquors (1871); W. T. Brandt, Distillation and Rectification of Alcohol (1904); H. H. Willey, Beverage and Their Adulteration (London, 1919); Report of Royal Commission on Whisky, CD. 4796, H.M.S.O. (1909); A. Harden, Alcoholic Fermentation (London, 1911); R. Dodge and F. G. Benedict, Psychological Effects of Alcohol (1915); V. A. H. Horsley and M. D. Sturge, Alcohol and the Human Body (London, 1915); Charles Simmonds, Alcohol (London, 1909); Sidney Young, Distillation Principles and Processes (London, 1922); Joseph Reilly, Distillation (London, 1938), S. S. (1916).

SPIRITUALISM, a name used by some philosophers instead of idealism to signify a philosophic attitude or point of view about the universe opposed to materialistic philosophy and to imply that the ultimate reality is more fundamentally on the mental or ideal side of things rather than on that which appeals most directly to the senses as the behaviour and modifications of matter. But the name spiritualism or spiritism is more usually employed to signify a growing persuasion on the part of certain people that the activity of human beings is not entirely limited to the use they make of their bodily or material organisms on this planet. It is held that those organisms were constructed by an animating principle which having entered into relation with matter for the purpose of developing an individuality can continue long after the temporary material body is worn out or otherwise resolved into its elements; and, further, that the personalities thus brought into existence shall carry with them their memory, character, tastes and affection, which they had developed here while in association with matter, and shall be able under certain limitations to guide and influence terrestrial affairs in co-operation with those still living on the earth. This may be taken roughly as the spiritualistic interpretation or explanation of certain obscure phenomena which have occurred sporadically from time immemorial and which may be said to constitute the phenomena of spiritualism.

General Principles.—There is however a group of investigators who, while they accept the phenomena on the grounds of experience, are not prepared to accept the explanation in terms of human survival and who therefore dislike the term spiritualism, preferring to employ some noncommittal term such as metapsychics or parapsychology; meaning thereby a study of those obscure phenomena which lie outside the region generally accepted as orthodox psychology, and which suggest a possible extension of human faculty in directions not as yet understood. The object of these investigators is first to verify and then to study the facts oas to disentangle the laws which regulate them and seek to bring them within the recognized domain of organized human knowledge, or else to expand that domain so as to include them. This is called psychical research.

A third group of scientific men not only discard the spiritistic hypothesis but feel a doubt about the facts, regarding them rather as the outcome of savage superstition and folklore and therefore unworthy of scientific attention.

The whole subject therefore at the present time is a debatable one, on which there are many more or less legitimate differences of opinion. On the whole however there is a general consensus of agreement among those who have devoted time and attention to the subject that some of the phenomena are genuine; so that in time they must be accepted and gradually incorporated into the main body of science. They admit bowever that the investigation is conducted under difficulties, inasmuch as the phenomena cannot be produced at will, and because the facts are largely dependent on the good faith and careful testimony of those who experience them or who are allowed to witness them under sufficiently strict conditions. In so far as the phenomena appear to be dependent upon the activity of agents whose existence is not generally recognized, and who have the spontaneity and it may be the capriciousness characteristic of live creatures, the phenomena differ in many

er of the same

respects from the purely mechanical behaviour of atomic groupings and material bodies, such as form the customary stock in trade of astronomers, physicists and chemists. They appear likely to belong more to the domain of biology or even of anthropology when those sciences are sufficiently enlarged to include them. Meanwhile there is a great body of testimony as to their actual occurrences, which cannot properly be ignored.

But, again, this testimony depends on the utilization of people endowed with exceptional faculties, and these faculties are occasionally imitated by those who do not really possess them—a procedure which must be stigmatized in the strongest terms as fraudulent. There are others who, while possessing the faculties in a small degree, are tempted to enlarge and extend the results by normal supplement: a tendency which has to be constantly guarded against, for, if unchecked, it tends to bring the whole subject into disrepute.

Meanwhile, however, a body of careful investigators, notably those who founded in London the Society for Psychical Research, and others who have joined them or formed similar societies, have accumulated a great mass of evidence in favour of the phenomena, and the inquiry is still proceeding.

Assuming, on the strength of the evidence, that human faculties are not so limited as was at one time thought, and that these obscure phenomena actually occur, they may be classified into two great groups: (1) the mental, or purely psychical branch, concerned with the reception of ideas and information—information which could not have been normally acquired by the operator and therefore has to be styled supernormal; and (2) the physical branch, which concerns the production of effects in ordinary matter by apparently a supernormal extension of physiological processes.

To the first group belong such subjects as may be summarized under the heads telepathy, clairvoyance (qq.v.), lucidity, trance utterance, automatic writing, premonition, xenoglossy, psychometry and other apparent extensions of receptive faculty occasionally summarized under the rather question-begging term of cryptesthesia. It is chiefly on the strength of these mental phenomena that the hypothesis about the continued activity of the discarnate has grown up. For most of the communications so received purport to come, and certainly have the superficial appearance of coming, from intelligences no longer in the flesh who desire to send messages of condolence, sympathy and assurance to surviving relatives and to furnish proof of their continued activity. To this group must also probably be added the visual and auditory hallucinations (if that term can be properly used) which many people have experienced in the form of apparitions or other apparently sensory manifestations of the people concerned. It has been found that these appearances, or voices, are not limited to those of dead people, as they can be traced sometimes to the unconscious influence of living people when they are either asleep or in some danger or subject to some strong emotion. And these are called phantasms of the living.

The discovery of telepathy, that is to say the transference of thought or of ideas or emotions from one person to another without the use of any of the normal means of communication-a power which has been established by direct experiment as possessed by some people-tends to throw light upon these apparitions and indeed upon the whole spiritistic hypothesis. For if it is possible for one mind to influence another without the use of the material mechanism commonly employed, it tends to demonstrate an independence between mind and body which cannot fail to have important implications. Though neither the vocal cords nor any other muscles are used for transmission; although neither the eye nor the ear nor any of the other senses are used for reception; yet, since some brain process must at least indirectly be involved, it is just possible that telepathy may be caused by some unknown method of transmission between brain and brain. But no evidence has ever been adduced, at least none of any trustworthy character, for the existence of what have been called brain waves. And many circumstances connected with telepathy seem to render it unlikely that a physical method of transmission, even of an etheric kind, could be utilized for the

purpose of transmitting information, even though something analogous to brain waves existed. The great distance over which thought transference occurs and its apparent independence of obstacles are against such a hypothesis. For although the analogy of wireless telegraphy is often adduced, it must be remembered that we have no means of apprehending etheric waves except by the use of definite instruments: (1) for producing such waves in conscious and prearranged manner at one end; and (2) of detecting and transmuting them into sound or other mechanical movements at the other. Telepathy occurs without such instruments (assuming that it occurs at all), and nothing that has been detected in a screened organ like the brain makes it able to act as either a receiving or a transmitting instrument except through the agency of the nerves and muscles. Consequently the most natural hypothesis is that telepathy is a purely mental phenomenon, an action of mind on mind apart from the bodily organs; though the ultimate realization and demonstration of the occurrence must of course depend on the normal methods of testimony and record.

Now mental activity apart from the body is of the essence of the spiritistic hypothesis: and there would be no reason to object to the idea that deceased people can communicate information provided the great and fundamental step is taken of assuming that they still continue to exist. Conversely, the fact, so frequently testified to, that such communications are actually received, whether in the form of apparition or audition, or of automatic writing, or trance speech, or any other way, would, when established, also strongly support or even demonstrate the continued activity of the apparently operating personality. Hence it may be held that the discovery of telepathy rationalizes and renders more acceptable many of the asserted occurrences which otherwise would seem absurd and incredible. If an apparition were regarded as an objective reality all manner of difficulties would arise about the details. But if it is only a mental impression, perhaps roughly analogous to an image in a looking glass, although produced in some obscure and not in a simply optical manner, difficulties tend to disappear. The image can then be thought of as something not seen at all, but mentally reconstructed in accordance with a telepathic impulse which, indirectly through the mind, influences that part of the brain which is accustomed to receive an optical, or it may be an auditory, impression through the nerves. For, on any hypothesis, the brain and mind are closely interrelated; and a mental impression cannot be testified to or realized without the operation of the brain-nerve-muscle system.

## PHYSICAL PHENOMENA

On the spiritistic view—that is to say granted the working hypothesis that individuals once generated and isolated from a cosmic reservoir of life and mind, by means of their association with matter, shall continue to function as mental or psychic entities—it is fairly easy to suppose that they may be able to influence other minds, especially now that telepathy is fairly established as a vera causa, and can thus presumably cause inspiration and convey ideas or information. For it may reasonably be assumed that they have a wider outlook than when limited by the flesh; and, being also less restricted in time, that they may be in occasional touch with greater and higher intelligences on their side. Thus not only could ordinary lucidity and clairvoyance and even premonition be accounted for, but also the more valuable inspirations of genius.

It is not difficult to suppose that the organisms of people thus acted upon could be stimulated to produce such muscular movements as speaking and writing, or any other familiar bodily activity. The influence exerted on such people might still be considered purely mental and might be thought likely to operate most freely on the recipient organism when the medium or possessor of that organism is normally in a state of unconsciousness or partially suspended mental activity; but it would hardly be expected that the influence would be such as to produce physical phenomena beyond the capacity of the ordinary unstimulated organism. Nevertheless there is a large and growing body of evidence for the occurrence of even physically supernormal phenomena. Undoubtedly this svidence must be scrutinized with extreme care

because of its unusual character, so that the further question whether in some cases these phenomena are produced by the latent power of the normal individual, or whether they are dependent on a stimulus received from some other intelligence, may remain an open one, to be considered and classified later when the facts are thoroughly established.

The physical phenomena which have thus been seriously vouched for are such as the following. First, movement of objects without apparent contact, in other words, the displacement of matter at some distance from the boundary of the normal organism with no perceptible link and therefore out of the normal reach of the muscles. This is known as telekinesis or locomotion of objects at a distance. A modification of this phenomenon is the moulding or rearrangement of matter so as to produce an imitation of known objects, after the manner of a sculptor or a painter, so as to produce simulacra of hands and faces and other parts of the human organism out of any material available. Another fact which is testified to is the rearrangement of the particles on a photographic plate, so that when the plate is developed in the ordinary way a supernormal image of some kind appears upon it, whether it be writing or a human or animal figure. It is further asserted that if no suitable material is provided, or cannot be collected, some organized material can be drawn, either from the medium or from any of those present, of apparently a living or protoplasmic nature, remaining still associated or connected with the organism from which it is drawn; and that this externalized protoplasm is then independently manipulated so as to display a likeness of some departed person, more or less unsatisfactory and incomplete, but far beyond the normal power of the medium from which the material is drawn. Such exteriorized protoplasm is now generally known as ectoplasm. It only lasts a short time and has to be returned to the body whence it came. But meanwhile it is said that it can achieve many odd results, among others that it is able to produce direct voice, to move about and also to exert considerable muscular force, thus effecting the locomotion of objects already spoken of as telekinesis.

The testimony of investigators suggests the idea that this extraneous material is worked by an intelligent mind, much in the same fashion as our own bodily organisms are normally worked by our own minds, and that its activities show will and intention analogous to the will and intention of our own movements. We know too little about the relation between mind and matter to stigmatize such an hypothesis as intrinsically absurd: we must be guided by the facts. But the asserted facts are so extraordinary. and physiologically so incredible, that the evidence will have to be of a strong and cumulative character before such an idea can be accepted. Nevertheless it is mainly by physiologists well acquainted with the difficulties of such an hypothesis that it has been most responsibly put forward. And there is considerable testimony from some physiologists in Europe that, however odd they may be, phenomena which suggest this kind of activity are definitely found to occur. The ectoplasm appears to have varying consistency, sometimes being visible only, sometimes tangible only, sometimes neither and occasionally both. Ectoplasmic formations have been photographed, though it is said that they can sometimes only be photographed in ultra-violet light, and with the use of a quartz lens.

One special difficulty surrounding this investigation is that the ectoplasmic material seems to be manipulated or controlled through an etheric connecting link, and that a tremor or vibration in the ether, of the kind which normally excites the retina of the eye, is detrimental to its activity; so that in most ordinary cases operations of this kind have to be conducted, or seem to be easier, in the dark—a circumstance which makes investigation specially difficult and unsatisfactory. It seems to have been found however that red light is not so deleterious as the brighter illumination of higher frequency, and that with due preparation the ectoplasmic formations can be photographed by a flashlight before they are thereby disintegrated. Moreover it is asserted that in the case of some exceptionally strong mediums, some of the effects have been produced in full daylight.

The force exerted by the ectoplasm can be quite considerable.

For instance a table can be raised completely off the ground; and have been testified to by all nations and peoples, although they the weight of a man clambering on the table need not be sufficient to bring it down. The forces have sometimes been measured by spring balances: and an attempt has been made to weigh the medium from whom ectoplasm has hypothetically been removed, with the result that the normal organism is said to have lost weight corresponding to that of the material which has been extruded and accumulated on another balance.

In quoting such assertions it is not to be supposed that they are as yet fully accepted; but they indicate the lines on which investigation should proceed. The hypothesis gives a link on which the phenomena can be threaded together, so as to give them a sort of coherence, which further experience may either substantiate or

Still More Obscure Phenomena .- All the movements and mouldings hitherto spoken of are within the power of normal individuals, if they are allowed free use of their limbs. There is no difficulty in levitating objects or people, or in moulding images and simulacra. Hence the evidence for the occurrence of these things in a supernormal manner must depend on whether the medium and all those concerned are under complete control. Much of the experimentation is complicated by this necessity.

But there are certain other phenomena asserted which are not of a normal character and could not be produced normally if the operator were free-phenomena which might be spoken of as miracles. The one most commonly attested to is the immunity to damage or destruction by extreme heat. It is said that certain people can hold flaming or red-hot coals in their hands without feeling pain and without being singed; that this power can be conveyed to other people under certain conditions; and that even fabrics, such as hair or cambric, can be rendered temporarily immune to fire. Travellers tell us of native races who can walk through fire or over hot coals without injury when in a state of exaltation. Heat is known to be a rapid vibration or tremor among the particles of a body, and it is difficult to see how the molecular or chemical changes normally associated with such tremor can be suspended. But again, when there is sufficient confirmation, we must be prepared to accept the facts, whether we feel able to understand them or not.

Another phenomenon of what is popularly called a miraculous character, has been often asserted to occur, namely the passage of a solid body into or out of a closed cavity; as, for instance, the introduction of an object into a closed room, such object having been previously known to be outside; a phenomenon known as an apport. Verification of such a fact as that is singularly difficult. especially when the enclosure is, like a room, such as can readily be normally opened; and, like all the rest of the phenomena, it must depend with excessive cogency on the good faith of all concerned. Indeed good faith alone might not be sufficient. Before accepting a thing like that, one would have to allow for hypnotic or other influence.

A modification of this passage of matter through matter, as it has been called, is the linking of two entire rings together, or the tying of knots on an endless string. These things have been testified to but are hardly as yet even tentatively accepted. The disintegration and reconstitution of matter have been contemplated as a working hypothesis by the few who do accept them; while others have taken refuge in a fourth dimension of space, in which a globe is no more a complete enclosure than a circle is in three dimensions. A quadruped is fully confined when enclosed in a village pound, but a bird is not. The parable is obvious.

It is however hardly worth while to seek for some mode of conceiving or formulating an explanation until the facts are established. The object of this article has been, first, to show the kind of assertions which are made, and then to indicate the kind of lines on which a rational explanation may be looked for; at least in connection with those for which a prima facie case has been established; and, next, to suggest that an enlarged psychology, and possibly an enlarged physiology-possibly even an enlarged physics-will have to take into account and rationalize a number of phenomena which so far have been mainly disbelieved or ignored.

Historical Summary.-Although spiritualistic phenomena

are spread over the historical documents collected in the Old Testament and have continued down to the time of John Wesley and later, it is usual to attribute the rise of what is called modern spiritualism to occurrences which took place in the U.S. about the middle of the 19th century, when they began to attract rational attention; passing through a time of much scepticism and contumely until they have emerged in the moderate and cautiously sceptical atmosphere of today.

Examples of mediumistic and prophetical incidents are common from the time of the Hebrew patriarchs downwards. David and the other kings did not hesitate to consult seers, and, sometimes unwisely, regulated their conduct accordingly. The episode of the infant Samuel is a good example of the phenomenon called the direct voice. In the Graeco-Roman period monitions were experienced and oracles consulted as everyone knows. Coming down to recent times, the phenomenon, now fairly common, of intelligent raps, seems to have begun in a family at Hydesville near Rochester, N.Y., about 1848. Stainton Moses, himself a powerful medium, helped to establish the London Spiritualist alliance, which was joined by the naturalist Alfred Russel Wallace, while the physicist and chemist Sir William Crookes began a series of investigations into a variety of physical phenomena, with the help of the exceptional medium D. D. Home, through whom startling results had been obtained in good light, as narrated by Lord Dunraven (see "Experiences with D. D. Home" printed by Maclehose for the S.P.R.).

In the '70s of the 19th century Sir William Barrett made preliminary experiments in thought transference; and Cambridge men of letters began to study the various phenomena seriously. In 1882 a special society was founded by F. W. H. Myers and Edmund Gurney under the presidency of Henry Sidgwick. Society for Psychical Research accumulated a mass of information, critically examined, recorded and discussed in its Pro-

On the continent the subject was taken up by Charles Richet in France, Von Schrenck Notzing in Germany, Morselli, Lombroso and Schiapparelli in Italy, and carried on under Gustave Gelev and his successors in the Institut Metapsychique of Paris and other organizations; while the American Society for Psychical Research published an extensive collection of records. Charles Richet wrote what is virtually a textbook of the subject under the title Traité de Metapsychique, translated into English as Thirty Years of Psychical Research. And Geley discussed the subject from the medical, biological and philosophic points of view in From the Unconscious to the Conscious. Books containing what purport to be records of communications received through mediums in the trance state are too numerous to mention; but the eloquent work of F. W. H. Myers entitled Human Personality and its Survival of Bodily Death not only fairly covers the subiect up to 1900, but bids fair to become a classic. Selection from other books is difficult. A history of the subject in two volumes by Frank Podmore eschews the spiritistic hypothesis in order to emphasize telepathy. Another history of the subject emphasizing its religious bearings is by Arthur Conan Doyle. Older treatises are Hare's Experimental Investigations of the Spirit Manifestations (1856); Sophia De Morgan's From Matter to Spirit (1863); Alfred Russel Wallace's Miracles and Modern Spiritualism (1876); Stainton Moses' Spirit Teachings; Zöllner's work translated by Gerald Massey as Transcendental Physics. Also Reports of the Dialectical Society in London, and of the Seybert Commission in the U.S. and the Proceedings of the Society for Psychical Research.

Research.

Billiography.—Books aiming at a philosophical or biological discussion of the subject, in addition to those already mentioned, are: Eugène Osty, Supernormal Faculties in Man; Morton Prince, Discussion of Personality; William McDougall, Body and Mind (1920); Woldin Tischner, Mind and Personality (1927); Rudolf Tischner, Telepathy and Clairvoyance (1925); Gustave Geley, Ectoplasm and Clairvoyance; Traugott Ocsterreich, Occultism and Modern Science. The Pacts of Psychic Science and Philosophy by Campbell Holms is an uncritical summary of a large number of asserted observations. Books containing detailed evidence are such as the following: F. W. H. Myers and Edmund Gurney, Phaniasms of the Living, 2 vols.

(1886); C. L. Tweedale, Man's Survival after Death; Delanne, Evidence for a Future Life; Joire, Psychical and Supernormal Fennemens; Nicholas Flammarion, After Death, etc, 3 vols.; William Barrett, On the Threshold of the Unseen (1918); and many books by J. Arthur Hill, H. A Dallas, Drayton Thomas and others. (O J L)

SPITALFIELDS, a district of London, Eng., in the western part of the metropolitan borough of Stepney. The name is derived from the fact that the land belonged to the hospital or "spital" of St. Mary Without Bishopsgate, founded in 1197.

SPITHEAD, the name of an important anchorage in the strait known as the Solent which stretches between the Isle of Wight and the mainland of England. The name has often been incorrectly applied to the eastern half of that strait, but is properly restricted to the anchorage extending along the south side of the Spit Sand, which runs from Gillicker point to the Spit fort in an east-southeasterly direction, outside Portsmouth harbour which is the principal station of the British navy. As a result of this position and of the space available, Spithead has been the scene of many of the great pageants and gatherings of the British navy on the occasion of coronations, mobilizations and special occasions, a historic one being that of the funeral of Queen Victoria, who died in the Isle of Wight in 1901.

SPITSBERGEN (Norwegian SVALBARD), an arctic archipelago between Greenland and Novaya Zemlya in 76° 25′ to 85° C., has a total area of 23,979 sq.mi. 80° O'N. and 10° 20′ to 35° E., has a total area of 23,979 sq.mi. 80° documents West Spitsbergen (15,000 sq.mi.), North-East Land (about 6,000 sq.mi.), Edge Island (2,300 sq.mi.), Barents Island (580 sq.mi.), Prince Charles Foreland, the Wiche Islands, Hope Island and many smaller islands, including Bear Island in about 74° 30′ N., 10° E. Norway took possession officially in 1925. The population, largely miners, shifts seasonally: the 1930 census showed 600; the 1946 census, 1,057; and a 1949 estimate, 3,950.

There is no indigenous population.

Geography.—The chief island is in the main a much dissected plateau with many deep fjords penetrating far inland. Small plains are found in the north and west. The sharp peaks that gave Spitsbergen its name rise to 4,060 ft. in Horn Sund Tind in the south. 3,450 ft. in Mt. Monaco on Prince Charles Foreland and 4,770 ft. in Mt. Eidsvoll in the northwest. In the middle and east the mountains are flat-topped and seldom over 2,000 ft., but Mt. Newton (5,445 ft.) in New Friesland is the loftiest peak in Spitsbergen. Rocks skirt many stretches of the open coasts but with accurate charting a number of safe harbours have been found. Glaciers fill the valleys except in the southern interior where they have receded. They generally reach the sea, often along broad fronts, but give rise to no large icebergs. Many are in a state of decrepitude, but a few seem to be advancing. An ice covering over New Friesland is the nearest approach to an ice sheet in West Spitsbergen. Barents and Edge Islands have glaciers only on the east. The Wiche Islands have no large glaciers, but North-East Land and Giles (Gillis) Land are each covered with a dome of ice that almost envelopes the island. Prince Charles Foreland has numerous glaciers. Bear Island with an area of 73 sq.mi. rises to 1,630 ft. in Mt. Misery. The northern part is a plain at an elevation of about 150 ft. There are no glaciers. Harbours are small and poor. Hope Island lies 125 mi. east of South cape, Spitsbergen, is 20 mi. long and not more than 1 mi. wide. It rises to 1,200 ft. There is no harbour.

Structure and Geology.—The principal features of the geology are known. Most formations from early Palaeozoic, and perhaps Archaean, to recent, occur. The oldest rocks appear chiefly on the west and north, including Prince Charles Foreland and North-East Land. They are the Hecla Hook series of Cambrian and Ordovician dolomites, limestones, shales and quartaites which form the Caledonian folds and overthrusts of the west. The folds can be traced as far east as the west of North-East Land. Granite and gneiss formerly believed to be Archaean probably belong to the same formation and were involved in the Caledonian foldings. Some of these crystalline rocks, however, may prove to be pre-Cambrian. Outside the area of these old rocks Spitsbergen is mainly a plateau of relatively undisturbed strata lying unconformably on a platform of pre-

Devonian crystalline rocks. In the northwest there are Devonian rocks. These are unconformably overlain by Lower Carboniferous or Culm sandstones and shales with some coal. Middle Carboniferous is rare and the Culm is generally succeeded by Upper Carboniferous limestones, Permo-Carboniferous cherts and Permian sandstones and shales. Next come Triassic, Jurassic and Cretaceous sandstones, limestones and shales. In the Cretaceous beds there is coal. Unconformably there follow Tertiary sandstones and shales with several coal seams. Tertiary folding is obvious in the west against the Hecla Hook beds in places and in the east, but in central Spitsbergen is noticeable only in gentle undulations. Heavy faulting occurred in Tertiary times. Intrusions of dolerites and basalt were probably of Cretaceous (Neocomian) date. An extinct volcano and several hot springs (temp. 82° F.) in Bock bay are Quaternary. The strand flat is well developed at 30-60 ft. and postglacial raised beaches are marked. Glacial and postglacial debris on low ground generally mask the solid rock and loose screes form fans on the lower slopes. Bear Island is built of Hecla Hook, Devonian and Carboniferous beds. latter series contain some coal.

Climate and Ice Conditions.—The sea around Spitsbergen is shallow and the ice readily accumulates round the shores. Pack ice prevents access to most shores except for a few months in the year. However, the warm North Atlantic drift sends a branch to the western shores of Spitsbergen, moderating its climate and leaving an open passage which permits vessels to approach the western coast during most months of the year. The fjords are

frozen from October or November to April or May.

Owing to the warm drift the climate of Spitsbergen is less severe than in the corresponding latitudes of Greenland. January and February means range from  $\circ^\circ$  to  $-8^\circ$  F., and July means from  $38^\circ$  to  $40^\circ$  F. Even in the coldest months of the winter a thaw may set in for a few days, but on the other hand snow sometimes falls in July and August. Spring comes in June; the snow becomes saturated with water and disappears in places and scurvy grass and willow open their buds. By the end of June the thermometer has ceased to sink below the freezing point at night; July, August and September are the best months. In September, however, autumn sets in. The arctic night begins in October and lasts through February. The annual precipitation at Green harbour is 11.6 in. and less in the interior. Winds are generally light except on the west coast and local winds in the fjords. There is mist on the west and around Bear Island in summer.

Fauna.—The Greenland whale has disappeared in consequence of the great havoc made by the early whalers. According to William Scoresby, no fewer than 57,590 whales were killed between 1669 and 1775. Reckless extermination of seals also took place. Walruses are now rarely seen in the waters of West Spitsbergen. Birds, also, have rapidly diminished in numbers. fulmar petrel meets ships approaching Spitsbergen far away from the coasts. It makes colonies on the cliffs, as also do the glaucous gull or the "burgomaster." Rotches, black guillemots, ivory gulls, auks, looms and kittiwake gulls breed on the cliffs, while geese, loons and snipe frequent the lagoons and small fresh-water ponds. The eider duck breeds on the islands, but its numbers have become noticeably reduced. These birds, however, are only guests in Spitsbergen, the snowy owl and ptarmigan being the only species which stay permanently. About 60 species have been recorded from Spitsbergen and Bear Island; about half of them breed there. Of land mammals, besides the polar bear, the reindeer and arctic fox have been greatly reduced. Norway has rigorously restricted the slaughter of reindeer; before 1868 from 1,500 to 2,000 were killed by hunters in a few weeks of summer.

Vegetation.—The only trees are the polar willow, which does not exceed two inches in height, and the rare dwarf birch; and the only bushes are the crowberry and cloudberry. But at the foot of the bird cliffs some loam has been formed notwithstanding the slowness of putrefaction, and there, in contrast with the brownish lichens that cover the rocks, grows a carpet of mosses of the brightest green, variegated with the golden-yellow flowers of the ranunculus, the large-leaved scurvy grass, the cuckoo flower, many saxifrages, foxtail grass, etc.; while on the driest spots yellow

SPITTA 24.9

poppies, whitlow grasses and rock roses are found. Even on the higher slopes, 2,500 ft. or more above the sea, the poppy is occasionally met with. In all about 130 species of flowering plants have been found. The distribution is suggestive: most species are found in Europe and 117 are circumpolar; many of the plants common on the west coast are absent in the eastern part because

of the greater cold.

Mining.—Coal, known since the 17th century, was not mined commercially until the 20th century workings at Advent bay. Progress was slow until 1914, when war curtailed other sources of Scandinavian supplies. The Longyear mine at Advent bay. U.S.-owned after 1905, was sold in 1916 to a Norwegian group. Norwegian mines have also opened at King's bay, Hjorth Haven and other places. Swedish mines were worked from 1917 to 1925 in Lowe sound (Braganza bay); British mining revived after 1919 at Klaas Billen bay, Temple bay and Coles bay; and the Dutch operated mines at Green harbour. In 1948-49 exports totalled 424,323 tons, used in northern Norway and for the Russian arctic fleet. The product is good steam coal of Tertiary and Cretaceous ages: bituminous coal of Carboniferous age is also available but as yet unmined. Mining continues through the year, but shipping is from late April through September.

Communication.-Regular boat sailings are lacking, but contacts are maintained through tourist steamers and the frequent colliers of the summer. A Norwegian radio station was established at Green harbour in 1911, and later stations and post

offices were set up at the chief mines.

Exploration.- It is probable that Svalbard, discovered by the Vikings in 1104, according to the Landnamabok, was Spitsbergen, but the discovery was forgotten. Modern knowledge dates from the discovery by Willem Barents and Jacob Heemskerk, on June 17, 1596. Barents saw parts of the west and north coasts, and he gave the name of Spitsbergen. In 1607 H. Hudson, after visiting Greenland, reached Spitsbergen and reported whales. Bear Island, midway between Spitsbergen and the North cape, had been discovered by Barents, and became important as a hunting ground (for walrus, etc.) after Stephen Bennet's visit in 1603. In 1600 Thomas Marmaduke reached Spitsbergen, and in the following year the first hunting expedition was dispatched thither by the Muscovy company under Jonas Poole, whose report resulted in the start of the whaling industry there in 1611. The Dutch quickly came in, causing collisions between the whalers of the two nationalities, and in 1615 the Danes laid claim to "this part of Greenland," as it was then considered. The Russians called the region Grümant, a corruption of Greenland, and well before 1740 were hunting there for walrus, seal, bear, fox, etc. Marmaduke had discovered Hope Island and North-East Land in 1613; Edge saw the Wiche Islands in 1617; and C. Gillis found Gillis (Giles) Land

Many expeditions have made Spitsbergen their base for polar exploration. The expedition in the "Racehorse" and "Carcass" sent from England in 1773 under C. J. Phipps was the first having a purely geographical purpose. Phipps mapped the north of Spitsbergen and reached 80° 48' N. In 1818 D. Buchan and J. Franklin reached 80° 34' to the north of the archipelago. Capt. D. C. Clavering and Sir Edward Sabine in 1823 explored the islands, and Sabine made his remarkable magnetic observations, while Clavering reached 80° 20' N. Sir William Parry in 1827 reached 82° 40' N, of Spitsbergen on sledges. In the same year the Norwegian geologist, B. M. Keilhau, visited the group. The Swede, Sven Loven, was the first to undertake, in 1837, dredging in Spitsbergen waters. In 1858 Otto Torell, accompanied by A. E. Nordenskiöld and A. Ouennerstadt made important observations and brought home rich geological collections. In 1861 a larger expedition led by Torell, Nordenskiöld, A. J. Malmgren and K. Chydenius investigated the possibility of measuring an arc of meridian in Spitsbergen. The work of the measurement of the arc was completed in 1864 by an expedition led by Nordenskiöld, assisted by Malmgren and N. Dunér. In 1868 Nordenskiöld sailed to the north coast, and a German expedition under K. Koldewey circumnavigated West Spitsbergen. In 1870 two young Swedes, A. G. Nathorst and H. Wilander, examined the phosphoric deposits at

Cape Thordsen, and two years later a colony tried unsuccessfully to work the beds. Leigh Smith and the Norwegian Capt. E. Ulve visited and mapped parts of east Spitsbergen in 1871 and reached 81° 24' N. In the same year the first tourist steamer visited the archipelago. In 1872 and 1873 expeditions under Nordenskiöld explored North-East Land and crossed the vast ice sheet which covers it. In 1882 the Swedish geologists A. G. Nathorst and G. de Geer gathered in Ice fjord data about the geology and flora of the islands. Also in 1882 a Swedish meteorological station was established at Cape Thordsen for carrying on the observations desired by the international polar committee. Expeditions of Gustav Nordenskiöld in 1890 and the circumnavigation by Nathorst in 1898 explored the coasts of the Wiche Islands and Giles Land. In 1892 C. Rabot made the first serious attempt to penetrate the interior from the head of Ice fjord, exploring a part of the Sassendal; and in 1896 Sir Martin Conway led an expedition which crossed the island for the first time and surveyed the region between Ice fjord and Bell sound. In 1897 Conway and E. J. Garwood surveyed the glaciated area north of Ice fjord and climbed Horn Sund Tind. In the same year S. A. Andrée made his fatal balloon ascent from Danes Island with the intention of floating over the pole. In 1806 a weekly service of Norwegian tourist steamers was established in summer, with an inn at Advent bay. In 1898, 1899 and 1906 the prince of Monaco made scientific investigations in the archipelago, and in 1898-1902 Swedish and Russian expeditions undertook the measurement of an arc of the meridian. W. S. Bruce, in 1906-07-09, made a complete survey and scientific investigations of Prince Charles Foreland, and in 1920 J. M. Wordie scaled some of its highest peaks, Monaco. Rudmose and Barents. In 1910 W. Filchner surveyed the glaciated region between Temple and Mohn bays. King's bay was used by R. Amundsen in his unsuccessful flight to the pole in 1925, and by him and R. E. Byrd in their successful flights in 1926. G. Wilkins alighted in the fjord in April 1928 after his flight from Alaska. The Norwegian government began regular summer expeditions in 1906, in which G. Isachsen, A. Staxrud and A. Hoel surveyed and conducted hydrographic research. Joint Norwegian and Swedish expeditions took place in 1931 and 1934. in the latter of which H. W. Ahlmann studied glaciology while H. U. Sverdrup studied the problems of heat, water vapour and momentum in the melting of the snow. In 1936 the Norwegians mapped about two-thirds of the group by aerial photography. (See also Arctic Regions: Exploration.)

Political History.-Despite diverse interests in and claims to the islands by British, Dutch, Norwegians, Swedes, Danes, Russians and even Americans, the question of sovereignty was long unsolved, and Spitsbergen was a terra nullius. Norway initiated a conference on the matter in Christiania (Oslo) in 1910, which was followed by others in 1912 and 1914, all without result. In 1919 Frits Wedel-Jarlsberg persuaded the Allied supreme council to grant to Norway sovereignty over Spitsbergen, Bear Island and all the lands lying between 74° and 81° N. and between 10° and 35° E. The act was validated by a treaty of Feb. 9, 1920, signed by Great Britain and the British dominions, the United States, France, Italy, Japan, Holland, Denmark, Norway and Sweden; soviet Russia adhered later. Norway took formal possession on Aug. 14, 1925. Norway then declared the region a part of the kingdom of Norway and appointed a governor (sysselmann).

In Aug.-Sept. 1941, a force of Canadians, British and "Free Norwegians" made a sudden landing, destroyed the radio stations, chief mines, about 450,000 tons of mined coal and 275,000 gal. of oil. The Norwegian population was evacuated to England, and about 2,000 Russian miners were transported to a north Russian port. The Allies established a base which was attacked by the Germans in Sept. 1943. (R. N. R.-B.; F. D. S.)

SPITTA, FRIEDRICH (1852-1924), German Protestant theologian, was born at Wittingen Jan. 10, 1852. He studied at Göttingen and Erlangen and in 1887 became professor ordinarius and university preacher at Strasbourg. In 1896 he began to edit, with J. Smend, the Monatschrift für Gottesdienst und Kirchliche Kunst. From 1919 until his death he taught at Göttingen, where he died June 8, 1924.

SPITTA, JULIUS AUGUST PHILLIP (1841–1894), German writer on music, was born at Wechold, Hanover, our Dec. 27, 1841. He studied philology at Göttingen and held seweral teaching posts before going to Leipzig, where he helped to found the Bachverein in 1874. A notable teacher, in 1875 he became professor of musical history at the university of Bellin and at the Hochschule für Musik, of which he became director in 1882. His J. S. Bach is one of the great classic musical biographies. Spitta was associate editor of the Vierteijahrsschrift für Musikusisenschaft from 1885 and played a leading part in publishing Denkmaler Deutscher Tonkunst. His other works include an important critical edition of the organ works of Dietrich Buxtehude and an edition of the complete works of Heinrich Schitz.

SPITTELER, CARL (1845-1924), Swiss poet and novelist, was born at Liestal, near Basle, April 24, 1845, and died at Lucerne Dec. 28, 1924. In youth he studied theology but he did not pursue a clerical career. After many years of teaching (eight of them in Russia), he published his first important work, Prometheus and Epimetheus, in 1880-81, under the pseudonym of "Felix Tandem." This was an epic, written in a rhythmical, quasi-biblical, hieratic prose. A little later appeared Extramundana (1883), a volume of apologues in verse. From 1885 to 1892 he engaged in journalism, but published Schmetterlinge (1889), a series of short poems. After 1892, when he settled in Lucerne, he was able to devote himself wholly to literature. Three other volumes of short poems were produced between 1892 and 1906-Literarische Gleichnisse, Balladen and Glockenlieder. In 1900-05 appeared his long epic, Olympischer Frühling, which was cited as the main ground for the award of the Nobel prize for literature in 1919. His prose writings include Imago (1906) and three other romances; Lachende Wahrheiten, a volume of essays (1898; Eng. trans. 1927); Die Mädchenfeinde (1907; Eng. trans., 1922), a story founded on a reminiscence of his boyhood; and Meine frühesten Erlebnisse (1914), a charming account of his childhood. His last work, published in 1924, shortly before his death, was Prometheus der Dulder, a metrical, compacter and maturer treatment of the theme of Prometheus and Epimetheus.

BIBLIOGRAPHY—See short lives and studies by Felix Weingartner (1904), Carl Meissner (1912), O. Kluth (1918, in French) and Rudolf Cottschalk (1928). The most complete English notices of him are in Studies of Ten Literatures by Ernest Boyd (1923) and in an article by J. G. Robertson in the Contemporary Review (Jan. 1921). See also the introductions to the translations of Lackende Wahrheiten (Laughing Truths; 1927) and Selected Poems (1928). (J. F. M.)

SPIX, JOHANN BAPTIST VON (1781–1826), German naturalist, was born in Hochstadt, Bavaria, Feb. 9, 1781. For a time he was curator of the Munich Zoological museum but in 1817 he left to accompany Karl Friedrich Philipp von Martius, Bavarian naturalist, to Brazil, a mission on which they were sent by the Bavarian government. They remained in Brazil until 1820, Martius studying its flora and Spix its fauna. On their return they collaborated on Reise in Brasilien, a three-volume work on the country's natural history. He died in Munich, March 13, 1826.

SPLEEN is a vascular type of organ without a duct and has been called a ductless gland. It is located in the upper left quadrant of the abdomen just below the diaphragm. It is soft and cannot be felt on abdominal examination when normal in size, consistency and position. It has important functions to perform in relation to the physiology and pathology of the blood. The functions are not fully understood. This organ often enlarges in diseases such as typhoid fever and malaria. It may be greatly enlarged in certain types of disease of the blood-forming organs, such as leukemia. It was thought at one time to have something to do with emotional reaction, which gave rise to such a phrase as "vent his soleen."

(See Blood.) (F. L. A.)

SPLIT or SPLJET, a city of Croatia, Yugoslavia (Ital. Spalato), has the finest harbour on the Adriatic coast, with a broad bay affording deep, sate anchorage. This, combined with its cental position, and good communication with other parts by road, rail and steamer, made it of great commercial importance, with an extensive trade in cement and marl. Pop. (1948) 49,885, almost entirely Serbo-Croatian. Spalato arose from the palace of Diocletian, who renounced the imperial crown in A.D. 303 and

lived here until his death. The palace was then allowed to fall into ruin, but when the incursion of the Avars was over (620) the inhabitants of the ruined city of Salona, near by, took refuge here, and built up homes within the nine and one-half acres covered by the palace, incorporating its walls and pillars. Its ground plan is like a Roman camp; i.e., almost a square with four quadrangular towers and four gates, with four streets meeting in the middle. The eastern gate or Porta Aenea is destroyed, but the western gate or Porta Ferrea and the main entrance to the building, the beautiful Porta Aurea, are still in fairly good preservation. The streets are lined with massive arcades. The vestibule now forms the Piazza del Duome or cathedral square; to the northeast of this lies the temple of Jupiter, or perhaps the mausoleum. Since the oth century this has been the cathedral of St. Doimo or Domnius, noteworthy for its finely carved choir stalls. To the southeast is the temple of Aesculapius, long transformed into a baptistery, a beautiful Romanesque campanile having been added in the 14th and 15th centuries.

Excavations have been carried on intermittently at the ruins of Salona, four miles northeast, since 1818, and many interesting architectural remains have been discovered together with many smaller relics, now housed in the Split museum. These include prehistoric objects. Salona was made a Roman colony in 78 B.C. and was one of the chief ports of the Adriatic. Soon after 313 the city became an episcopal see with St. Doimo as its first bishop. The palace was transformed into an imperial cloth factory. The town was captured several times by the Goths and Huns and in 630 was destroyed by the Avars, but was not entirely deserted until the end of the 12th century. In 659 John of Ravenna, the papal legate, was created bishop of Spalato, as the new city was called, the origin of the name being uncertain. A little later it became an archbishopric and its holders were metropolitans of all Dalmatia until 1033. In 1105 Spalato became a vassal state of Hungary; in 1327 it revolted to Venice, but in 1367 returned to Hungary. It was ruled by the Bosnian king, Tvrtko, from 1390 to 1391, and in 1402 by the famous Bosnian prince, Hrvoje. A large octagonal tower is still known as Torre d'Harvoye. In 1420 Spalato fell to Venice and ceased to have an independent history. The castle and walls were erected by the Venetians between 1645 and 1670 and dismantled during the French occupation of Dalmatia (1805-13) in which latter year the province came under Austrian rule and remained there until 1918. In that year Italy occupied the town for a short time, but from 1919 to 1941 the town was Yugoslav. In 1941 it was again occupied by Italians.

town was Yugoslav. In 1941 it was again occupied by Italians. Ser T. G. Jackson, Dalmatia, the Quarnero and Istria (Oxford, 1887); E. A. Freeman, Subject and Neighbour Lands of Venice (London, 1881); R. Munro, Bosnia, Hercegovina and Dalmatia (London, 1900); for researches at Salona, R. Adams, Ruins of the Palace of the Emperor Diocletian at Spalato, in Dalmatia (London, 1764) with engravings by Bartolozzi; L. J. Cassas and J. Lavallee, Voyage pittoresque et Historique de l'Istrie (Paris, 1802) illustrated; and G. Lucio, De Regno Dalmatiae et Croatiae (Amsterdam, 1666) for chronicles relating to Spalato and Salona.

SPLÜGEN PASS, one of the passes across the main chain of the Alps from Switzerland to Italy. The route from Thusis passes first through the celebrated gorge of the Via Mala, then through the Schams basin and past Andeer, beyond which the Rofna gorge gives access to the village of Splügen in the upper reach of the main or Hinter branch of the Rhine (q.v.). Leaving to the west the road over the San Bernardino pass, 6,769 ft., the Splügen road (constructed in 1823) mounts south to the pass (6,946 ft.) which forms the political frontier. On the other side the road avoids the old path through the dreaded Cardinello gorge (here passed Alexandre Macdonald's army in Dec. 1800) in order to descend by zigzags to Pianazzo. Thence past Campo Dolcino and Gallivaggio the descent is made to the ancient town of Chiavenna at the junction of the road from the upper Engadine over the Maloja pass, and 17 mi. by rail above Colico, at the northern end of the lake of Como.

**SPODUMENE**, a lithium-aluminum silicate (LiAl[SiO<sub>8</sub>]<sub>2</sub>) belonging to the pyroxene group (see Pyroxene), named in 1800 from Gr.  $\sigma\pi\delta\delta\omega$ s (ash-coloured), in allusion to its colour, and soon afterwards termed by J. R. Haiy triphane  $(\tau\rho\iota\phi\alpha\nu\dot{\eta}_5, appearing threefold)$  because it exhibited certain characteristics

equally in three directions. Spodumene crystallizes in the monoclinic system, the crystals having generally a prismatic habit and being often striated longitudinally. It has perfect prismatic cleavage and imperfect cleavage parallel to the clinopinacoid, while a lamellar structure may be developed by parting along the orthopinacoid. The hardness is 6.5 to 7, and the specific gravity about 3.16. Though generally a dull mineral, some varieties of spodumene are so brightly coloured and transparent as to be valued as gemstones; e.g., the emerald-green hiddenite and the lilac-coloured kunzite, while a yellow or yellowish-green spodumene found as pebbles in the state of Minas Gerais, Brazil, resembles, when cut, some kinds of chrysobeyl.

Common spodumene is used as a source of lithium in chemical preparations.

Spodumene occurs in granite and crystalline schists. The original specimens came from the isle of UG. Swed, but the finest examples are found in the United States, especially in Massachusetts, fine specimens having also been obtained from the Black Hills of South Dakota. Some remarkable deposits containing spodumene were discovered many years ago at Branchville, Conn, and were exhaustively studied by G. J. Brush and E. S. Dana. The spodumene occurred in large quantity, in a vein of albitegranite, associated with apatite, garnet, columbite, pitchblende and other uranium minerals, with several manganese phosphates.

SPOFFORTH, FREDERICK ROBERT, (1853–1926), Australian cricketer, was born at Sydney, N.S.W., on Sept. 9, 1853, and died at Surbiton, Sur., on June 4, 1926. He was educated at Eglington college, Sydney, and played in Australia up till 1888, when he came to England, and played occasionally in England until 1896. He visited England in the five tours from 1878 to 1886, and in his two great years, 1882 and 1884, took 188 and 218 wickets.

SPOHR, LUDWIG (1784–1859), German composer and violinist, was born at Brunswick on April 24, 1784. He spent his childhood at Seesen, where in 1789 he began to study the violin, and at six years old was able to take part in chamber music. He learned a great deal from studying the scores of Mozart, and later became a student of Franz Eck.

His first violin concerto was printed in 1803, and in 1805 he became violinist to the duke of Gotha. Spohr failed to have his first two operas (Die Prijung and Alruna) produced, but his third, Der Zweikampt mit der Geliebten, was successfully performed in Hamburg in 1810, a year after it was written. In 1811 he produced his (first) Symphony in E flat, and in 1812 composed his first oratorio, Das jüngste Gericht. In that year he also became leader of the orchestra at the Theatre an der Wien, Vienna, and began his faramatic masterpiece, Faust, which he completed in 1813. He resigned his post at Vienna in 1815 and toured Italy, returning to Germany to become conductor of the opera at Frankfurt (1817) and later Kapellmeister at Cassel (1822).

In 1822 Mendelssohn, then a boy of 13, visited Cassel; a friendship sprang up between the two, which ceased only with Mendelssohn's death in 1847. Spohr's next three operas, Der Berggeist (1825), Pietro von Abano (1827) and Der Alchymist (1830), attained only temporary success. At the Rhenish musical festival held at Düsseldorf in 1826, his oratorio Die letzten Dinge (The Last Judgment), the most famous of his sacred compositions, was produced. In 1831 Spohr published his Violin School. The year 1834 was saddened by the death of his first wife, Dorette Scheidler, a celebrated harpist. Two years later he married a pianist, Marianne Pfeiffer. During 1833 he worked on an oratorio-Des Heilands letzte Stunden (Calvary or The Crucifixion), which was performed at Cassel on Good Friday 1835, and sung in English at the Norwich festival of 1839 with an effect which he later referred to as the greatest triumph of his life. For the Norwich festival of 1842 he composed The Fall of Babylon, which was also a success, though the elector of Hesse-Cassel refused Spohr leave of absence to conduct it. His last opera, Die Kreuzfahrer, was produced at Cassel in 1845. Of his nine symphonies the finest, Die Weihe der Tone, was produced in 1832.

Spohr's compositions for the violin include concertos, quartets, duets and other concerted pieces and solos, and among these a high place is taken by four double quartets; i.e., octets for two antiphonal string-quartet groups, an art form of his own invention. He died in Cassel on Oct. 16, 1859.

SPOIL FIVE, once known as the national card game of Ireland, akin to the British napoleon, the American euchre and the French écarté. Not only spoil five but its variant forty-five were carried to the United States and Canada, while the variant auction forty-fives, introduced into Newfoundland in 1912, became the principal club game there.

The pack of 52 cards is used in spoil five. Any number from two to ten may play, but four, five or six make the best game. The ace of hearts is always third-best trump, and the rank of the cards is unique:

As trumps, spades and clubs rank 5 (high), J (knave),  $\nabla$  A, A, K, Q, 2, 3, 4, 6, 7, 8, 9, 10; hearts rank 5 (high), J, A, K, Q, 10, 9, 8, 7, 6, 4, 3, 2; diamonds rank 5 (high), J,  $\nabla$  A, A, K, Q, 10, 9, 8, 7, 6, 4, 3, 2.

When not trumps, spades and clubs rank K (high), Q, J, A, 2, 3, 4, 5, 6, 7, 8, 9, 10; hearts rank K (high), Q, J, 10, 9, 8, 7, 6, 5, 4, 3, 2; diamonds rank K (high), Q, J, 10, 9, 8, 7, 6, 5, 4, 3, 2, A.

Each player puts an equal number of counters in the pool. Five cards are dealt to each player in rounds of three and two, or two and three, at a time. The next card is turned for trump; if it is an ace, the dealer may discard any card and take the ace (or may refuse to do so). If the turned-up card is not an ace, the player holding the ace of trumps may exchange any card for it or may refuse to do so.

Éldest hand leads, and each player in turn must either follow suit or play a trump if he is able to follow suit. When a lower trump is led, the holder of the five or knave of trumps or the heart ace may renege (refuse to follow suit) if he wishes. A trick containing a trump is won by the highest trump it contains, and any other trick by the highest card of the suit led. The winner of each trick leads next. A player who has won three tricks must abandon his hand and take the pool; or jink it (play on to win all five tricks and receive the pool plus an extra chip from each other player). If he jinks it and loses a trick, he does not get the pool. A pool not won in one deal is added to the next pool.

Forty-five is a variant in which there is no pool; four or six play, in partnerships of two or three to a side respectively. A side winning three tricks scores five points; all five tricks, ten points. As some play, winning four tricks scores 15 points and all five tricks 25 points. The first side to reach 45 points wins.

SPOILS SYSTEM. The practice in the United States under which the political party winning an election rewards its campaign workers and other active supporters by appointment to public office. It involves political activity by public employees in support of their party and the consequence of removal from office if their party loses the election. A change in party control of government necessarily brings new officials to those high positions carrying political responsibility, but the spoils system extends personnel turnover to varying proportions of routine or subordinate governmental positions. In the most extreme form of the spoils system the primary test for appointment is excellence of party service, with almost complete disregard of capacity to perform the duties of the public office concerned.

The term spoils system is often applied to the great variety of means by which money may be transferred move or less indirectly from the public treasury to the party coffers, as well as to other abuses of governmental power for partisan advantage. So used, the term includes abuses in the management of public expenditures, irregularities in the granting of franchises and like privileges, partisan favouritism in the administration of criminal law, discrimination in the levy of taxes and other corrupt uses of public power. The term will be limited here to its earlier and narrower usage.

Although patronage existed in colonial times, the spoils system came to full bloom in the period 1800-29. When Jefferson became president in 1801, he found the public offices filled with persons generally hostile to him and to his party. Without espousing the principle of rotation in office, he replaced enough Fed-

eralists with Republicans to assure a more even distribution between the two parties of posts in the civil service. Yet in both appointments and removals partisan considerations were not the sole criterion; it remained for President Jackson to adopt the principle of the spoils system in the national government. Spoils practices were instituted earlier in the governments of states and cities. The system first became firmly rooted in New York; it was established almost as soon in Pennsylvania. By 1828 in all the states of the north and west the system existed or strong groups desired to introduce it.

In his annual message in 1829 Jackson presented a reasoned philosophy of the spoils system. "There are," he said, "perhaps few men who can for any great length of time enjoy office without being more or less under the influence of feelings unfavourable to the faithful discharge of their public duties. Their integritmay be proof against improper considerations immediately addressed to themselves, but they are apt to acquire a habit of looking with indifference upon the public interests and of toleration in office, then, was not an evil but a positive good. "The duties of all public offices are," he declared, "or at least admit of being made, so plain and simple that men of intelligence may readily qualify themselves for their performance; and I cannot but believe that more is lost by the long continuance of men in office than is generally to be gained by their experience."

The common explanation of the rise of the spoils system is that ways had to be found to support the activities of political parties. With the broadening of the suffrage, the use of elections to choose large numbers of officials and other tendencies toward democratization, political parties had to assume heavy burdens in the conduct of campaigns and leadership of debate on public issues. No class existed with the time or inclination to assume these responsibilities and parties had to be maintained by patronage. Practical considerations of party finance were re-enforced by a democratic dislike of the idea of public office as private property and a hostility toward the rise of an officeholding class,

The spoils system is often said to be peculiar to the United States, but similar practices have existed elsewhere from time to time. In fact, the distribution of public offices to strengthen a regime is an ancient practice of statecraft. At the time of the founding of the United States government, the tests for appointment to the civil service were probity, ability and loyalty to the constitution. The test of loyalty aided in buttressing a new government emerging from controversy. The installation of fascist dictatorships in Germany and Italy was accompanied by considerable partisan dilution of the permanent civil service. If the nature of a government changes radically, a degree of turnover in the civil service is likely to occur. The introduction of the spoils system into the national government of the United States coincided with a veritable revolution as new classes came to power in national affairs. Even systems for the selection of public employees on the basis of merit may reserve by effect the higher positions for members of the dominant groups within the com-

The spoils system flourished unchallenged in the United States until after the Civil War. Bills to reform the civil service were introduced in congress in the 1860s but they attracted little attention and less support. In 1871 congress empowered the president to prescribe regulations to govern the selection of civil servants and to employ persons to aid him in determining the fitness of applicants. President Grant appointed a civil service commission, but it was dissolved in 1873 after congress had failed in 1873 and 1874 to provide funds for its support.

The National Civil Service Reform league, established in 1881, led a reform movement which succeeded gradually in restricting the spoils system by the introduction of the merit system for the selection of civil servants. The movement gained impetus from the assassmation of President Garfield by a disappointed office seeker and in 1883, the Pendleton act, largely drafted by leaders of the Reform league, was adopted by congress. It provided for the creation of the United States Civil Service commission and for the merit system in the recruitment of some fed-

eral civil servants. In the same year the New York legislature adopted a civil service law—that is, in American usage, a law requiring the selection of civil employees through competitive examination. Massachusetts followed in the next year.

The merit idea spread slowly but steadily. After 1939, all states were compelled to institute merit systems for those of their employees engaged in security programs aided by federal subsidies

The exact extent of the merit system in municipalities was difficult to ascertain, but by the 1950s about 75% of the U.S. cities had established some type of formal merit system, according to The Municipal Year Book (1953). However, only 25% of the cities covered all employees, and almost half of those reporting cities with a population of less than 25,000 had established no formal civil service system. As the merit system encroached on the spoils system in state and local governments, its application was broadened in the national government by actions of various presidents. A major setback to the principle of merit occurred after World Wars I and II in the extension to veterans of preference in appointments.

The coverage of civil service legislation, however, does not indicate accurately the extent to which the spoils system has been superseded. In jurisdictions with civil service laws, spoils practices may prevail. In those lacking formal merit systems, ability may govern selection of employees and their tenure may be permanent. Nevertheless, great progress was made toward the elimination of the spoils system. (See CIVIL SERVICE.)

(V. O. K.; X.)

SPOKANE, a city of eastern Washington, U.S., at the falls of the Spokane river, 50 mi. from its mouth in the Columbia river; a port of entry and the county seat of Spokane county. It is on federal highways 2, 10, 95, 195 and 395, and is served by the Chicago, Milwaukee, St. Paul and Pacific, the Great Northern, the Northern Pacific, the Spokane International, the Spokane, Portland and Seattle and the Union Pacific railways, by Northwest and United air lines and by numerous motor-coach lines. Pop. (1950) 161,721; (1940) 122,001 (85% native white).

Spokane is the metropolis of the "Inland empire" of 100,000 sq.mi., lying between the Rocky mountains on the east and the Cascade or Coast range on the west and embracing eastern Washington, northeastern Oregon, northern Idaho, western Montana

and eastern British Columbia.

The city has an area of 41.4 sq.mi. and an altitude of 1,898 ft. It is surrounded by pine-clad mountains, rivers, cascades, waterfalls, lakes, orchards and fertile fields of grain. It is protected by the mountain ranges from extremes of heat and cold and from the fogs of the coast. The average year has 208 days of sunshine, 16.6 in. of rainfall and a growing season of 183 days between killing frosts. Through the city, in the heart of the business section, flows the Spokane river, tumbling over cataracts. The city is clean and well built, with substantial business buildings and commodious hotels, well-paved, well-lighted and well-kept streets and delightful views in every direction. In 1911 it adopted a commission form of government.

The park system includes about 3,000 ac.

A short distance to the west of Spokane, in central Washington, is the basin of the Columbia, containing a hydroelectric power development, Grand Coulee dam, and a great reclamation project. Spokane is the main gateway and an important supply centre for this development.

Military installations at Spokane include the U.S. air force base (heavy bomber), the U.S. naval supply depot and a \$5,000,coo veterans' hospital. Other important air, naval and ground reserve components occupy portions of Geiger and Felts fields.

Spokane is the home of Gonzaga university (Roman Catholic), Whitworth college (Presbyterian) and Holy Names college (Catholic). About 35 mi. from the city's centre is Mount Spokane State park, with the peak rising to 5,881 ft. Riverside State park, just outside the Spokane city limits, borders the shores of the Spokane river.

Spokane is important in the field of light metals, with a reduction plant and a giant aluminum rolling mill. There are 12

hydroelectric plants in the district (not including Coulee) with an installed capacity of 266,050 h.p., of which 183,000 h.p. represents the developed capacity of seven plants on the Spokane river in and This electric power operates mines, maintains exnear the city tensive irrigation projects, runs transcontinental trains and supplies current for industrial plants and street and domestic lighting.

History.-The first permanent settlement on the site of Snokane was made in 1874 by James N. Glover, who bought a tract of land from two trappers. The town was incorporated in 1881 as Spokane Falls, received a city charter later in the year and became the county seat in 1882. In 1890 "Falls" was dropped from the name.

an Indian tribe of Salishan stock which had formerly occupied the river valley.

The Northern Pacific railroad reached the city in 1883, the Union Pacific in 1889 and the Great Northern in 1892. On Aug. 4-6, 1889, a fire destroyed 30 blocks in the heart of the city, practically the entire business section, at a loss estimated at \$5,000,000, but within two years the district was rebuilt, with great improvements. The population was 19,922 in 1890, 36,848 in 1900 and 104,402 in 1910.

The pioneer who laid out the town site lived to see a city of more than 100,000.

SPOLETO (anc. Spoletium), a town and archiepiscopal see of the province of Perugia, Italy, 18 mi. N.N.E. of Terni, and 88 mi. N. by E. of Rome by rail. Pop. (1936) 10,579 (town); 32,341 (commune). It is situated on a hill, so that the lowest part is about 1,000, the highest 1,485 ft. above sea level, at the south end of the open valley of the Topino, a tributary of the Tiber, which it joins near Assisi. The principal industries are the collection and preparation of truffles and preserved foods, also tanning and the manufacture of earthenware, cotton and wool spinning. Spoleto is also the centre of an agricultural district, and contains a government experimental olive oil factory. There are few towns of Italy which possess so many Roman remains in good preservation under the mediaeval buildings, and few mediaeval towns with so picturesque an appearance. There are considerable remains of pre-Roman polygonal walls. There are remains of a Roman theatre, over 370 ft. in diameter, and an amphitheatre 390 by 295 ft. A Roman bridge of three arches, 80 ft. long and 26 ft. high, exists at the lower (north) entrance to the town.

The rock above the town was included within the polygonal walls: but Totila fortified, not this rock, but the amphitheatre, which remained the citadel until 1364, when Cardinal Albornoz destroyed it and erected the present Rocca, which was enlarged by Pope Nicholas V; it is now a prison. The Porta Fuga (the name alludes to the repulse of Hannibal) occupies the site of a Roman gate, but is itself mediaeval: while the mediaeval enceinte encloses a somewhat wider area than the ancient. The Piazza del Mercato represents the Roman forum; close by is a triumphal arch of Drusus and Germanicus (A.D. 21), and a temple (?) over which is built the church of S. Ansano. A Roman house in the upper part of the town, with mosaic pavements, probably belonged to Vespasia Polla, the mother of the emperor Vespasian. The Palazzo Municipale, above it, contains the archives and picture gallery. The cathedral of S. Maria Assunta, much modernized in 1634 by Bernini, occupies the site of a church of the Lombard dukes erected about 602. The present church was consecrated in 1198; the façade with eight rose windows belongs to the middle of the 12th century. Over the main entrance is a large mosaic of Christ enthroned, with the Virgin and St. John. by the artist Solsernus (1207). The Early Renaissance vestibule (after 1491) is fine. In the choir and on the half dome of the apse are the finest frescoes of Fra Filippo Lippi (scenes from the life of the Virgin) completed after his death by Fra Diamante: his tomb, erected by Lorenzo de' Medici, with the epitaph by Politian, is on the left of the choir. The fine stalls and panelling in the winter choir date from 1548-54. The Campanile is beautiful.

The church of S. Pietro, outside the town, has a façade richly sculptured with grotesque figures and beasts, of two different dates, about 1000 and about 1200. The little church of SS.

Giovanni e Paolo (12th century) contains frescoes of the 12th-14th centuries notably an early representation of the martyrdom of S. Thomas à Becket and a portrait of S. Francis of Assisi. S. Domenico is a fine example of later Italian Gothic with bands of different coloured stone. Both the church and its crypt contain 14th century frescoes. The triple-apsed crypt of S. Gregorio probably dates from the 9th century; the upper church was consecrated in 1146 and the Romanesque work covered with stucco in the restoration of 1744. S. Nicolò is a beautiful example of Pointed Gothic. The basilica of S. Salvatore (il Crocefisso) at the cemetery belongs to the 4th century A.D. The fine sculptures of the facade, with its beautiful windows, as also the octagonal dome, Spokan (said to mean "children of the sun") was the name of all belong to this period. It was restored in 1815. S. Ponziano, not far off, belongs to the 13th century. The city is still supplied with water by an aqueduct, to which belongs the huge bridge called the Ponte delle Torri, crossing the ravine which divides the town from the Monte Luco (2,723 ft.). The bridge is 253 ft. high and 755 ft. long and has ten arches: it was erected in 1364.

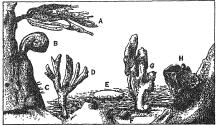
After the battle of Trasimenus (217 B.C.) Spoletium was attacked by Hannibal, who was repulsed. It suffered greatly during the civil wars. Sulla, after his victory over Crassus, confiscated the territory of Spoletium (82 B.C.). Under the empire it again became a flourishing town. It was situated on a branch of the Via Flaminia, which left the main road at Narnia and rejoined it at Forum Flaminii. An ancient road also ran hence to Nursia. Martial speaks of its wine. Aemilianus, who had been proclaimed emperor by his soldiers in Moesia, was slain by them here on his way to Rome (A.D. 253), after a reign of three or four months. The foundation of the episcopal see dates from the 4th century. Owing to its elevated position it was an important stronghold during the Vandal and Gothic wars. It was beautified by Theodoric (493) and fortified by Belisarius (536) but its walls were dismantled by Totila (546). Under the Lombards Spoleto became the capital of an independent duchy (from 570), and its dukes ruled a considerable part of central Italy. Together with other fiefs, it was bequeathed to Pope Gregory VII by the empress Matilda, but for some time struggled to maintain its independence. In 1155 it was destroyed by Frederick Barbarossa. In 1213 it was definitely occupied by Gregory IX. During the absence of the papal court in Avignon it was a prey to the struggles between Guelphs and Ghibellines, until in 1354 Cardinal Albornoz brought it once more under the authority of the Church. In 1809 it became capital of the French department of Trasimene. In 1860 it was taken by the Italian troops after a gallant defense.

At Monteleone di Spoleto a circular tumulus was found in 1902, with a rectangular chamber in the centre, and in it was the famous biga (two horse chariot), the only ancient one found in a complete state, which is now in the Metropolitan Museum at New Vork (T. A.)

SPONGES, or Porifera (from Latin porus, pore, and fero, to bear), are the simplest animals of the subkingdom Metazoa, which comprises all the multicellular forms. The body of a sponge consists of a rather loose aggregation of cells supported by a framework of spicules or fibres which form intricate skeletal structure. The differentiation into definite tissues, such as muscular, glandular, nervous, connective, etc., is incomplete and consequently there is but little co-operation and co-ordination among the parts of the body. The majority of sponges are of irregular shape, forming branching or encrusting structures attached to the bottom or to the submerged objects (fig. 1). Some of the sponges have, however, definite form and symmetry.

John Ellis (1765) was the first to demonstrate the animal nature of sponges by observing the water currents produced by a sponge and noticing the contractions on the surface of its body. For a long time sponges were grouped together with the Coelenterates (Linnaeus, Jean Lamarck, Georges Cuvier), until H. M. D. de Blainville (1816) placed them into a special group, Spongiaria, which he considered related to Protozoa. His idea received, however, no recognition from his contemporaries. The present name Porifera was created in 1836 by R. E. Grant, who devoted many years to the study of sponge morphology and anatomy. Separation of sponges from other multicellular forms (Metazoa) was proposed by T. H. Huxley (1875) and W. J. Sollas (1884), the view still held in 1945. Modern zoology places the sponges into a special branch of Metazoa called, after Sollas, Parazoa.

General Characters.-As the name Porifera implies, the surface of a sponge is covered with a multitude of minute openings or pores through which the current of water is maintained by flagellated cells located inside the sponge body. The water drawn in by the beating of the flagella passes through a complex system of canals and is expelled from several large vents, so-called oscula.



AFTER BIDDER IN "PROCEEDINGS OF THE S W. NATURALISTS" UNION

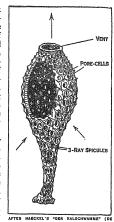
FIG. 1 .- COMMON SPONGES OF TEMPERATE SEAS A. Branched Finger Sponge (Chalina ceulata): B. Sea Fig (Suberites icus): C. Tow Sponge (Vibulinus stupesus): D. Axinelia dissimilis; E. Common Sponge (Leucandar ilstuloss): F. Sea Sponge (Donatal ylncurium); G. Mermald's Glove (Desmacidon fruticosum); H. Brittle Horry Sponge (Spongelia Iragilis)

The tissues are kept in place by a skeleton composed of mineral spicules or made of a mesh of elastic fibres (horny sponges). The simplest organization is found in the so-called ascanoid type of sponges represented by a few genera of calcareous sponges, Leucosolenia (fig. 2), Ascute, Ascyssa and Dendya. The latter genus approaches a more complex syconoid type. The vaselike symmetrical body of an ascanoid sponge is made of three layers of tissues forming the walls around a large central cavity (fig. 3). The outside covering consists of epidermis made of a single row of thin and flat cells. The central cavity is lined by a layer of collar cells or choanocytes, recognizable because of the presence of a contractile collar surrounding the base of a single long flagellum (fig. 4). The intermediate layer or mesenchyme (fig. 3, [7]) separating the collar cells from the epidermis consists of gelatinous material with spicules embedded in it and numerous amoeboid cells, the amoebocytes (fig. 3, [8]), freely wandering about. The incurrent pores or ostia are not simple holes in the epidermis but represent intracellular channels passing through special tubular cells, the so-called porocytes (fig. 5). Water is discharged through a large opening known as the osculum (fig.

In the next more complex type of organization, represented by the genus Sycon and called syconoid, the continuous layer of choanocytes is pushed outward at regular intervals to form pouchlike projections or radial canals. The walls of the canals may fuse, leaving between them narrow spaces, the inward-leading canals, lined with the surface epidermis. The spreading of the epidermis and mesenchyme to form a cortex (fig. 6) and the underlying subdermal spaces presents a further advance in the complexity of sponge organization and leads to a final or socalled leuconoid type. The latter type of organization and its numerous variations are represented in a vast majority of sponges. The leuconoid sponge (fig. 6, D) is characterized by clusters of small rounded flagellated chambers formed as a result of the outfolding of a continuous choanocyte layer of the ascanoid sponge. The choanocytes occur only in these chambers. The water is conveyed to the flagellated chambers through the ostia, subdermal spaces, inward-leading channels and pores (prosopyles) and is expelled through the outward-leading pores (apopyles) to the outward-leading canals, larger channels and is finally discharged through the oscula. A large layer of mesenchyme fills up the space between the canals and the flagellated chamber. The

large central cavity so prominent in the asconoid type is obliterated and the entire body of the sponge consists of a maze of water channels and flagellated chambers supported by a skeleton made of mineral spicules or spongin fibres. The development of a complex leuconoid type of organization is accompanied by a greater efficiency in producing and maintaining strong currents of water which provide the sponge with food and oxygen for respiration.

Size, Shape and Colour .--The size of sponges varies from a fraction of an inch, the usual length of small inconspicuous calcareous sponges of temperate seas (Sycon, Grantia), to huge masses of irregular or global shape several feet in diameter found in tropical and subtropical waters (Hircinia and many other horny sponges). Some of the sponges have definite symmetrical bodies, but the majority grow as irregular encrusting



AFTER HAECKEL'S "DER KALSCHWAMNE" GRUYTER & CO.)

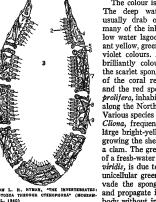
FIG. 2 .--- YOUNG LACE-CHALK (LEU-COSOLENIA PRIMORDALIS) "OLYNTHUS" STAGE, MAGNIFIED

masses or form large branching colonies. Of particular interest are many deep-sea sponges which display greater regularity of growth not found in their relatives inhabiting shallow waters. This secondary symmetry clearly shown in a remarkable species, Esperiopsis challengeri (fig. 7), is probably correlated with life in still water at great oceanic depths, which according to the generally accepted view the sponges invaded only in a comparatively recent time.

Sponges are completely devoid of organs of locomotion and are usually fastened to bottom, rocks, piles or other submerged

objects. Those living on muddy bottoms are anchored by roots consisting of bundles of long spicules (fig. 8).

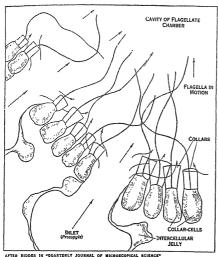
The colour is greatly variable. The deep water sponges are usually drab or brownish, but many of the inhabitants of shallow water lagoons display brilliant yellow, green, red, scarlet and violet colours. Among the most brilliantly coloured sponges are the scarlet sponge, Tedania ignis, of the coral reefs in Bermuda, and the red sponge, Microciona prolifera, inhabiting the estuaries along the North American coast. Various species of boring sponge, Cliona, frequently are found as lärge bright-yellow masses overgrowing the shell of an oyster or a clam. The greenish colouration of a fresh-water sponge, Spongilla viridis, is due to the presence of unicellular green algae which invade the sponge cells and live and propagate inside the sponge body without injuring their host (see Symbiosis).



-DIAGRAM OF THE ASCA-

1, osculum; 2, layer of choanocyte 1, osculum; 2, layer of choancoytes; 3, central cavity; 4, epidermis; 5, pore through porceyte; 6, porceyte; 7, mesenchyme; 8, amoebocyte; 9, spicula

Classifications.—The sponges are classified primarily on the basis of the type of skeleton and shape and size of their spicules. SPONGES 255



AFTER BIDDER IN "QUARTERLY JOURNAL OF MICROSCOPICAL SCIENCE"
FIG. A.—WALL OF FLAGELLATE CHAMBER OF THICK WALLED BANANACHALK (LEUCANDRA ASPERA); ARROWS SHOW DIRECTION OF CURRENTS

The chemical composition of the skeletal material serves to separate the calcareous, or chalky sponges, with the spicules composed of calcite, from siliceous and horny sponges in which the spicules are composed of siliceous and horny sponges in which the spicules are composed of siliceous and orders of siliceous sponges are not, however, clearly defined and no uniform system of classification has yet been agreed upon by zoologists. The classification commonly used in the United States is based on the works of E. Topsent, H. V. Wilson and M. W. deLaubenfels. The phylum Porifera is usually divided into three classes:

Class I.—Calcarea, the calcareous sponges. Skeleton is made of one-,three-,or four-rayed spicules of calcite.

Class II.—Hexactinellida, the glass sponges. Skeleton consists of a network of separate six-rayed (triaxon) siliceous spicules, finger-shaped flagellated chambers, no surface epithelium.

Class III.—Demospongiae. Sponges of leuconoid type with siliceous spicules, not of triaxon type, or of horny fibres or both. Spicules are differentiated into megascleres and microscleres; small flagellated chambers.

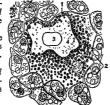
Subclass I.—Tetractinellida—with tetraxon spicules and no spongin. Spicules sometimes absent.

Sub class II.—Monaxonida large spicules (megascleres) of monaxonal type, spongin may be present or absent.

Subclass III.— Keratosa—the horny sponges. Skeleton consists of a meshwork of spongin fibres. Spicules absent.

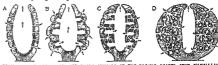
For more detailed study of sponge taxonomy, consult monographs and special publications listed by G. C. J. Vosmaer.

Histology.—The differentiation of cells in sponge tissues is much less pronounced than in the higher forms which possess various organs or systems such as digestive tracts, musculature, kidneys, etc., lacking in Porifera-



FROM L. H. HYMAN, "THE INVESTERRATES: PROTOZOA THROUGH CTENOPHORA" (MCGRAW-HILL, 1840)

FIG. 5.—POROCYTE OF LEUCOSO-LENIA WITH SURROUNDING CHOAN-OCYTES; 1, POROCYTES; 2, CHOANO-CYTES; 3, INWARD-LEADING PORE; 4, PORE DIAPHRAGM In spite of the low degree of organization, cellular elements of the sponge body are specialized to perform definite functions. Several distinct categories of cells can be distinguished in sponge tissues. The first group comprises various cells of the cortex and of the



FROM JOHNSON AND SHOOK, "SEASHORE ARREADS OF THE PACIFIC COAST" (THE MACMIL CO., 1927)

Fig. 6.—Diagram of various types of sponge organization A, assandd; B, Syconold, without cortex; C, final syconold, with cortex; D, Leuconold. Cheanocyte layer shown in heavy black, mecenchyme cross-hatched. Arrows indicate the direction of water current

lining of the canals and central cavity. The pinacocytes, as these cells are called, form a single layer of epithelium consisting of flattened platelike elements with a large nucleus in the thicker portion of the cell. Sometimes the pinacocytes are provided with the cilia which help in maintaining the current of water. According to Wilson, in some of the sponges the true epithelium is replaced by a continuous "epithelioid membrane" or syncytium with scatered nuclei. The intake of water is regulated by means of special cells, porocytes, pierced by a canal and supplied with a highly con-

tractile diaphragm consisting of a thin sheet of cytoplasm stretched across the opening (fig. 5). The origin of porocytes, which by some of the investigators are considered as degenerate cells, has not yet been determined.

The flagellated cells or choanocytes lining the flagellated chambers are typical structures of sponge organization. They are easily recognized by transparent contractile collars and long flagella (fig. 4) attached to the cell body by means of a basal granule. In appearance and structure the choanocytes resemble the flagellated Protozoa of the family Craspedomonadidae. One representative of this group, a colonial protozoan Proterospongia (fig. 16), is regarded as a probable link between the sponges and flagellates.

The inner layer of a sponge body consists of transparent intercellular ground substance of variable consistency which gives support or acts as a scaffolding for widely separated mesenchyme cells. The latter are represented by different kinds of amoebocytes, or wandering cells, varying in size, character of pseudopodia, and type of inclusions. The mesenchyme also contains a large number of undifferentiated cells called archaeocytes, which may develop into more specialized types and apparently play an important role in regeneration. Mesenchyme cells which secrete spicules and spongin fibres are called scleroblasts. According to the type of skeleton they produce (fig. 12), they are designated as calcoblasts (secreting calcite



FROM RAY LANGASTER, "TREATISE ON ZOOL-OGY," PART II, "THE PORIFERA" BY E. A. MINCHIN, ADAM & CHARLES BLACK, LONDON (THE MACMILLAN CO., NEW YORK AGENT)

FIG. 7.—ESPERIOPSIS CHALLEN-GERI, A DEEP-SEA SPONGE WITH A SECONDARY SYMMETRY spicules), silocoblasts (producing siliceous spicules) and spongio- calcareous sponges CaCO3 content of ash varies from 84.9% to blasts (forming spongin fibres).

The sex cells, ova and spermatozoa, are apparently derived

from choanocytes which lose their flagella and collars and penetrate into mesenchyme. During this stage they look like true amoebocytes. Because of this similarity the old view maintained in the last century by F. E. Schulze, N. Polejaeff and O. Maas that the germ cells arise directly from amoebocytes cannot be discarded without further study.

True muscles in sponges are wanting. but special fusiform contractile cells, the mvocvtes. somewhat resembling smooth muscle cells of higher forms have been described. In certain species they form sphincters which regulate the afferent stream of water (fig. 9). Sensory and nerve cells are absent. The contractions of the surface of the body, or of the oscula, noticeable in some of the species, are the result of the direct stimulation of the pinacocytes and myocytes.

Skeleton.-Soft tissues are supported by a complex framework of hard spicules made of calcite (CaCO<sub>3</sub>) in calcareous sponges or of opal (SiO2nH2O) in siliceous sponges. In horny sponges the skeleton consists of a meshwork of elastic fibres made of spongin, an albuminoid of a highly complex chemical structure. The spicules vary in size, shape, and number of axes. Since the taxonomists use them as principal characters for the identification of sponges, elaborate terminology has been developed for designating various skeletal elements (fig. 10). In general there are two principal types: the large skeletal spicules, the megascleres which form the framework of the sponge body; and the small microscleres of variable and irregular shape scattered throughout the tissues.

Various classes of spicules are distinguished by the number of their axes or rays. Thus, monaxon designates the needlelike spicule with one axis; tetraxon has four rays emerging from one point and extending into different planes; three axes Fig. crossing at the right angles typical for DRY SPECIMEN (AFTER Hexactennellid sponges produce an element with six rays (fig. 11) or triaxon; several equal rays emerging from a central point characterize the polyaxons known TRAL CONE: 3, also as asters. The classification and the corresponding terminology become greatly

involved as various modifications caused by the loss of rays, bending of axes, etc., are taken into account and each type denoted by special term.

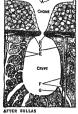
Mineral substance of a spicule is deposited around a central axis of organic material. In siliceous sponges the silica is laid in the form of concentric cylinders. Usually two scleroblasts (fig. 12) participate in the formation of a monaxon spicule which is laid down by one of them, the founder, while the other, the thickener, deposits additional mineral material. When the spicule is completed the two cells move apart. Several cells combine in secreting more complex spicules and spongin fibres (fig. 12. K, 0).

Chemical Composition.—Mineral constituents of the skeleton comprise a very large portion of sponge body. From 15% to 97% of the ash of siliceous sponges consists of SiO2, while in



8. - HYALONEMA, SCHULZE. 1887). HEXACTINNELID SPONGE WITH ROOT SPICULES: 1. ROOT SPICULES: 2, GAS-OTIC ZOANTHIDS ON ROOT 86.8%. Other mineral constituents include MgO, P2O5, Fe2O3Al2O3, Na2O, K2O, SO3, Si and minute quantities of Mn. Zn. B. Br. Cu and As.

The presence of relatively large quantities of iodine in dried commercial sponges, first demonstrated in 1819 by Andrew Fyfe, is of considerable scientific interest. It is known that iodine present in various species occurs in a combination with an organic compound of the skeleton known as iodospongin. The percentage of iodine in iodospongin varies from 1.5% to 4.86% in bath sponge (Euspongia sp.) to 8%-10% in Luffaria cauliformis. More detailed studies identified the iodine compound obtained from spongin as di-iodotyrosine, a complex which also contains bromine. Calcareous and siliceous sponges are, as a rule, poor in iodine; but the red sponge Microciona prolifera is apparently an exception, for according to the determinations made in 1933 by W. Bergman its iodine content comprises 0.3% of the



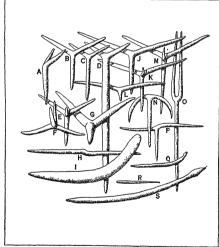
WHICH REGULATES THE AFFERENT STREAM IN CYDONIUM EOSASTER, A GRAPNEL-SPONGE

(A) Dermal pores; (B) Solid-stars; (C) Contractile cells; (D) Grapnel spirule; (E) Flagellate chambers;(F) Inward-leading canals; (G) Afferent canal

total dry weight. The physiological role of the iodine in sponge body is not known.

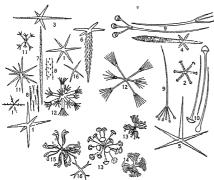
Physiology.—The water pumping mechanism of sponges consists of thousands of choanocytes which line the flagellated chambers. Because of their position inside the sponge body and small size, their action is difficult to observe. Only in calcareous sponges are the choanocytes relatively large and therefore observable with less difficulty. In action the flagellum of a choanocyte makes an undulating spiral movement which starts at its base and proceeds toward the tip. As the flagellum points toward the out-

ward leading pores, apopyles (fig. 4), each of its strokes draws



FTER MINCHIN IN LANKESTER'S "TREATISE ON ZOOLOGY" (A. R. C. BLACK)

FIG. 10.-CALCITE SPICULES OF CHALKY SPONGES [16, 10,—CALCITE SPICULES OF CHALKY SPONGES (A, B, E, F, G), Ascadits cerbrum lacunosa; (C) Clathrina blanca; (D, H) Clathrina lacunosa; (1) Luce-chalkts: 4'-candra falcata; (J, K) +chaped (alate) spicules of Leucosofenia variabilis; (L) alate and (O) tuning-fork spicule of Leucosofenia variabilis; (L) alate and (O) tuning-fork spicules of Leucosofenia variabilis; (L) alate and (O) tuning-fork spicules of Leucosofenia variabilis; (R) needle and (Q) lance-spicule of Leucosofenia variabilis; (R) needle and (S) lance-spicule from Leucosofenia complicata chamber. The pressure so produced stretches the walls of the flagellated chamber and is extended to the outward leading canals and central cavity. Apparently there is no co-ordination of the beating of the flagella, each choanocyte working more or less independently of the others. As a result of the movement of thousands of minute flagella the water is sucked into the flagel-



FROM L. H HYMAN, "THE INVERTEBRATES PROTOZOA THROUGH CTENOPHORA" (NCGRAW HILL,

FIG. 11 .- SPICULES OF HEXACTINELLID SPONGES

1, hexactines; 2, spiny hexactine; 3, modified hexactine with one long ray; 4, pinulated hexactine; 5, 6, pentacts; 7, unclinate; 8, small part of uncinate greatly magnified; 9, scopules; 10, calvules; 11, cxyhexatters; 12, discoctasters; 13, discohexasters; 14, plumicome; 15, floricome; 16, stau-

lated chambers through the dermal pores and inward leading canals and escapes through the outward leading canals and oscula. The velocity of current in each flagellated chamber is rather slow, but as thousands of tiny pumps deliver water into a relatively small number of vents, or oscula, the rate of the current increases. G. P. Bidder showed that in Leucandra aspera the current velocity at the osculum was about 8 cm. a second, while the velocity at the same moment past collar cells was only from 2 cm, to 4 cm, an hour. The pressure inside the oscula can be measured by inserting a glass tubing of corresponding diameter and observing the height of the water column above the surrounding level. By this method G. H. Parker found that hydraulic pressure in Stylotella was about 4 mm. These observations and other indirect methods can be used to compute the rate of pumping water by the whole sponge. According to Bidder, Leucandra aspera requires about 5 gal. of water a day and discharges it at a distance of about 9 in, from its body. A fingerlike branching sponge, Spinosella sororia, was observed by Parker to filter 1,575 litres of water per day. F. G. Walton Smith, working with cultivated horny sponges in the Bahamas, found that a wool sponge of 500 cu.cm. in volume pumped approximately 2 litres per minute. At this rate its daily requirement may be estimated at about 600 gal., but observations are still lacking to determine whether such a rate of pumping is maintained for 24 hours a day.

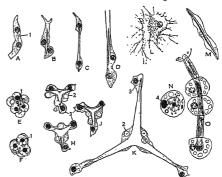
The flow of water through the body, maintained by the beating of the flagella, is regulated by the contractions and expansions of the oscula and dermal pores. In spite of the absence of any co-ordinating centre, the pumping mechanism works with great efficiency. The water sucked in by the sponge moves very slowly through the dermal pores, inward leading canals, and flagellated chambers, and provides the tissues with food and oxygen for respiration. Since the outgoing currents discharged through the oscula have much greater velocity, the water filtered by the sponge and contaminated with the products of its metabolism, is discharged far away and cannot be re-used. The presence of toxic or irritating substances dissolved in water is easily detected by the porocytes, which react by contracting their diaphragms

a little water and pushes it forward, gradually filling up the and closing the pores. In this way the sponge protects itself against possible injury. Structure and functioning of the pumping mechanism can be regarded as an efficient adaptation of sponges to the sedentary conditions of life in the ocean.

Food and Nutrition.-The food of sponges consists of minute organisms suspended in water. Bacteria probably play an important role in the feeding of horny sponges which frequently inhabit waters containing but small numbers of other micro-organisms in suspension. Thus, for instance, principal commercial species of sponges in the Bahamas are found on mud bottoms in waters containing very abundant bacterial flora but poor in plankton. The role of bacteria in the feeding of sponges has not been, however, adequately studied and requires further inves-

Ingestion and digestion of food can be observed by feeding the sponges with easily identifiable materials such as carmine or carbon powder, milk, starch grains or bacteria, and examining their tissues at regular intervals after feeding. As the flow of water passing from the narrow inward leading channels slows down after entering the flagellated chambers, the suspended particles settle and are caught by collar cells. In calcareous sponges the material entrapped in the collars of choanocytes becomes engulfed and digested by the cytoplasm. Some of the particles may be passed, however, to the amoebocytes surrounding the flagellated chambers (fig. 13). More complete division of functions exists in siliceous sponges. Here food is also caught by the choanocytes but digestion is accomplished only by amoebocytes.

Respiration.-Since special organs of respiration and circulation are lacking, the need for oxygen is supplied through direct exchange between the tissues and the surrounding water. Consequently, the rate of metabolism (O2 consumption) is controlled by the rate of exchange of water. Hyman found that the O2 consumption in Sycon may decrease by 80% when the oscula are closed. The observed rates per hour in this sponge vary from 0.04 to 0.16 ml. of oxygen per gram of fresh weight. The figures are of the same degree of magnitude as those observed for many other marine invertebrates. Sponges have no organs of excretion. Products of their metabolism and indigestible material,



-SECRETION OF MONAXON, A-D. AND TRIRADIATE (E-K) SPIC-ULES (AFTER WOODLAND, 1905); L, CALCOBLAST (AFTER DENDY, 1893); M, SILICEOUS MONAXON OF FRESH-WATER SPONGE (AFTER EVANS, 1901); N, O. SECRETION OF SPONGIN IN RENIERA (AFTER TUZET, 1932); 1. SPICULE; 2, FOUNDER; 3, THICKENER; 4, SPONGIN MASS

ejected by the amoebocytes, are discharged with the outgoing currents.

Poisonous and Injurious Sponges .- The surface of many sponges is slimy because of the excretion of mucous, which may cause unpleasant but not dangerous irritation of the skin. For instance, the scarlet sponge of the Bermuda islands, Tedania ignis, when handled with naked hands, causes painful dermatitis. The nature of the active substance is not known. Of special in- still arranged in one plane. After the 32-cell stage has been terest are the boring sponges of the genus Cliona, widely distributed in the coastal water of North America. As the name indicates, the sponge bores through the shells of oysters and other molluscs and in case of severe infestation may destroy them. The method by which the sponge makes its long and branching passages in the shell substance is not known. Secretion of acid has been suggested but not corroborated by observation. Studies conducted by P. S. Galtsoff and V. Pertzoff in 1926 showed, however, that the suspension of cells of Cliona behaves as a much stronger acid than that of the nonboring sponge Microciona. Mechanical action may also be involved in boring, but the process has not yet been adequately studied.

Regeneration .- The power of regeneration, i.e., the ability to restore lost parts, is very high in sponges. Not only is a piece cut off from a body capable of growing into a complete sponge, but the cells separated by squeezing a piece of sponge through fine silk cloth, and suspended in water, reunite and develop into a new spenge. The phenomenon discovered by Wilson in 1907 is of considerable theoretical interest. It was thought first that the development of a new sponge from reunited masses is to a certain extent similar to the development of an embryo, and that the separated cells undergo dedifferentiations and return to the embryonic state. It was shown by P. S. Galtsoff that certain cells retain their morphological characteristics and the first steps in regeneration are accomplished by the sorting out and rearrangement of the old cellular material.

Under unfavourable conditions sponges collapse, disintegrate and leave only small reduction bodies which consist of a mass of amoebocytes covered by epidermis. With the return of normal conditions these bodies are capable of developing into complete sponges.

Asexual Reproduction .-- All fresh-water and some marine sponges reproduce by means of gemmules, small, hard and rounded bodies consisting of a mass of archaeocytes laden with reserve food and surrounded by a columnar layer of flattened cells (fig. 14). The formation of gemmules in fresh-water sponges begins with the gathering of amoebocytes, which are joined by special nurse cells, the trophocytes, carrying food reserves. Some of the amoebocytes arrange themselves in columnar layers and secrete two concentric membranes around the central core. The inner membrane is usually much thicker than the outer. The growing gemmule is invaded by the scleroblasts, which secrete the so-called amphidisks, the spicules having the appearance of ordinary cuff links, and place them between the two membranes of the columnar layer. The amazing part of cell behaviour is that when the gemmule is completed, the columnar cells, nurse cells and scleroblasts depart.

Fresh-water sponges usually disintegrate with the onset of cold weather but gemmules survive and hatch in spring. The content of the gemmule emerges through a small opening, the micropyle (fig. 14, [11]), and develops into a new sponge through the differentiation and rearrangement of the archaeocytes.

Sexual Reproduction.-Hermaphroditism is apparently prevalent among the sponges, although in some of them the sexes are separate. Fertilization of the ovum, studied by J. B. Gatenby in calcareous sponges, is rather unique, for the sperm brought in by current of water first enters the choanocyte which acts as a nurse cell. The fusion of the choanocyte with the nearest egg, which occupies a position close to the flagellated chamber, sets the sperm free. Insemination is then accomplished in a regular manner.

Similar process was described by O. Tuzet in siliceous sponges, with the only difference that sperm enters the amoebocyte, which in turn transfers it to the egg.

Detailed information about the breeding periods of sponges is lacking. In the commercial sponges of the Bahamas (sheepswool and velvet) breeding takes place all the time, but the greatest proportion of specimen with embryos ready for release were found by F. G. W. Smith in March and April.

Development.—The fertilized egg divides into two, four and eight blastomeres which surround a central cavity while they are

reached the divisions become somewhat irregular. At this time the embryo, called now blastula, has a shape of an oval vesicle, one end of which is flattened and the other rounded. The central cavity of the blastula opens to the exterior at the flattened sur-



H. HYNAN, "THE INVERTEBRATES: THROUGH CTENOPHORA" (MCGRAW-FIG. 13 .-- AMOEBOCYTE OF A CAL-

BON PARTICLES FROM CHOANG-CYTES (AFTER POURBOIX, 1933): 1. CARBON PARTICLES

face. This opening or pore is surrounded by the cells distinguishable from the others by heavy granular inclusions, while the remaining cells are columnar and have long flagella.

Rapid proliferation of granular cells produces a thick mass which bulges into the central cavity (fig. 15A). By this time the embryo, by means of the flagella, forces its way into the nearest CAREOUS SPONGE RECEIVING CAR- flagellated chamber and escapes through the osculum. Apparently through the absorption of water, the layer of invaginated

cells is forced out and the embryo acquires an oval shape. The sponge larva at this stage is called amphiblastula, from Greek, amphi, around or on both sides and blastos, germ, (fig. 15, B). One half of it consists of columnar and brightly pigmented cells with long flagella, the other half is made of round granular cells. The amphiblastula type of larvae occurs in all families of sponges and is, therefore, typical of the entire group. The larva swims with its ciliated end forward. After a few days of free life it settles on a smooth surface of a stone or shell, with its ciliated portion directed downward, and almost immediately flattens. The ciliated cells become invaginated and the central cavity of the larva, the blastocoele, reduced to a narrow slit. The larva now becomes attached to the substratum. At this stage it consists of two layers. The granular cells form the outer covering and the flagellated cells line the inside cavity. Very soon the flagellated cells develop characteristic collars and are transformed into choanocytes. The appearance of the granular substance between the two layers, the formation of the pores and osculum, and the secretion of spicules complete the development. At this stage the young sponge is usually referred to as "olynthus." Its final transformation into an adult sponge is a matter of continuous slow growth and rearrangement of cellular elements. Although the details of the development may vary in different classes and families the essential steps are similar in all of them.

Individuality of Sponges.-Lack of a central regulatory or co-ordinating organ, great variability in shape or form, and remarkable regenerative power, make it difficult to decide whether sponges are individuals or colonies. This theoretical question, much debated by the zoologists of the last century, has not yet been satisfactorily settled. It is generally considered that the osculum with the contributing part of the canal system is an individual element or a "person," and that several of these units are combined in a colony of individuals grown together and performing common functions. The fact that the osculum controls the flow of water through the adjacent part of the body and is the most conspicuous part of the sponge anatomy, seems to give weight to this view. The boundaries of individual units are, however, indistinct and their individuality is of very vague nature. It is remarkable that, in spite of the absence of central organs, many species of sponges developed very definite shape and symmetry. Their skeletons also show progressive complexity from a rather simple arrangement of spicules to a very complicated symmetrical framework built according to a definite structural pattern.

Relationship.—On the basis of our knowledge of the anatomy and histology of sponges, it is reasonable to suppose that this group evolved from colonial choanoflagellate Protozoa similar to Proterospongia (fig. 16). In the subsequent evolutionary process sponges formed a separate branch of Metazoa which failed to develop higher grades of organization characterized by the formation of a head, nervous system, organs of digestion, circulation and respiration present in other multicellular forms. The sponges

retained their ancestral protozoan features in the structure of choanocytes, in the intracellular digestion, and in the mode of production of the skeleton, the elements of which are secreted by single cells or group of freely moving cells. Progressive evolution in sponges consisted chiefly in the perfection of the canal system and in developing a more complex skeleton. Sponges appeared very early in geological history, for their spicules are found in the upper Cambrian deposits.

Ecology .- The distribution of sponges is world-wide. They inhabit all the oceans, seas, freshwater lakes and rivers, and grow on all kinds of bottoms from tidal flats to abvssal depths. Their most favoured environment is,

however, that of rocky or hard bottom along the seashores and in coral-reef lagoons. The greatest percentage of more than 2,500 known species of sponges is confined to this habitat. Close association with other invertebrates seems to be one of the most interesting features of sponge ecology. Porous structure and numerous cavities of sponge body provide safe abode for hydroids, worms, shrimps, crabs, molluscs and other invertebrates. Some of these animals invade the sponges accidentally, while others form more permanent association. Thus, thousands of shrimps of the family Alpheidae are found in every loggerhead sponge of the British West Indies. The young shrimp of the genus Spongicola enter the cavity of glass sponges (Hexactinellida), where they live in pairs and soon become imprisoned because their grown-up bodies cannot escape through the small openings of the sieve plates guarding the oscula of their host. Sponges of the family Suberitidae are often found overgrowing snail shells occupied by hermit crabs. The relation is obviously advantageous for both parties. The crab is well protected by sponge spicules and its repelling taste, while the sponge is carried about by the crab and gets better opportunities for feeding. Crabs of the genus Dromia break pieces of sponges with their legs and place them on their backs where the sponge becomes implanted.

Sponges are apparently distasteful to other animals and are usually avoided. They are eaten only by a few species of nudibranch molluscs.

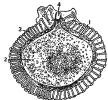
Diseases.-Widespread mortalities frequently occur among commercial sponges. In the fall of 1938 a devastating disease which rapidly spread from the Bahamas to Cuba, British Honduras, Mexico and the east coast of Florida almost completely destroved the velvet sponge and killed more than 70% of wool sponges. The disease was associated with an infection by a funguslike micro-organism tentatively identified as Spongiophaga. No control measures were suggested to check the infection except the closing of grounds to commercial fishery.

Utilization of Sponges.-Horny sponges (Keratosa) have been in use from the earliest times. In ancient Greece, mothers pacified their crying babies by giving them a piece of sponge soaked in honey. According to Pliny, sponges were employed as paint brushes and mops, and Roman soldiers carried with them a piece of sponge to be used instead of a drinking vessel. This custom makes comprehensible the manner in which vinegar was offered to Christ on the cross-in a soaked sponge (Mark XV, 36). In the 13th century A.D. Arnold of Villa Nova introduced the "burnt sponge" as medicinal preparation to be used internally in scrofula, a term which usually refers to tuberculosis of lymphatic glands, but formerly also covered other diseases. The therapeutic effect, if any, was possibly due to a high content of iodine present in the carbonized sponge in the form of NaI.

TABLE 1.—Common and Scientific Names of Principal Commercial Sponges						
Common Name	Scientific Name	Fishing Areas				
Turkey cup; Turkey solid, Fine Levant; Silks	Euspongia officinalis molissima	Eastern Mediterranean, Tunis				
Turkey toilet	Euspongia officinalis adriatica	Adriatic, Tunisia, Eastern Mediter-				
Zimocca	Euspongia simocca	Adriatic, Dardanelles, Greece, Egypt, Tripoli, Tunisia				
Elephant's ear	Euspongia officinalis lamella	Provence, Dalmatia, Egypt, Tunisia, Algeria				
Honeycomb; bath	Hippiospongia equina elastica	Mediterranean				
Wool; sheepswool	Hippiospongia lachne	Florida, West Indies, Honduras				
Velvet	Hippiospongia grossypina	Bahamas, Honduras, Cuba				
Yellow	Spongia barbara. Probably also other species					
Grass	Spongia graminea	Florida, Bahamas, Cuba, Mexico, British Honduras				
Glove	Hippiospongia canaliculata var. flabel- lum	Florida, Bahamas				
Reef	Spongia obliqua, and probably S. aga- ricina and other species	Florida				
Hardhead	Spongia dura, S. agaricina corlosia and probably other species	Bahamas, British Honduras, Haiti				

In modern times, besides obvious toilet and household uses, sponges are required for scores of purposes such as the manufacture of special surgical and hygienic preparations, leather dressing, application of glaze to fine pottery, scouring and sponging of cloth. They are extensively employed by tile and bricklayers, painters, decorators, lithographers, jewellers and silversmiths. Probably the largest number of sponges is used for washing railroad cars and automobiles.

Industrial Types.—The trade recognizes several types which correspond to different species listed in Table I. There is, how-



FROM L. H. HYMAH, "T PROTOZOA THROUGH CTE HILL, 1940)

FIG. 14 .-- THE GEMMULE OF A EVANS, 1901); 1, INNER MEMBRANE; 2. MASS OF ARCHAEOCYTES; 3, A LAYER OF AMPHIDISKS: 4. MICRO- ever, no general agreement regarding the specific names of different varieties of commercial sponges.

259

Good commercial sponges occur also in the Philippines and in Australia. Contribution to the world trade of sponges from these countries is, however, insignificant. Several varieties of horny sponges of the Hawaiian Islands are not suitable for the trade because of their extreme softness and lack of durability.

The annual world production FRESH-WATER SPONGE, EPHYDATIA, of sponges in 1938, the last "nor-WITH INNER MEMBRANE (AFTER mal" year before World War II, was estimated at 2,102,400 lb., valued at \$2,556,398. The U.S. contributed 28.8% of the total catch and 41.9% of the total

value. The contributions of the principal sponge producing countries for the years 1938 and 1939 are shown in Table II.

In 1943 the production of sponges in the U.S. dropped to 3e5,-822 lb., almost one half of that of 1938, but the value increased to \$2,305,070.

The most valuable of the commercial sponges are the Turkey Cup and Turkey Toilet. Best specimens of these varieties sometimes are sold as high as \$50 per pound. The total quantity of these high priced sponges offered on the world's market is, however, insignificant in comparison with the wool sponge, which in the western hemisphere constitutes about 80% of the catch.

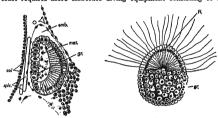
Fishing Methods.—Commercial sponges are taken from the bottom of the sea from tidal level to a depth of about 200 ft. In the shallow inshore waters the sponges are picked by means of a two- or three-pronged hook attached to a long pole. The hooker, as the fisherman is called, operates from a small skiff which he pushes by pole. When the sponge is noticed, sometimes at the depth of 25 or even 30 ft., the pole is lowered and the hook

Table II -Estimated World Production of Sponges

	1938		1939	
Country	Quantity (pounds)	(U S. dollars)	Quantity (pounds)	(US dollars)
United States	606,000	\$1,070,848	484,400	\$1,161,945
Bahamas	670,000	400,000	470,000	120,000
Cuba	410,000	205,000	330,000	230,000
Greece	87,000	262,680	78,000	100,000
Italvi	130,000	210,000	*	*
Egypt	1	t '		
Turkey	75,000	180,000	55,000	150,000
Libya	70,000	120,000	٠ ٠	*
Caicos Islands	19,500	11,000	6,850	2,500
Syria-Lebanon .	3,000	4,500	*	*
British Honduras	1,100	1,770	1,960	2,660
Philippine Islands	800	600	350	250

\*No data available; †100,000 pounds produced in Egypt included in the Greek and Italian production because taken by fishermen of those nationalities; ‡except Libya. \$\frac{2}{5}\cappaignoin \text{cappaignoin} \text{ Nassau not included.}

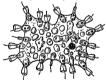
placed under the sponge, which is then detached from the bottom by a slight pull and is brought to the surface. This primitive and slow method of fishing can be used only in clear and calm inshore waters. Nude diving, without equipment of any kind, is still practised in Greece, along the Libyan coast and in the Philippines. Fishing in the deeper water near Greece and off the Florida coast requires more elaborate diving equipment consisting of a



HOBBIDE, "TEXTBOOK OF EMBRYOLOGY" (MACHILLAN CO., 1914) FIG. 15 -- DEVELOPMENT OF GRANTIA LARVRINTHICA (AFTER DENDY) FIG. 10.—DEVELUPMENT OF GRANIA LAUTRINTHICA (AFTER DEMDY)
A, blastula in the embryonic chamber of the mother; B, amphiblastula larva.
Col., collared cells lining flagellated chamber; emb., embryonic chamber; fl.,
flagellated cells; gr., granular cells; mes., mesenchyme cells; spio., maternal
spicules. Magnified

regular diving suit, scaphander and boat with mechanically operated air pump. A small dredge, known as "gangave," is used in Libya. The implement is very destructive and its use is prohibited in the western hemisphere. Sponges caught in the Bahamas, Cuba, Turks and Caicos islands are picked exclusively by hookers

Sponges gathered by divers or hookers are cleaned aboard the boat or placed in "crawls," i.e., small ponds along the shore where the soft parts of sponge tissues rot. The remaining skeletons are



L. H. HYMAN, "THE INVERTEBRATES: DZOA THROUGH CTENOPHORA" (MCGRAW-Fig. 16 .- PROTEROSPONGIA (AFTER KENT, 1881). A COLONIAL FLAGEL-

AND SPONGES

taken out, squeezed, rinsed in water, strung in clear sea bunches and dried in air.

An interesting feature of the sponge industry in the U.S. is a co-operative selling association, the Tarpon Springs Sponge exchange, which auctions all the sponges brought by fishermen. A similar organization, but under direct control of the colonial government, was established in Nassau. Bahamas. The auction is LATE CONSIDERED AS A PROBABLE rather unique, for the selling is LINK BETWEEN THE FLAGELLATES conducted in complete silence. As the buyers examine the vari-

ous lots of sponges they write down on a piece of folded paper the highest price they are willing to pay and hand it to the auctioneer. When the auction is over the bids are opened by the representative of the association and the highest bidder is awarded the sponges, provided the price is acceptable to the owner. Before reaching the retail market sponges are sorted, cleaned, bleached and sometimes dyed.

Conservation .-- At the end of World War II, no system of conservation or management of natural sponge resources was being exercised by any government. The only protection effective in the U.S., Bahamas, Turk and Caicos islands consisted in the enforcement of the size limit laws which prohibit the taking and selling of sponges less than five inches in diameter.

Sponge Farming or Sponge Culture.-Because of their high regenerative power, sponges can be grown from small cuttings. Experiments in this method of cultivation were made at the end of the last century by H. F. Moore in Florida and were also conducted on a larger scale in the estuarine waters of Tunisia. The practicability of the method was definitely demonstrated by large scale operations conducted by the British government in the West Indies and British Honduras. From 1935 to 1939 more than 140,000 sponges were growing on government grounds in the Bahamas, and more than 700,000 cuttings were planted at Turneffe, British Honduras. Unfortunately, the mortality of 1938-39 was particularly severe among the cultivated sponges and the beds were almost completely destroyed.

The farming method consists in growing sponges from rectangular slices about 2" x 4" x ½", cut with a very sharp knife from a healthy sponge and attached with a string to a piece of rock or cement disk. The cuttings are immediately placed in water. From 16 to 32 pieces can be cut from one adult wool sponge of six to eight in. in diameter. Regeneration begins immediately and the sponge, firmly adhering to its base, grows as a well-shaped round specimen. In the Bahamas, sponges grown from cuttings reach marketable size in about four years.

If correctly conducted, sponge culture may become a profitable occupation, but because of the scarcity of suitable inshore grounds it cannot replace the fishery on natural grounds. The possibility of propagating sponges through sexual reproduction has not vet been explored.

BBILIOGRAPHY.—E. A. Minchin, "Porifera," Ray Lancaster's Treatise of Zoology, v. ii (1900); I. B. J. Sollas, "Porifera," Cambridge Nat. Hist., v. i (1900); L. H. Hyman, The Invertebrates, Protozoa through Ctenophora, pp. 284–364 (1940); G. P. Bidder, "The Relation of the Form of a Soonge to its Currents," Quart. Journ. Micr. Sc., v. 67 (1923); P. S. Galtsoff, "Regeneration after Dissociation," Parts I and Form of a Sponge to its Currents," Quart. Journ. Micr. Sc., v. 67 (1923); P. S. Galtsoff, "Regeneration after Dissociation." Parts I and II, J. Exp. Zool., 42 (1925); P. S. Galtsoff and V. Petrzoff, "Some Physiochemical Properties of Dissociated Sponge Cells," J. Gen. Phys., x (1926); P. S. Galtsoff, H. H. Brown, C. L. Smith and F. G. W. Smith, "Sponge Mortality in the Bahamas," Nature, v. 124, (1939); J. B. Gatenby, "Germ Cells, Fertilization and Early Development of Grantia," Journ. Linn. Soc., 34 (London, 1920); jurther notes, etc., Quart. Journ. Micr. Sc., 71 (1927); A. Hyatt, "Revision of the N. American Porifera," Mem. Bost. Soc. Nat. Hist, v. ii, Part iv (1877); M. W. deLaubenfels, "A Discussion of the Sponge Fauna of the Dry Tortugas," Carn. Inst. of Washington, Papers from Tortugas Laboratory, v. 30 (1936); R. V. vonLendenfeld, "A Monorgraph of the Horny Sponges," Acr. Nov. Soc. (London, 1889); H. F. Moore, "The Commercial Sponges and the Sponge Fisheries," Bull, U. S. Bur. of Fisheries, v. xviii (1908) (1910); G. H. Parker, "On the Strength and the Volume of the Water Currents Produced by Sponges," J. Exp. Zool., v. 16 (1914); N. Polejaeff, "Report on the Keratosa," Challenger Reports, Zoology, v. xi (1884); G. C. J. Vosmaer, A Bibliography of Sponges, 1515—103 (Cambridge, 1928); H. V. Wilson, "The Sponges," Mem. Mus. Amp. Zool. Harv. Univ. 30 (1904) and "On some Phenomena of Coalescence and Regeneration in Sponges," J. Exp. Zool., v. v. (1907); H. V. Wilson and J. T. Penney, "Regeneration of Sponges from Dissociated Cells," J. Azp. Zool., v. 5 (1930). Penney, "Regenerati Zool., v. 56 (1930). (P. S. G.)

SPONSOR, one who stands surety for another (from Lat. spondere, to promise), especially in the rite of Christian baptism, a godfather or godmother. The practice originated not in infant baptism, but in the custom of requiring an adult pagan who offered himself for the rite to be accompanied by a Christian known to the bishop, who could vouch for the applicant and undertake his supervision, thus fulfilling the function performed in the Eleusinian mysteries by the mystagogus. The Greek word for the person undertaking this function is araboxos, to which the Latin susceptor is equivalent. The word "sponsor" in this ecclesiastical sense occurs for the first time, but incidentally only, and as if it were already long familiar, in Tertullian's treatise De baptismo (ch. 18), where, arguing that in certain circumstances baptism may conveniently be postponed, especially in the case of little children, he asks, "For why is it necessary that the sponsors like-

wise should be thrust into danger, who both themselves by reason Jan. 14, 1851. of mortality may fail to fulfil their promises, and may also be disappointed by the development of an evil disposition [in those for whom they become sponsors?"

The sponsors here alluded to may have been in many cases the actual parents, and even in the 5th century it was not felt to be inappropriate that they should be so; Augustine, indeed, in one passage appears to speak of it as a matter of course that parents should bring their children and answer for them "tanquam fidejussores" (Epist. . . . ad Bonif. 98), and the oldest Egyptian ritual bears similar testimony. Elsewhere Augustine contemplates the bringing of the children of slaves by their masters. and of course orphans and foundlings were brought by other benevolent persons.

The comparatively early appearance, however, of such names as compatres, commatres, propatres, promatres, patrini, matrinae, is of itself sufficient evidence, not only that the sponsorial relationship had come to be regarded as a very close one, but also that it was not usually assumed by the natural parents. How very close it was held to be is shown by the Justinian prohibition of marriage between godparents and godchildren. On the other hand, the anciently allowable practice of parents becoming sponsors for their own children, though gradually becoming obsolete, seems to have lingered until the 9th century, when it was at last formally prohibited by the council of Mainz (813). For a long time there was no fixed rule as to the necessary or allowable number of sponsors and sometimes the number actually assumed was large. By the council of Trent, however, it was decided that one only, or at most two, these not being of the same sex, should be permitted.

The rubric of the Church of England, that "there shall be for every male child to be baptized two godfathers and one godmother, and for every female one godfather and two godmothers," is not older than 1661; the sponsors are charged with the duty of instructing the child, and in due time presenting it for confirmation. In the Roman Catholic Church the spiritual relationship established between the sponsor and the baptized, and the sponsors and the parents of the baptized, constitutes an impediment to marriage. (See MARRIAGE, LAW OF: Canon Law.)

SPONTINI. GASPARO LUIGI PACIFICO (1774-1851), Italian composer, was born on Nov. 14, 1774, at Majolati (Ancona) in Italy. He was the son of a poor cobbler and was intended for the priesthood. But he obtained lessons from Kapellmeister Quintiliani, and in 1791 went to the Conservatorio de' Turchini at Naples, where he studied under G. Paisiello, D. Cimarosa and Fiorivanti. By 1799 he had already written and produced eight operas, After becoming court composer to King Ferdinand of Naples in this year an intrigue with a princess of the court compelled Spontini to leave Naples in 1800. In 1803 he settled in Paris, where he had no success until the production of Milton, a one-act opera, in 1804. Thereafter his powers and ambitions steadily developed, being manifested to the full for the first time in La Vestale, produced on Dec. 15, 1807. Ferdinand Cortez was received with equal enthusiasm in 1809; but Olympia (1819) had less success.

Spontini had been appointed director of the Italian opera in 1810; but his quarrelsome and grasping disposition led to his summary dismissal two years later, and though reinstated in 1814, he voluntarily resigned his post soon afterward. In 1820 he settled in Berlin by invitation of Frederick William III, commissioned to superintend all music performed at the Prussian court and compose two new grand operas, or three smaller ones, every three years. But he began by at once embroiling himself with the intendant, Count Brühl. La Vestale, Ferdinand Cortez and Olympia-the last two entirely remodelled-were produced with great success in 1821. But Spontini's fame was entirely eclipsed by the appearance of Carl Weber's Der Freischütz. A new opera, Nourmahal, founded on Thomas Moore's Lalla Rookh, was performed in 1822, and another, entitled Alcidor, in 1825; and in 1826 Spontini began the composition of Agnes von Hohenstaufen, (produced in 1829), which undoubtedly will rank permanently as his greatest work.

Dismissed from his court position in 1841, he settled in Paris. In 1850 he retired to his birthplace, Majolati, and died there on

SPOON, a table implement, bowl-shaped at the end, with a handle varying in length and size. From the derivation of the word the earliest northern European spoon would seem to have



BY COURTESY OF THE METROPOL-OF THE CHOU DYNASTY

been a chip or splinter of wood; the Greek κοχλιάριον (Lat. cochleare) points to the early and natural use of shells, such as are still used by primitive peoples. Examples are preserved of the various forms of spoons of ivory, flint, slate and wood many of them carved with the symbols of their religion, used by the ancient Egyptians. The spoons of the Greeks and Romans were chiefly made of bronze and silver, and the handle usually takes the form of a spike or pointed stem. Mediaeval spoons for domestic use were commonly made of horn or wood, but brass, pewter and "latten" spoons appear to have been common about the 15th century. The full descriptions and entries relating CHINESE BRONZE SPOONS to silver spoons in the inventories of the royal and other households point to their

special value and rarity. The earliest English reference appears to be in a will of 1259. In the wardrobe accounts of Edward I for the year 1300 some gold and silver spoons marked with the fleur-de-lis, the Paris mark, are mentioned. One of the most interesting mediaeval spoons is the coronation spoon used in the anointing of the sovereign. The sets of spoons popular as christening presents in Tudor times, the handles of which terminate in heads or busts of the apostles, are a special form to which antiquarian interest attaches. (See Apostle Spoons.) The earlier English spoon handles terminate in an acorn, plain knob or a diamond: at the end of the 16th century the baluster and seal ending becomes common, the bowl being "fig shaped." At the Restoration the handle becomes broad and flat, the bowl is broad and oval and the termination is cut into the shape known as the pied de biche, or hind's foot. In the first quarter of the 18th century the bowl becomes narrow and elliptical, with a tongue or "rat's tail" down the back, and the handle is turned up at the end. The modern form, with the tip of the bowl narrower than the base and the rounded end of the handle turned down, appeared about 1760.

See C. J. Jackson, "The Spoon and its History," in Archaeologia (1892), vol. liii; also Cripps, Old English Plate. SPOONBILL, any one of six species of moderately large

wading birds constituting the subfamily Plataleinae and, with the ibises (q.v.), the family Threskiornithidae (order Ciconiiformes). The head is partly or entirely bare, the plumage white (except in the roseate spoonbill). often with a rosy tinge, some with a nuptial crest or foreneck plumes. They differ from ibises in having a long nearly straight bill, narrow in the middle and broad and flat at the end, which they immerse in feeding, swinging it from side to side and sifting small animals from the mud and water of estuaries, salt-water bayous and lakes. In flight they flap steadily, usually without sailing. They breed in colonies, often with ibises and herons, build a good nest of sticks some-



BY COURTESY OF THE NATIONAL ASSOCIATION OF AUDUBON SOCIETIES THE ROSEATE SPOONBILL (AJAIA AJAJA), FOUND ONLY IN TROPICAL AND SUBTROPICAL AMERICA

times lined with leaves or bark, among reeds or in a low bush or tree about 10 ft. up, and lay three to five white eggs blotched with reddish-brown. The beautiful roseate spoonbill (Ajaia ajaja), 32 in., head and throat bare, legs red, is deep pink with neck and upper back white, wing coverts and tail coverts deep carmine and tail and sides of breast tawny-buff. It ronges from the gulf states, West Indies and central Mexico to the Argentine and Chile. In many places it was exterminated by plume hunters. The yellow-legged spoonbill (Platibis flavipes) of Australia is white with foreneck straw-coloured, has the forehead, upper throat and bill yellow. The crested white spoonbill (Platiblea leucorodia), 24 in, with cinnamon-buff on the foreneck, breeds in marshes of central and southern Europe and Asia, south to Egypt, India and Formosa; the black-billed spoonbill (P. regia), white with black wing-tips and black legs, from Australia and New Zealand to New Guinea, Celebes, Moluccas and Solomons; the lesser spoonbill (P. minor), from Korea and southern Japan to southern China and the Philippines; the African spoonbill (P. alba), over Africa south of the Sahara and in Madazasca.

(G. F. Ss.) SPORADES, the scattered islands of the Greek Archipelago, distinguished from the Cyclades, which are grouped round Delos, and from the coastal islands of Europe and Asia. Ancient and modern writers differ as to the list. The Doric Sporades-Melos, Pholegandros, Sikinos, Thera, Anaphe, Astypalaea and Cos-were by some considered a southern cluster of the Cyclades. In modern times the name Sporades is applied to two groups: The northern Sporades lie northeast of Negropont (Euboea), Skiathos, Skopelos and Ikos being included in the department of Magnesia, and Scyros (q.v.) in that of Euboea. Scyros has a fine harbour. Skiathos is beautifully wooded; the town overlooks an excellent harbour. Skopelos is also well wooded. Almost every householder in both islands is the owner, joint owner or skipper of a sailing ship. The southern Sporades, lying off the southwest of Asia Minor, formerly included in the Turkish vilayet of the "Islands of the White Sea," are as follows: Icaria, Patmos (q.v.), Leros, Calymnos, Astypalaea (Astropalia or Stampalia), Cos (q.v.) (Turk. Stanko), Nisyros, Tilos or Episcopi, Syme, Khalki, Rhodes (q.v.) and many smaller isles.

See C. Bursian, Geographie von Griechenland (Leipzig, 1862-71), ii, 348 ff.; L. Ross, Reisen auf den Griechischen Inseln (1840-45).

SPOROZOA, a group of parasitic Protozoa which produce unicellular spores within a tough envelope or cyst. Since formerly various Protozoa, which had only this character in common and were not truly related to one another, were classed with the Sporozoa, some protozoalogists have split up the class Sporozoa into two classes, Amoebosporidia and the true Sporozoa. For further particulars see Protozoa.

SPORTS, ARTICLES ON. Almost all varieties of indoor and outdoor sport have separate articles in this Encyclopedia. Among the chief are: Angling; Athlepig Sports; Baseball; Billiards; Bowling; Boxing; Bridge; Bullfight; Camping; Charade; Chess; Conjuring; Coursing; Chicket; Sycling; Palconry; Football; Game; Games, Cycling; Driving; Falconry; Football; Game; Classical; Gole; Gymkhapa; Gymnastics and Gymnasium; Hockey; Horsemanship and Riding; Horse; Racing and Breeding; Hunting; Hurdling; Jumping; Lacrosse; Lawn Tennis and Tennis; Mountaineering; Patience; Pigeon-Flying; Pig-Sticking (Hog-Hunting); Pinocle; Poker; Poll-Guglism; Rackets; Roller-Skating; Rowing; Running;

Shooting; Skating; Ski; Swimming; Tobogganing; Ventriloquism; Walking Races; Water Polo; Weight Throwing; Whist; Wrestling; and Vachting.

SPORTS, THE BOOK OF, or more properly the DECLARATION OF SPORTS, an order issued by James I in 1617 on the recommendation of Thomas Morton, bishop of Chester, for use in Lancashire, where the king on his return from Scotland found a
conflict on the subject of Sunday amusements between the Puritans and the gentry, many of whom were Roman Catholics. Permission was given for dancing, archery, leaping, vaulting and
other harmless recreations, and of "having of May games, Whitsum ales and morris dances, and the setting up of maypoles and
other sports, therewith used, so as the same may be had in due
and convenient time without impediment or neglect of divine
service, and that women shall have leave to carry rushes to church
for the decorating of it." On the other hand, "bear and bull-baitlag, interludes, and (at all times in the meane sort of people by

law prohibited) bowling" were not to be permitted on any Sunday (Wilkins, Concilia, iv, 483).

In 1618 James transmitted orders to the clergy of the whole of England to read the declaration from the pulpit; but so strong was the opposition that he prudently withdrew his command (Wilson, in Kennet, ii 709; Thomas Fuller, Charch History, v, 452). In 1633 Charles I not only directed the republication of his father's declaration (Rushworth, ii, 193), but insisted upon the reading of it by the clergy.

Many of the clergy were punished for refusing to obey the injunction.

With the fall of Laud all attempts to enforce it necessarily came to an end.

SPOTSWOOD, ALEXANDER (1676-1740), American colonial governor, was born of an old Scots family, in Tangier, Africa, in 1676.

He served as aide to Marlborough in the War of the Spanish Succession, and was wounded at Blenheim. He was appointed lieutenant governor of Virginia in 1710, and was received with enthusiasm, because he brought to the colony the privilege of habeas corpus; his term as governor closed in Sept. 1722, but he remained in Virginia, living near his ironworks in Germanna, a settlement of Germans, on the Rapidan in Spotsylvania county (named in his honour); and he was deputy postmaster general of the colonies from 1730 to 1739.

He was the first representative of the British government in America who fully appreciated the value of the western territory. As governor he recommended the establishment of a Virginia company to carry on trade with the Indians, he urged upon the provincial government and also upon the British authorities the wisdom of constructing forts along the frontier, and he personally organized and conducted in 1716 an exploring expedition into the Shenandoah valley.

He developed the iron industry of Virginia, promoted the religious education of the Indians, and tried to advance the interests of education, especially at the College of William and Mary. He died at Annapolis, Md., June 7, 1740.

See R. A. Brock (ed.), "The Official Letters of Alexander Spotswood" (with a memoir), in The Collections of the Virginia Historical Society (1882-85).

SPOTSYLVANIA, a county of Virginia, U.S.A., so called after Alexander Spotswood (g.v.), lieutenant governor of Virginia in 1710-22, who owned extensive estates and mines therein. It is bounded on the north by the Rapidan and Rappahannock rivers and on the south by the North Anna. It is celebrated as containing several of the most famous battlefields of the Civil War—Fredericksburg, Chancellorsville, the Wilderness and particularly that of Spotsylvania Courthouse, where the armies of U. S. Grant and Robert E. Lee fought for two weeks (May 8-21, 1864). Pop. (1950) 11,900.

SPOTTED JEWFISH (Promicrops itaiara), an immense marine bass (fam. Serranidae) found on the coasts of tropical America, which sometimes at-

tains a length of 8 ft. and a weight of about 700 pounds.
The adult is dull olive-brown

The adult is dull olive-brown in colour, with faint spots and bands; the young are yellowish-green, with dark crossbars and spots about the head. The South Pacific iewfish reaches 12 ft.

SPOTTISWOODE (Sport-TISWOOD, SPOTTSWOOD or Sports-WOOD), JOHN (1565-1639), CROPS



BY COURTESY OF THE M.T. ZOOLOGICAL SO-CIETY
THE SPOTTED JEWFISH (PROMI-CROPS ITAIARA)

archbishop of St. Andrews and historian of Scotland, eldest son of John Spottiswood, minister of Calder and "superintendent" of Lothian, was born in 1565. He was educated at Glasgow university (M.A. 1581), and succeeded his father in the parish of Calder in 1583. In 1601 he attended Ludowick, duke of Lennox, as his chaplain, in an embassy to the court of France, returning in 1603. He followed James to England on his accession, but was the same year nominated to the see of Glas-

Oct. 1610. On May 30, 1605, he became a member of the Scottish privy council. In 1610 he presided as moderator over the assembly in which presbytery was abolished, in 1615 he was made archbishop of St. Andrews and primate of Scotland. and in 1618 procured the sanction of the privy council to the Five Articles of Perth with their ratification by parliament in 1621. In 1633 he crowned Charles I at Holyrood. In 1635 he was appointed lord chancellor of Scotland, an office which he retained till 1638. He was a spectator at the 11ot of St. Giles', Edinburgh, on July 23, 1637, endeavoured in vain to avoid disaster by concessions, and on the taking of the Covenant perceived that "now all that we have been doing these thirty years past is thrown down at once." He escaped to Newcastle, was deposed by the assembly on Dec. 4, on trivial charges, and died in London on Nov. 26, 1639, receiving burial in Westminster abbey. His most considerable work was The History of the Church and State of Scotland (London, 1655, seg.).

See the accounts prefixed to the first edition of Spottiswoode's History of Scotland and to that published by the Spottiswoode society in 1851; also David Calderwood's Hist. of the Kirk of Scotland (1842-49).

SPOTTISWOODE, WILLIAM (1825-1883), English mathematician and physicist, was born in London on Jan. 11, 1825. His father, Andrew Spottiswoode, who was descended from an ancient Scottish family, represented Colchester in parliament for some years, and in 1831 became junior partner in the firm of Eyre & Spottiswoode, printers. William was educated at Laleham, Eton, Harrow and Balliol college, Oxford. His bent for science showed itself while he was still a schoolboy, and indeed his removal from Eton to Harrow is said to have been occasioned by an accidental explosion which occurred while he was performing an experiment for his own amusement. At Harrow he obtained in 1842 a Lyon scholarship, and at Oxford in 1845 a first-class in mathematics, in 1846 the junior and in 1847 the senior university mathematical scholarship. In 1846 he left Oxford to take his father's place in the business, in which he was engaged until his death. In 1847 he issued five pamphlets of original mathematical work; and from this time scarcely a year passed in which he did not give to the world further mathematical researches. In 1856 Spottiswoode travelled in eastern Russia, and in 1860 in Croatia and Hungary; of the former expedition he has left an interesting record entitled A Tarantasse Journey through Eastern Russia in the Autumn of 1856 (London, 1857). In 1870 he was elected president of the London Mathematical society. In 1871 he began to turn his attention to experimental physics, his earlier researches bearing upon the polarization of light and his later work upon the electrical discharge in rarefied gases. He wrote a popular treatise upon the former subject for the "Nature" series (1874). In 1878 he was elected president of the British association, and in the same year president of the Royal society, of which he had been a fellow after 1853. He died in London of typhoid fever on June 27, 1883, and was buried in Westminster abbey.

SPRAT, THOMAS (1635-1713), English divine, was born at Beaminster, Dorsetshire, and educated at Wadham college, Oxford, where he held a fellowship (1657-70). Having taken orders he became a prebendary of Lincoln in 1660. In the preceding year he had gained a reputation by his poem To the Happie Memory of the most Renowned Prince Oliver, Lord Protector (London, 1659), and he was afterward well known as a wit, preacher and man of letters. His chief prose works are the Observations upon Monsieur de Sorbier's Voyage into England (London, 1665), a satirical reply to the strictures on Englishmen in Samuel de Sorbière's book of that name, and a History of the Royal society of London (London, 1667), which Sprat had helped to found. In 1669 he became canon of Westminster, and in 1670 rector of Uffington, Lincolnshire. He was chaplain to Charles II in 1676, curate and lecturer at St. Margaret's, Westminster, in 1679, canon of Windsor in 1681, dean of Westminster in 1683 and bishop of Rochester in 1684. Although he opposed the motion of 1689 declaring the throne vacant, he assisted at the coronation of William and Mary. As dean of Westminster he directed Sir

gow, his consecration in London, however, not taking place until Christopher Wren's restoration of the abbey. He died on May Oct. 1610. On May 30, 1605, he became a member of the

SPRAT, a marine fish (Clupea spratus), one of the smallest species of the genus Clupea or herrings, rarely exceeds 5 in. In length, and occurs in large shoals on the Atlantic coasts of Europe. The sprat spawns in the open sea from February to May. Its eggs are buoyant and pelagic and easily recognized. The sprat is one of the more important food fishes because of the immense numbers in its shoals. In Norway large quantities are tinned in oil, or are eaten fresh, pickled, smoked or prepared as anchovies

SPRATT, THOMAS ABEL BRIMAGE (1811-1888), English vice-admiral, hydrographer and geologist, was born at. East Teignmouth on May 11, 1811. He was the eldest son of Commander James Spratt, R.N., and entered the navy in 1827. He was attached to the surveying branch, and was engaged almost continuously until 1863 in surveying the Mediterranean. As commander of the "Spitfire" he rendered distinguished service in the Black sea during the Crimean War, and was appointed C.B. in 1855. At an early date he was associated with the naturalist Edward Forbes with whom he studied the bathymetrical distribution of marine life and later published Travels in Lycia, etc. (1847). Spratt investigated the caves at Malta, studied the geology of several Greek islands and the shores of Asia Minor, and made detailed observations on the Delta of the Nile. He was especially distinguished for his Travels and Researches in Crete (2 vols., 1865), in which he described the physical geography, geology, archaeology and natural history of the island. He was commissioner of fisheries from 1866 to 1873 and acting conservator of the Mersey from 1870 until his death at Tunbridge Wells on

March 10, 1888. SPRAYING AND DUSTING MACHINERY. A great variety of equipment is available for applying certain organic and inorganic substances in solution or dust form to combat insect pests and plant diseases of field, garden and orchard crops, and to kill certain noxious weeds. Spraying is also used for thinning fruit with blossom-killing solutions, and to prevent preharvest drop of fruit.

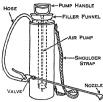
So far, experiments in the application of sprays to prevent preharvest fruit drop have shown their practicability only in the cases of apples and pears. Promising work was underway in 1944 on the use of aerosol fog spraying, which is highly toxic to a large number of insects, is not toxic to man, and is noninflammable. This method makes use of an insecticide such as pyrethrum or rotenone dissolved in a highly volatile substance such as freon (widely used as a refrigerant), the mixture or solution being contained in a steel "bomb" where a constant pressure of about 90 lb. per sq.in, is developed at summer temperatures. When released through a small nozzle the mixture comes out as a fine spray or fog. The entire output of this material was used during World War II by the U.S. armed forces for ridding tents and other quarters of flies, mosquitoes and other insects. Aeroplanes returning from tropical regions were also treated with it, as a control over the malarial and yellow fever mosquitoes.

There was promise in 1944 of hormone spraying, particularly in the case of tomatoes, to set the fruit, instead of relying on pollenizing which under some conditions is difficult. The term sprayer refers to the devices which apply solutions, and duster to those which apply dusts.

Spraying Equipment.—Sprayers utilize pressure produced by pumps to force the solution through specially designed nozales which break it up into mists. Sprayers differ in construction according to make, power by which they are operated, and type.

Accessories such as nozzles are highly important in spraying and dusting. Nozzles for spraying are of two general types; one produces a spray in the form of a cone for medium and close application, and the other produces a comparatively solid stream which breaks into a spray at a considerable height. There are, however, many variations in nozzles and most manufacturers have developed their own designs. The cone-shaped spray is often produced by forcing the liquid into a small eddy chamber of the nozzle through tangential channels in a disk. This action tends to break up the liquid just before it is forced out of the nozzle.

The solid-stream type is generally used in single units and for spraying tall trees. The cone type may be used on a single-jet gun for general purpose spraying or on a multiple-jet gun to pro-



COURTESY, U.S. DEPT. OF AGRICULTUDE

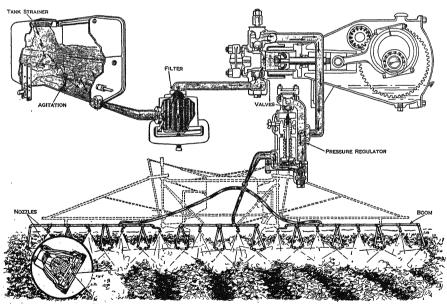
duce a foglike spray, desirable in orchard spraying. Except for the simple sprayers, the nozzles are attached singly or in multiple to a rod with cutoff for general purpose or orchard sprayers, and to adjustable pipes of booms for row crop spraying. Grape and hop growers spray with vertical pipes having nozzles fitted on the sides. Weed-killing sprays are applied from a horizontal boom with nozzles attached directly to -COMPRESSED AIR SPRAYER the under side. The solution

supply is controlled by means of suitable valves at the pump. Manual Sprayers.-The simplest form of sprayer consists of a bicycle-type hand pump with small container attached, and a suitable nozzle. In another type the hand pump, sometimes with an air chamber, is clamped to a bucket. The knapsack sprayer, as its name implies, is carried on the back of the operator, pressure usually being provided through a diaphragm pump which also actuates an agitator. In the compressed-air sprayer pressure is built up with a plunger-type air pump housed in the container with the solution and air. The one shown in fig. 1 has a capacity of from 1½ to 4 gal. Of this same type but of larger capacity are the wheelbarrow and barrel sprayers. The barrel type may either be stationary or portable.

Power Sprayers.—There are three types of power sprayers: those powered with an engine mounted on the frame with the tank, those powered through a power take-off, and those deriving their power from a traction drive. With the first two the same type of sprayer may be used. This consists essentially of a single-

acting, plunger-type, reciprocating pump (usually 2- or 3-cylinder), strainer, a pressure regulator which also acts as a safety valve, a metal or wooden tank containing the liquid and an agitator for stirring it, together with such accessories as pressure gauges, cut-off valves, and, frequently, air chambers. Such a sprayer is shown in fig 2. The pumps obtain their reciprocating motion most commonly from either a crankshaft and connecting rods, eccentric and connecting rods, or a Scotch yoke assembly (fig. 3), and are available in a wide range of sizes and capacities with pressures up to 1,000 lb. per sq in. Corrosion-resistant valve seats and ball-type valves, usually of hardened stainless steel, are used in the pumps and two types of plunger-cylinder combination; the "plunger-cup," where the cup is fastened to and moves with the plunger rubbing against the cylinder wall, which is usually coated with porcelain; and the "outside-packing" type, in which a stainless steel plunger works back and forth in the stationary packing lining the cylinder walls. The engine-powered sprayer, together with engine, may be mounted on skids for semistationary work and supplied with portable pipe lines to conduct the solution; or it may be fixed as a stationary plant and powered either with an engine or electric motor. In this case the conducting pipes are buried in the ground and lead to risers at strategic points for attachment of the spraying equipment. It may also be mounted on a motor truck or on a 2- or 4-wheel chassis and pulled by horses or a tractor.

The sprayer with power take-off may be mounted on a 2- or 4-wheel trailer and driven by a power take-off connection from the tractor pulling it, or from the transmission case of the truck transporting it. Occasionally the whole spraying outfit may be mounted on the tractor. While truck-mounted sprayers already have the advantage of pneumatic tires, and tractors are usually thus fitted, pneumatics are being increasingly used on sprayequipment trailers. An important accessory for orchard spraying is an elevated platform or tower. This permits the operator to do a better spraying job on the tops of trees and with less



COURTERY OF JOHN BELD WEG. CO.

FIG. 2.-TYPICAL POWER SPRAYER

material than from the ground. Traction-driven sprayers derive their power from the transport wheels and their use is limited largely to row crops. This type of sprayer is being replaced by the power take-off or auxiliary-engine drive.

Dusting Equipment.—Dusters for applying insecticides and fungicides make use of an air blast produced by means of a fan or plunger-type air pump, which blows the dust into a discharge

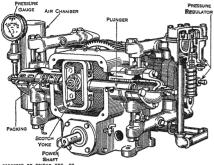


FIG. 3.—SPRAYER PUMP. CUT AWAY TO SHOW WORKING PARTS

pipe which may be fitted with a straight tube or fan-shaped nozzle. The many makes and models of dusters are of four classes: (1) hand operated, in which the air pressure is built up with a plunger pump or with a crank-operated fan; (2) the traction machine, in which the power for operating is taken from the ground wheels through chains or gears; (3) the power duster (horse or tractor drawn), operated by an auxiliary gasoline engine and suitable for

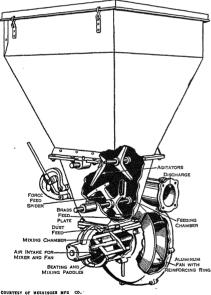


FIG. 4.-TYPICAL DUSTER

single-spout orchard dusting, or (by changing to a multiple nozzle unit) useful in row-crop dusting; and (4) the tractor-power duster mounted on the tractor and driven through the tractor power take-off. The power and traction types consist essentially of a hopper, agitator, feed control, blower fan, mixing chamber, discharge tubes and nozzle or nozzles.

Aeroplane Dusting.—In the cotton belt of the United States, as the committed of the plants by means of aeroplanes has proved economical. The work is done during daylight, generally in the early morning or late afternoons, when it is considered safest to fly at the low altitudes necessary, and when, too, the moisture on the plants causes the dust particles to adhere better. Commercial firms usually do the dusting on a per-acre basis and commonly dust at a rate of 350 or more acres of cotton per hour.

Dusting by aeroplane has also been employed in California to control insect pests and plant diseases attacking a number of fruit, nut, vegetable and small grain crops. In 1941 the acreage so treated in that state amounted to 176.600.

Experiments have shown the practicability of applying certain dusts to hasten the ripening of certain crops. In the case of cotton, such dusting causes leaves to drop and the rapid ripening of all bolls.

This facilitates mechanical picking of the fibre and permits of a once-over picking job in place of about three pickings otherwise necessary when the bolls ripen unevenly. Likewise with soybeans, if there are indications of an early frost previous to the time the crop should ripen, maturity can be hastened by the application of a defoliating dust. This procedure also causes uniform ripening of the plants.

ripening of the plants.

BBLIOGRAPHY.—State of California Department Bulletin, vol. 30, No. 4 (1941); O. C. French, Spraying Equipment for Pest Control, University of California Bulletin No. 666 (1942); L. P. Batjer, Harvest Sprays for the Control of Fruit Drop, U.S.D.A. Circular No. 685 (1943); N. F. Howard, C. A. Weigel, C. M. Smith and L. F. Steiner, Insecticides and Equipment for Controlling Insects on Fruits and Vegetables, U.S.D.A. Miscellaneous Publication No. 526 (1943); Chester N. Husman, A Hopper and Mackanism for Distribution of Batin and Dust by Airplanes for Insect Control (ET-21-U.S.D.A.-1943); E. R. McGovran, J. H. Fales and L. D. Goodhue, "Testing Aerosols Against House Flies," Soap and Sanitary Chemicals (Sept. 1943).

SPREE (sprā), a river of Prussia, 227 mi. in length, rising in Saxony, close to the Bohemian frontier, and flowing north past Bautzen, Spremberg and Kottbus, dividing between the first two towns for a time into two arms. Below Kottbus the river splits into a network of channels in the peculiar marshy region known as the Spreewald, then passes Fürstenwalde and Köpenick, threads Berlin in several arms and joins the Havel at Spandau.

More than 100 mi. of it are navigable and it is connected with neighbouring rivers by canals.

SPREEWALD, a district of Germany, in the province of Brandenburg, a marshy depression of the middle Spree valley, to sq.mi. in extent, 27 mi. long and varying from 'x to 7 mi. in width. The river Spree above Lübben splits into more than 200 arms, and in seasons of flood generally overflows considerable portions of this region.

Part of the region is cultivated, part used as pasture land and wooded like a park especially in the lower districts. Fishing, cattle breeding and the growing of vegetables, more particularly small pickling cucumbers, are the chief occupations of the people, some of whom retain their original Wendish language, customs and costumes. Spreewald is a popular summer resort of the Berlin people, and in winter is popular for skating.

SPREMBERG, a town in the Prussian province of Brandenburg, Germany, partly on an island in the river Spree and partly on the west bank, 76 mi. S.E. of Berlin by the railway to Görlitz. Pop. (1930) 14,515.

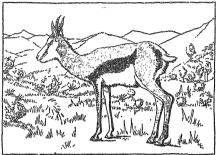
There are a pilgrimage chapel, dating from 1100 and a ducal château, built about the end of the 16th century (now utilized as government offices). Woollen cloth, bicycles, bricks and cigars are manufactured there.

**SPRING**, the act of springing, or leaping; hence applied in various senses: to the season of the year in which plant life begins

to bud and shoot; to a source of water springing or welling up from below the surface of the earth (see WATER SUPPLY); or to an elastic or resilient body or contrivance for receiving and imparting mechanical power.

In architecture, the level of the plane at which an arch or vault begins to curve inward toward the centre; in an arch or vault whose curves are circular or segments of circles, the level of the centre points from which the circular curves are described.

SPRINGBUCK or Springbok (Antidorcas marsupialis), a small South African gazelle inhabiting the country south of



BY COURTESY OF THE N Y. ZOOLOGICAL SOCIETY
SPRINGBUCK OR SPRINGBOK (ANTIDORCAS MARSUPIALIS), THE SOUTH
AFRICAN GAZELLE

the Zambezi, but ranging northwestward to Mossamedes. In the more settled parts of Cape Province, the Transval and the Orange Free State it now exists only within the enclosures of the large farms. Both sexes carry lyrate horns; the shoulder height of an adult male is about 30 in., and an average pair of horns measures 14 in. along the curve; in the female the horns are more slender. The general colour above is reddish fawn, separated from the white of the underparts by a dark band on the flanks.

SPRINGER, the term given in architecture to the stone from which an arch springs (see ARCH); in some cases this is the stone resting on the impost or capital, the upper surface of which is a plane directed to the centre of the arch.

SPRINGFIELD, the capital city of Illinois, U.S., and the county seat of Sangamon county near the Sangamon river, 99 mi. N.E. of St. Louis, Mo., and 185 mi. S.W. of Chicago, Ill. served by the Gulf, Mobile and Ohio, the Baltimore and Ohio, the Chicago and Illinois Midland, the Illinois Central, the Illinois Terminal system (electric) and the Wabash railroads; has a class IV public airport; and is at the intersection of U.S. highways 36, 66 and 54 and of state highways 4, 29 and 125. Pop. (1950) 80,832; (1940) 75,503 by federal census. The city occupies an area of 10.3 sq.mi. The state capitol (begun in 1868 and occupied since 1876) is in the form of a Latin cross, surmounted by a massive, symmetrical dome. The Illinois Centennial building, erected 1918-22 to mark the 100th anniversary of the admission of Illinois into the union, is also in the capitol group. In this building are the state historical and general libraries, the state museum, the Hall of Flags (in which are the battle flags of all Illinois regiments since Illinois became a state) and a number of state departments and offices. Facing the capitol building is the Illinois supreme court building. Adjacent to the capitol on the north is the Illinois state armoury, completed in 1936 at a cost of more than \$1,000,-000; also on the capitol grounds is the state archives building, completed in 1939, the second such state archives building to be constructed in the country. A short distance from the capitol grounds is the executive mansion, the residence of governors of Illinois, first occupied in 1856. The old capitol building, begun in 1837 and occupied from 1840 to 1876, is now used as the Sangamon county courthouse. In this building Abraham Lincoln served as a member of the legislature, and made many of his famous pre-Civil War speeches, including the "House divided against itself cannot stand" speech.

Near the centre of the business section is the Lincoln home, the only one he ever owned, which he bought two years after his mariage and occupied until he moved to Washington to assume the presidency. It is owned and maintained as a state memorial by the state of Illinois. The Lincoln tomb and monument, in Oak Ridge cemetery about 1 mi. N. of the capitol, is a granite structure 121 ft. high over the mausoleum containing the bodies of Lincoln, his wife and three of his four children, Edward Baker, William Wallace and Thomas, known as "Tad." (Lincoln's eldest son, Robert, was buried in Arlington National cemetery.) This historic structure is owned and maintained by the state of Illinois. In 1930–31, because of structural faults in the edifice, it was completely rebuilt in the original form and with the original material so far as the exterior is concerned, but with the interior redesigned.

Springfield is full of spots associated with Abraham Lincoln: so of his law offices, boardinghouses and homes of friends; courtrooms where he practised; the old statehouse, now the county courthouse, where he maintained headquarters during his campaign for the presidency in 1860 and where his body lay in state in 1865; the site of Wabash station where, on leaving for the White House, he bade goodbye to his friends in his noted farewell address; and many others. The city has nine parks containing more than 1,000 ac., and 1 mi. N. of the centre of the city are the grounds of the Illinois State fair, held annually in August. These grounds contain more than 400 ac. of land. The city is governed under the commission form of city government, adopted in 1911. The assessed value of property within the city limits for 1949 was \$209,567,856.

Springfield is in the centre of soft-coal mining fields, and several coal mines are in and adjacent to the city. The city is also the centre of a rich agricultural area with farming, stock raising and dairying. It is a large wholesale and retail centre. Among the leading industrial products are electric meters, agricultural implements, industrial tractors, road graders and road machinery, flour and cereal products, soybean oil and meal, garage and automobile equipment, house and industrial paints, ladies' shoes, miners' lamps and equipment, heavy-duty steam boiler installations, electronic equipment and mattresses.

Bank clearings in 1949 totalled \$178,172,999. The city obtains its water supply from a large artificial lake known as Lake Springfield, completed in 1935. This body of water is 15 mi. in length, with a shore line of more than 45 mi. A water treatment plant, owned and operated, as is the lake, by the city through its department of public property, affords an adequate supply of pure water. The city owns and controls more than 4,000 ac. of land bordering the lake, developed as a residential and recreational area.

Springfield was first settled in 1818–19 by trappers and hunters from North Carolina, Virginia and Kentucky. In 1823 it became the county seat and was named Springfield, no reason being discovered for the choice of its name. It was incorporated as a town in 1832, and was selected as capital of the state in 1837 in place of Vandalia. In 1840 it was chartered as a city.

Gen. U. S. Grant assumed his first command during the Civil War in Springfield when he was named Colonel in charge of a volunteer regiment on July 3, 1861. Springfield was the birth-place and lifetime home of Nicholas Vachel Lindsay, the American poet, and was the early home of Julius Rosenwald, mail-order merchant and philanthropist.

SPRINGFIELD, a city of Massachusetts, U.S., at the intersection of federal highways 5 and 20, on the east bank of the Connecticut river, 6 mi. from the southern boundary of the state; the county seat of Hampden county. It is served by the New York Central (Boston and Albany division), the Boston and Maine and the New York, New Haven and Hartford railways; several air lines also serve Springfield from Bradley field, Windsor Locks, Conn., 12 mi. from the city. Pop. (1950) 162,601; (1940) 149,554 by the federal census. The area of the city is 31.90 sq.mi. It has many buildings of architectural importance, and from 1921

its development was guided by an official planning board. The Union railroad station, opened in 1926, is one of the most commodious and complete in New England. The courthouse, two churches and other buildings were designed by H. H. Richardson. Facing a public park is the fine municipal group (designed by Pell and Corbett) which was dedicated in 1913, replacing the city hall completed during 1854 and completely destroyed by fire in 1905. The group consists of twin buildings (one an auditorium and the other an administration building, each 115 ft. wide, with a portico formed by ten Corinthian columns 41 ft. high) on either side of a campanile 300 ft. high, which contains a carillon of 12 bells. The city's parks, playgrounds and lands cover more than 2,000 ac. Forest park has an area of 754 ac. and includes a zoological section and fine collections of lotus plants. A museum (1895) contains the valuable collections of George Walter Vincent Smith, Near it is the Museum of Natural History; the city library; the William Pynchon Memorial building, home of the Connecticut Valley Historical society; and the Museum of Fine Arts, built in 1932 with funds left by Mrs. James Philip Gray. In Merrick park, adjoining the library, stands Augustus Saint-Gaudens' statue of "The Puritan." The city has its own symphony orchestra,

The public-school system includes commercial, technical, trade and classical high schools. The American International college (1885) and Springfield college (the International Young Men's Christian Association college, 1885) are in Springfield. There are 90 churches in the city, and it is the see of a Roman Catholic and a Protestant Episcopal bishop. The city operates under a bicameral form of government. The assessed valuation for 1949

was \$281,477,400.

There has been a U.S. arsenal in Springfield since the American Revolution, when it was established by the continental congress. and an armoury since 1794, when congress authorized the building of one of the government's first gun factories on a hill (near the present railroad station) which had been selected by Washington for the purpose in 1789. More than 800,000 of the famous Springfield muskets were made there during the Civil War. It later became the home of the famous Springfield rifle and the Garand rifle and a principal manufactory of small arms for the U.S. army. The Smith and Wesson revolver factory is located there. Other important manufactures include electrical products, matches, chemicals, valves, machinery, automotive products, leather goods, aluminum and bronze products, plastics, clothing and paper products. G. & C. Merriam company, publishers of Merriam-Webster dictionaries from 1843, has its headquarters in Springfield. The city's trade area has a population of approximately 670,000. Three insurance companies-Massachusetts Mutual Life Insurance company, Springfield Fire and Marine Insurance company and Monarch Life Insurance company—have their home offices in Springfield. Bank clearings in 1949 for the city amounted to \$399,990,902. Springfield is headquarters for the Farm Credit administration for district no. 1 which includes the Federal Land bank, Federal Intermediate Credit bank, Production Credit bank and the Springfield Bank for Cooperatives. Organization of a regional co-operative purchasing association known as Eastern States Farmers' Exchange, Inc., with headquarters in West Springfield, occurred there in 1918, and by midcentury it was serving approximately 100,000 farms in nine states. Through it farmers were buying about \$80,000,000 of feed, fertilizer, seed and other supplies annually. Also in West Springfield are the Eastern States exposition grounds, where an annual exposition is held in September. On the grounds is Storrowton, a New England colonial village given by Mrs. James J. Storrow of

Springfield was founded in 1636 by a group of settlers from Roxbury under the leadership of William Pynchon (1590?-1662), one of the original patentees of the Massachusetts Bay Colony, who left Roxbury because of increased opportunities for fur trading in the Connecticut river valley. The town was incorporated in 1642 and named after Pynchon's birthplace in Essex, Eng. For several years he ruled it with the power of an autocrat, but in 1652 he was removed from the magistracy, in consequence of a tract in which he attacked the Calvinistic doctrine of the Atonement, and

returned to England.

In King Philip's War Springfield was a centre of hostilities. After the establishment of the arsenal in 1777 it was an important military supply depot of the continental army. During Shays's Rebellion, a riot took place in Sept. 1786, and on Jan. 25, 1787, the insurgents, led by Shays, attacked the arsenal, but were dispersed by the militia. Industrial development began with the establishment of the government armoury (1794), which brought in skilled workmen and attracted other enterprises. In nine years the population increased 50%. A second impetus was given by the completion in 1839 of what later became a part of the Boston and Albany railroad. By 1850 the town had a population of 11,766 and in 1842 it was chartered as a city.

SPRINGFIELD, a city of southwestern Missouri, U.S., 185 ni. S.E. of Kansas City; the county seat of Greene county. It is on federal highways 60, 65, 66, 160 and 166; has a municipal airport; and is served by the Frisco and the Missouri Pacific railways. Pop. (1950) 66,302; (1940) 61,238; and (1930) 57,527. The city has a beautiful location on the crest of the Ozark plateau, 1,300 ft. above sea level, and is surrounded by charming scenery. The region is rich in timber, and is known for its poultry, egg production, cheese output and fruit. The creameries of Springfield handle dairy products totalling \$40,000,000 annually. Beef cattle and hogs are factors in the \$22,00,000 annual business of the stockyards. Annual sales of retail stores total approximately \$500,000,000.000. The annual pay roll of the Frisco railroad is in excess of \$9,000,000.

Springfield is the seat of Drury college (1873), the Southwest Missouri State college (1906) and Central Bible institute and seminary. Adjoining each other are a national and a Confederate

cemetery

Springfield was founded about 1829; laid out in 1833; incorpoincorpolated as a town in 1838 and again in 1846; and chartered as a city in 1847. It has a commission form of government. At the opening of the Civil War Springfield was an important strategic point. It was occupied alternately by Confederate and Union Forces until the spring of 1862, after which the Unionists retained control. The battle of Wilson's creek (Aug. 10, 1861), 10 mi. S. of the city, was one of the bloodiest engagements of the war. The first railroad reached the city in 1870.

SPRINGFIELD, a city of Ohio, U.S., the county seat of Clark county; 45 mi. W.S.W. of Columbus, on Lagonda creek, near the Mad river. It is on federal highway 40, and is served by the Big Four, the Detroit, Toledo and Ironton, the Eric and the Pennsylvania railways, by Trans World Airline, and by motorbus and truck lines. Pop. (1950) 78,029; in 1940 it was 70,662 (12% Negroes). The city occupies 13,12 sq.mi. of undulating land, reaching an allitude of 990,27 ft.

On hills north of the creek is Wittenberg college (coeducational; founded 1845). Immediately west of the college campus is

beautiful Ferncliff cemetery.

There is a large municipally owned hospital and the private Mercy hospital. A 268-ac. municipal park affords recreational facilities, and there is Clark County fairgrounds. The city has a full-sized symphony orchestra, amateur theatrical groups giving winter schedules of plays and frequent appearances of travelling theatricals.

Industrial production in Springfield is highly diversified. Chemicals, caskets, dresses, awnings, machine tools, production machinery, road building machinery, motors and thermometers are among the principal products. In 1914 Springfield adopted a commission-manager form of government. In 1799 Simon Kenton and a small party from Kentucky built a fort and 14 cabins 3 or 4 mi. W. of Springfield's present limits. Later in the year James Demint settled on a hill overlooking Lagonda creek. In 1801 he engaged a surveyor to plat a town there, and soon after this Kenton's settlement was abandoned. Trouble from the Indians threatened the new town until 1807, when peace was more firmly established at a council held on a neighbouring hill, where Tecumseh was the principal speaker. In 1818, when Clark county was established, Springfield was made the county seat. It was incorporated as a town in 1828, and in 1850, when

the population was 5,108, was chartered as a city.

SPRINGFIELD, a city in Lane county, west central Oregon, U.S.A., on the east bank of the Willamette river, with an altitude of 456 ft. It is on U.S. highways 28 and 99£, about 4 mi. E. of Eugene, and is served by the Southern Pacific railroad. The population was 10,807 in 1950 and 3,805 by the census of 1940, of whom 3,687 were native white. The chief industry is lumbering (fir), and there is a large plywood mill. Kraft paper, wax from bark, and wood sugar from the waste materials of fir are also produced. Diversified farming is carried on. Springfield, which was classified as an urban community in 1940, was incorporated in 1888.

SPRINGFIELD, the county seat of Robertson county, in northern Tennessee, U.S. It is 28 mi. N.W. of Nashville at the fork of Carr's creek and a branch of the Red river, with an altitude of 595 ft. and an area of 1.1 sq.mi. It is on U.S. highway 41E and is served by the Louisville and Nashville railroad. The population was 6,506 in 1950 and 6,668 in 1940 (4,790 native white and 1,867 Negro). As an important market for loose-leaf tobacco, the town has numerous warehouses for tobacco storage. The active trading season lasts from January through June or July. The chief industry is the manufacture of woollen blankets. Other products include chairs, flour, feed, liquid fertilizer and dairy products. Farming is diversified and includes the raising of tobacco, corn, wheat and livestock. Springfield owns and operates its electric distribution system, sewage treatment plant and waterworks. Administration is by a commission-mayor form of government through direct nonpartisan election.

Springfield was incorporated as a town in 1819. A general hospital, owned and managed by the county, was established there in

1934.

SPRINGFIELD, a town with a village by the same name, on the Connecticut river, in Windsor county, Vt., U.S., through which the Black river flows with a picturesque falls near the centre of the village. It is served for freight by an electric line connecting with the Boston and Maine railroad. Pop. (1950) town, 9,190; village, 4,940. It is a machine-tool manufacturing village with a large agricultural area. It was chartered in 1761 and has the town-manager form of government, adopted in 1920, the first town in Vermont to adopt the system.

SPRING-GUN, a device formerly in use against poachers and trespassers. Since 1827 spring-guns and all man-traps are illegal in England, except as a protection against burglars.

SPRING-RICE, SIR CECIL ARTHUR (1859-1918), British diplomatist, was born in London on Feb. 27, 1859, the second son of the Hon. Charles Spring-Rice (1819-70), and grandson of the 1st Baron Monteagle. Educated at Eton and Balliol college, Oxford, he entered the foreign office in 1882, becoming private secretary to Lord Granville in 1884 and précis writer to Lord Rosebery in 1885. He went to Washington as third secretary in 1886, and in 1895 proceeded to Berlin. In 1898 he became secretary at Teheran, and in 1901 British commissioner on the Caisse de la Dette in Cairo. In 1903 he went to St. Petersburg (Leningrad), first as secretary and later as councillor of embassy, remaining in Russia till the end of 1905. In 1906 he was sent to Persia as minister, having lately been created K.C.M.G. In 1908 he was created G.C.V.O. and went to Sweden as minister. and in 1912 was appointed ambassador to the United States. He died at Ottawa on his way home to England, Feb. 14, 1918. See Sir v. Chirol, Cecil Spring-Rice: In Memoriam (1919); Stephen Gwynn, ed., The Letters of Sir Cecil Spring-Rice (1929).

SPRINGS are, in almost all cases, the natural overflow or point of escape from some underground reservoir of water. Their classification may be either according to the geological conditions governing the point of location, or according to the chemical composition of its waters. When considerable chemical impurity is present they are usually termed "mineral springs."

The rocks which constitute the crust of the earth are either permeable or impermeable to water. During most seasons of the year, in temperate climates, a certain amount of rainfall soaks into any crust formed of permeable strata; the part absorbed may be the complete rainfall during winter months, when the

air is saturated with moisture, or may fall to near zero during a dry summer, when all the rainfall is returned to the air as evaporation from the surface. That portion of the rainfall which soaks down below the level of plant roots goes to replenish the underground reservoir. The shape of the reservoir varies indefinitely, according to the geological structure of the area; but it is only the shape of its water surface that concerns springs. This surface, known as the water table, divides the fully saturated rocks from those which only hold moisture in their minute pores,

In an area of completely permeable rocks the springs issue at or near the valley bottoms; when, however, the district is made of alternating permeable and impermeable beds, each impermeable bed holds up water on its surface. If the strata are horizontal, small springs may be found all round the outcrops; but if they are tilted or folded the flow of the underground water will be towards the lowest point on the base of the permeable water-bearing bed. At this point the main spring for that local reservoir will be located.

In strata which are, in the main, impermeable, but somewhat brittle the presence of joints and cracks is of prime importance in determining the direction and amount of flow in the underground waters. In jointed rocks the rain water may sink to great depths down one set of joints and rise again along a second, issuing at the surface as a warm or thermal spring; this is the probable cause of the hot springs at Bath. When a permeable bed and an impermeable one are brought into juxtaposition through faulting the flow of water in the permeable one is checked; but since faulting frequently shatters the rock it affords a plane of weakness along which the water will tend to flow. If the water is flowing under pressure due to an overlying impermeable cover, it may reach the surface as an "artesian spring." The water of artesian springs sometimes carries small particles of solid matter in suspension as well as salts in solution. The solid particles are dropped at the point of exit of the spring and may be cemented by the salts deposited from solution. When this takes place a mound is built up, from the summit of which the spring issues. Hence the "mound springs," such as are seen at their best in the great artesian basin of Australia.

Some of the largest springs issue from thick beds of massive limestone. This type of rock is usually well jointed and, being soluble in rain water, the joints and marked bedding planes become enlarged by solution and the whole of the rainfall is absorbed in the mass of the rock and flows underground to issue as large springs. Frequently these springs yield a somewhat hard water of otherwise great purity.

Mineral Springs.—All springs containing noticeable quantities of salts in solution, other than the carbonate and sulphate of lime, are known by this name. The commonest minerals found are common salt, giving rise to "bitter springs"; and iron, sulphur, magnesia, etc., giving "medicinal" waters.

Thermal Springs.—The springs coming under this heading are derived from two sources. Firstly, meteoric waters which have penetrated down to considerable depths and rise again along well-defined fissures issuing as springs at the surface, but with the temperature of the rocks from which they have come; and, see ondly, volcanic waters, either in the form of geysers or hot springs (see Volcano); in these the water may be either meteoric or in part, at any rate, juvenile—that is, water which is issuing at the surface for the first time. Most of these waters contain much mineral substance in solution, which is deposited on cooling and forms marked basins and terraces of sinter, such as the famous pink and white terraces of New Zealand.

(W. B. R. K.)

SPRINGTAIL, any one of the small wingless insects of the order Collembola, so-called because many of them possess a pair of tail-like abdominal appendages adapted for springing. They are widely distributed in the world, and are abundant in the soil and in decaying vegetation. Springtails lay small almost spherical eggs. The newly hatched young are, except for their small size, very similar to the adults. The food of springtails consists largely of decaying bits of vegetation. Some species, however, feed on the tender tissues of growing plants and are of consid-

erable economic importance. (See also APTERYGOTA ) (H. E. E.)

SPRING VALLEY, a city of Bureau county, Illinois, U.S.A., on the north bank of the Illinois river, 104 mi. S.W. of Chicago. It is served by the Burlington Route, the Chicago and North Western and the Rock Island railways. Pop. 4,916 in 1950; in 1940 it was 5,010. It is a shipping point for coal, zinc, cement and farm products. The city was founded in 1885 and chartered in 1886.

SPRINKLERS, AUTOMATIC. These are a means of combating fire which has the approval of fire insurance companies, who often make a reduction in their premiums when it is employed. The essence of the device is to arrange, under the ceiling of the building to be protected, a series of sprinklers which discharge water as soon as the temperature reaches a certain point. The automatic release of the water is contrived by closing the valves of the sprinklers with fusible metal; the alloy employed being such as to fuse at a temperature of say 150° F. The sprinkler is so devised that the jet spreads the water in a shower, and the distance between the sprinklers is so arranged that every part of the floor is covered. The sprinklers are connected with lines of pipes conveying the water under pressure. In buildings where the water-pipes are likely to freeze, the ceiling connections are filled with air under pressure, so that when the valve opens through the metal fusing, the air escapes and the loss of pressure in the pipes works a lever that opens the valve of the water main. (See also FIRE PROTECTION.)

SPRUCE (Picea), an important genus of evergreen coniferous trees of the pine family (Pinaceae), called also spruce fir, includ-

ing about 40 species, natives of the cold and temperate regions of the northern hemisphere. They are pyramidal trees, with whorled branches; thin, scaly bark; linear, spirally-arranged leaves, each jointed near the stem on a separate woody base; and ovoid, oblong or cylindrical spreading cones, which become pendent when mature. The spruces are readily distinguished from the pines by their solitary instead of fascicled leaves, which leave peglike projections on the twig when they fall, and from the firs in having pendent cones with persistent scales instead of upright cones with deciduous scales.

In an economic sense the most valuable species is the Norway spruce (P. excelsa), native to



BRANCH OF THE NORWAY SPRUCE (PICEA EXCELSA) BEARING CONES Small figure shows single scale with two winged seeds

northern Europe and Asia and well known in plantations in the British Isles and eastern North America, though hardly attaining in cultivation the great height and noble form which it displays in its native woods. In favourable situations it becomes the tallest and one of the stateliest of European trees, sometimes rising to a height of 170 ft, and attaining a trunk diameter of 5 to 6 ft. at the base. It has a nearly straight, tapering trunk, throwing out in somewhat irregular whorls its widespreading branches densely clothed with dark clear green foliage. The boughs and their side branches, as they increase in length, have a tendency to droop, the lower tier, even in large trees, often sweeping the ground, a habit that gives a peculiarly picturesque effect. The slender, sharp, slightly curved leaves are scattered thickly around the shoots; the upper ones pressed toward the stem, and the lower directed sideways, giving a somewhat flattened appearance to the individual sprays. The cylindrical cones, 4 to 7 in. long, grow chiefly at the ends of the upper branches.

The Norway spruce is very widely distributed, growing on most of the mountain ranges of Europe from the Pyrenees northward and extending to 68° N., while in Asai it extends eastward to the Lena river and from the Altai mountains to beyond the Arctic circle. On the Swiss Alps it is one of the most prevalent and 21—K

striking of the forest trees. In the lower districts of Sweden it is the predominant tree in most of the great forests; in Norway it constitutes a considerable part of the dense woods of the southern valleys, flourishing on mountain slopes up to 3,000 ft. and clothing the shores of some of the fjords to the water's edge

While less valuable than the pine, the Norway spruce is an important timber tree. When produced in close forests the white wood is of compact and even grain and suitable for a great variety of uses. Immense quantities of spruce lumber are imported into Great Britain from northwestern Europe. Great quantities also of younger trees are imported as poles, used for scaffolding, ladders and mining timber. In Norway the wood is very extensively made by hydroelectric power into wood pulp.

As an ornamental tree Norway spruce has been commonly planted in Great Britain since about 1600. It is also grown as a "murse" for other trees, for shelter for wall fruit, for cover for game, and for small stakes and poles. As a picturesque tree for park and other ornamental plantation it ranks among the best of the conifers, bearing the smoke of cities better than most of the fir group, though subject to blight, which gives it an unhealthy appearance after a certain age. In North America the Norway soruce is extensively oblated in the eastern states and Canada.

In North America there are seven native species of spruce; of these, three are found in the eastern United States and Canada, two occur in the Rocky Mountain region and two are confined to the Pacific coast. The white spruce (P. glauca) is found from Maine to Minnesota northward to Labrador and Hudson bay and northwestward to Bering strait in Alaska. It grows to a height of 150 ft. and a trunk diameter of 4 ft., with cylindrical cones 2 in. long. The white spruce is very valuable for lumber and especially for wood pulp, being the chief species utilized in the Canadian wood pulp industry. The red spruce (P. rubens) occurs from Nova Scotia to New York and southward in the mountains to Tennessee. It is the dominant spruce in the Adirondack region, attaining a height of 60 to 100 ft., with brownish-red ovoid cones, about 11 in. long; it is extensively used for lumber and pulp wood. The black or bog spruce (P. mariana), native to swamps from Newfoundland to Alaska and southward to Virginia and Minnesota, commonly 20 to 30 ft. but sometimes 90 ft. high, with small globose cones, is utilized for pulp wood and is the source of spruce gum.

The Engelmann spruce (P. engelmanni), native to the Rocky Mountain region and extending westward to British Columbia and California, is a handsome tree of high altitudes. It grows from 20 to 150 ft. high, with slender branches and oval cones, sometimes 3 in. long. The blue or Colorado spruce (P. pungens), native to the central Rocky Mountain region, is one of the most distinctive American species. It grows from 80 to 150 ft. high, with stiff, horizontal branches, and rigid, bluish-green to silverwhite, spiny-tipped leaves, and oblong cones, 2½ to 4 in. long. Several varieties with characteristically blue foliage, as the well-known Koster blue spruce (var. kosteriana) are widely grown for ornament.

The Sitka or tideland spruce (P. sitchensis) occurs along the Pacific, extending about 50 mi. inland, from Kodiak island, Alaska, southward to northern California. It is the most massive of the spruces, sometimes attaining a height of 790 ft. and a basal trunk diameter of 20 ft., but it usually grows about 100 ft. high, with a trunk 3 ft. in diameter, with widely spreading, rigid branches, stiff, usually prickly-pointed leaves, and oblong cones 2 to 4 in. in length. The Sitka spruce is a valuable timber tree, and is extensively lumbered. The rare weeping spruce (P. breweriana), with hanging branches clothing the trunk to the ground and with the few horizontal branches decorated with cordlike hanging branchelets, is confined to the coastal mountains of northern California and adjacent Oregon.

Among the various old world spruces planted as ornamental trees are the Serbian spruce (*P. omorika*); the oriental spruce (*P. orientalis*), of Asia Minor; the Himalayan spruce (*P. smithiana*), the Alcock spruce (*P. bicolor*) and the tiger-tail spruce (*P. polita*), natives of Japan.

See Veitch, Manual of Coniferae (2nd ed., 1909); C. S. Sargent,

Manual of the Trees of North America (1905; new ed., 1933); L. H. Balley, Standard Cyclopedia of Horticulture (1943) and Manual of Cultivated Plants (1924), and G. B. Sudworth, "Check List of the Forest Trees of the United States, Their Names and Ranges," U.S. Dept. Agric., Misc. Cir. 92 (1927).

SPRUE. Sprue is a disease of tropical and subtropical regions,

and possibly cases arise in temperate climates also.

Symptoms.-The symptoms usually begin with dyspepsia and irregularity of bowel action. In a fully declared case the chief signs are the passage of bulky, frothy, pale porridge-like, stools, much flatulence and acidity, a sore, ulcerated mouth, a red, smooth and tender tongue, often with exquisitely painful ulcers on the fraenum and at the sides. Loss of flesh is very rapid amounting perhaps to 40 lb. in two months. Cramps of the fingers and of the feet and calves are common in severe cases. Death occurs from exhaustion and intercurrent disease or, more usually, from intense anaemia, or rarely from perforation of an intestinal ulcer.

Treatment.-The treatment is rest in bed for a fortnight on a diet restricted to milk (increasing from 4 to 71 pints daily) together with calcium lactate (gr. 15 thrice daily) and extract of parathyroid (gr. 1/10th twice daily). The parathyroid must be free from admixture with thyroid (most preparations contain some of the latter) for if any of the latter be present, the symptoms become aggravated and palpitation and other indications of thyroid excess are superadded. With a pure preparation, however, the sprue symptoms improve within a fortnight, the ionic calcium increases to about 8 mg. %, the stools are reduced to one a day and the soreness of the mouth disappears. At the end of four weeks in favourable cases, the calcium lactate can be dropped and the parathyroid reduced to half doses. About this time the blood serum will show a normal calcium content, but the parathyroid extract should not be left off entirely for another three to four weeks. Should symptoms recur, a return for a few days to a simpler diet and to the parathyroid extract will restore health.

Many patients treated on these lines have returned to their duties abroad, many others have been treated in the tropics and have recovered. A few years ago the appearance of sprue meant immediate return to a temperate climate and prohibition of future residence in the tronics. (H. H. S.)

SPUR, an instrument attached to the heel of a rider's boot for the purpose of goading the horse. (A.S. spura, spora, related to spornan, spurnan, to kick, spurn.) The earliest form of the horseman's spur armed the heel with a single prick. In England the rowel spur is shown upon the first seal of Henry III, but it did not come into general use until the 14th century. In the 15th century spurs appear with very long shanks, to reach the horse's flank below the outstanding bards. After this time, and until the Restoration, they take many decorative forms, some of which remain in the great spurs worn by Mexican cavaliers. Gilded spurs were reckoned the badge of knighthood, and in the rare cases of ceremonial degradation they were hacked from the knight's heels by the cook's chopper.

In architecture, a spur (Fr. griffe, Ger. Knoll), is the ornament carved on the angles of the base of early columns; it consists of a projecting claw, which, emerging from the lower torus of the base, rests on the projecting angle of the square plinth; the earliest known example is in Diocletian's palace at Split (Spalato). In Romanesque work the oldest examples are those found on the bases in crypts, where they assumed various conventional forms; being, however, close to the eye, the spur soon developed into an elaborate leaf ornament, which in French 13th-century work and in the early English period is of great beauty.

SPURGE, a name applied to plants known botanically as Euphorbia (q.v.). The spurge-flax is Daphne gnidium, and the spurge-laurel Daphne laureola, both found in Great Britain.

SPURGEON, CHARLES HADDON (1834-1892), English Nonconformist divine, was born at Kelvedon, Essex, on June 19, 1834. In 1852 he became pastor of Waterbeach. His powers as a boy preacher became widely known, and at the close of 1853 he was "called" to New Park Street chapel, Southwark. Exeter hall was used while a new chapel was being erected, but even that could not contain Spurgeon's hearers. The enlarged chapel at once proved too small for the crowds, and a huge taber-

nacle was projected in Newington causeway. The Tabernacle was opened for service on March 25, 1861. Spurgeon preached at the Tabernacle on Sundays and Thursdays.

His Sunday sermons were sold literally by tons. They are models of Puritan exposition and of appeal through the emotions to the individual conscience, illuminated by frequent flashes of spontaneous and often highly unconventional humour. Collected as The Tabernacle Pulpit, the sermons form some 50 volumes. His book of savings called John Ploughman's Talks; or, Plain Advice for Plain People (1869) found many readers. In 1887 his distrust of modern Biblical criticism led to his withdrawing from the Baptist union. He died at Mentone on Jan. 31, 1892.

See the Life by Schindler (1892) and Spurgeon's Autobiography, compiled by his widow and his private secretary from his diary sermons, records and letters (1897-1900).

SPURN HEAD, foreland of the North sea coast of Yorkshire, England, projecting across the mouth of the Humber. From Kilnsea it is 4 mi. long but seldom exceeds 300 yd. wide. Formed of sand and shingle from the rapidly denuding Holderness coast to the north, it is only a few feet above sea level.

SPY, a commune near Namur, Belgium. Pop. (1939) 3,243. Here in 1886, in Betche aux Roches cavern, Maximin Lohest and Marcel de Puydt found two nearly perfect skeletons (man and woman) at the depth of 16 ft., with numerous implements of the early Aurignacian period. All the human remains are in the Lohest collection, Liége. The skulls are of the Neanderthal type.

See L'Homme Contemporain du Mammouth à Spy (Namur, 1887); G. de Mortillet, Le Préhistorique (1900); Sir A. Keith, Antiquity of Man, 2nd ed. (1925).

SPY: see LAWS OF WAR.

SQUADRON, (1) a military term referring to the subdivision of a cavalry regiment, (2) a naval term referring to a detachment of war vessels, and (3) an air force term denoting a unit of a "group." Literally the term means a body of fighting men formed into a square. In 1656 the term was appropriated by horsemen but even in 1810 Scott in The Lady of the Lake refers to "squadrons tramping." The earliest use of the word in the military sense appears to be in 1562 and in 1581 Styward in Martial Discipline gives a clue to its origin: "The poore Swizers not being able to furnishe themselves with horse, were the first devisers of the pike and the squadrone," from which it is inferred that a body of pikemen formed into a square were employed on the flanks of a formation. This appears to be confirmed by Bullokar who wrote in 1616 that a squadron was a "square form in a battel." Previous to this, Sir John Smyth in 1500 refers to squadrons in reference to infantry, as also does Ward as late as

Morvson in 1617 mentions "two squadrons of foot 250 men each." In 1702 a squadron of horse was anything between 100 and 200 men but by 1779 the number had been reduced to 80-120. At that date the squadron was composed of three complete troops.

The Cavalry Regulations (British) of 1832 state that "Two or more squadrons compose a regiment." In the modern military sense a squadron is one of the principal units into which a regiment of cavalry is divided, corresponding to a company of infantry, the normal being three or four squadrons, subdivided into "troops." Squadrons are usually between 120 and 200 men. (See CAVALRY.)

In the naval sense the term refers to a part of a fleet usually commanded by a flag officer, or it may be applied loosely to any number of vessels less than a whole fleet. For its application to the air force see AIR WARFARE.

In British military use, "squad" (a shortened form of "squadron") is used of any small detachment of men temporarily formed for drill or fatigue work or other duty. In the U.S. army, however, the squad is the basic infantry unit.

SQUALL, the name given to any sudden large increase of wind velocity of less transient character than a "gust." A squall, usually lasting for some minutes at least, is attributable to meteorological causes, while gusts, which may succeed one another every few seconds, are the result of some mechanical interference with the direct flow of air and are thus produced by turbulence. A squall may include a succession of gusts.

It is difficult to give exact figures for the actual force of the wind during gusts, but 106.5 m.p.h. were recorded at Pendennis castle on March 14, 1905; and 231 m.p.h. on Mt. Washington, New Hampshire, April 12, 1934. Squalls with velocities reaching 55 m.p.h. are not uncommon, and the range of wind velocity during gusts in such a squall may be anything between 40 m.p.h. and upwards of 100 m.p.h.

A squall may be either a rotary wind covering a small area (sometimes called a bull's eye squall) or a straightaway wind. The latter type frequently accompanies the onset of a thunderstorm; as the storm approaches, the wind dies down, then blows gently toward the storm; finally, as the rain is almost at hand, a violent gusty wind abruptly sets in, blowing directly outward from the storm and usually lasting for only a short time. At many places on the earth, local conditions result in the frequent occurrence of squalls of characteristic types, which are called by local names; e.g., the "williwaws" common on many steep coasts in high latitudes, caused by a brief violent drainage of cold air down the steep slopes.

These phenomena are best exhibited in "line squalls." As the name suggests, a number of places arranged, roughly, in a continuous line, often hundreds of miles long, experience simultaneously a similar sequence of events. The course of events in typical line squalls has been worked out by R. G. K. Lempfert and Richard Corless.

The violent winds may be attributed to the breakdown of the dynamical system under the stress of these local but sharp differences of pressure. A line squall commonly marks the "Gold front" of an extratropical cyclonic storm; to the rear of the storm, a cold air current is advancing against warmer air, and undercutting the latter.

The boundary between these two air masses is called a cold front; it is the familiar wind-shift line, along which the direction of the wind undergoes a rapid and often considerable change—e.g., from southwest to northwest—usually accompanied by a sharp drop in temperature, an abrupt increase in pressure and a break in the direction of the isobars.

This line has long been known as the squall line, because all along it sudden gusts, squalls and, in summer, thunderstorms, are very common owing to the vigorous ascent of warm air initiated by the lifting caused by the underrunning cold air. (See Giblett, "Line Squalls," Journal of the Royal Aeronautical Society, vol. 198, 1927.)

In this respect a V-shaped depression may be regarded as a special case of a line squall in which the two currents are from approximately opposite directions, and the line of the trough which sweeps forward, keeping parallel to itself, represents the linear front.

An example of a violent and destructive form of line squall is shown in the records for June 1, 1908. The Kew squall of wind which destroyed a number of the trees of Bushey avenue maintained its violence for a considerable period. Many other famous line squalls, such as those of Feb. 19, 1907, 0ct. 14, 1909, etc., have been examined. (See Lempfert and Corless, "Line Squalls and Associated Phenomena," QJ.R. Met. Soc., vol. xxxvi, 1910.) One of historic interest caused the loss of H.M.S. "Eurydice" off the Isle of Wight on March 24, 1878.

It was among the first to receive special attention and was discussed by Abercromby in 1884 (Quart. Journ. Roy. Met. Soc., x, 172) and previously by Clement Ley (Symon's Met. Mag.,

SQUARE, a term variously used in mathematics, in technical work and metaphorically. In geometry it designates a rectilinear figure having four equal sides and four equal angles, the angles being right angles. Such a figure is a special kind of rectangle cquilateral) and of parallelogram (equilateral and equiangular). It has four axes of symmetry, and its two finite diagonals (as in the case of any rectangle) are equal. If the side is s, the area is  $s \times s$ , or  $s^2$ , the name  $s^2 \times s$ , or  $s^2$ , the mane  $s^2 \times s$ , or  $s^2$ , the mane  $s^2 \times s$ , or  $s^2$ 



the side of a square its latus (side), and hence the square root of a number was often called the latus. In technical work the word is applied to instruments used for drawing or testing right angles, as in the T-square here shown and the familiar carpenter's square.

SQUASH is the fruit of Cucurbita maxima and certain varieties of C. pepo. (See Pumpern.) Summer squash is a quick-growing, small-fruited, non-trailing or bush type of C. pepo. The plants are upright-spreading, 1½ to 2½ ft. high and produce a remarkable diversity of fruit forms, ranging from flattened through oblong to elongate and crooked.

Colours range from white through cream to yellow, also green and variegated. The fruit surfaces or contours may be scalloped, smooth, ridged or warty. The fruits develop very rapidly and must be harvested only a few days after they form, before the seeds and rinds harden. They must be used soon after harvest. The entire fruit is usually cut into pieces, boiled and served with butter. The bush forms are grown about 2 ft. apart in rows 3 to 4 ft. apart. To obtain early yields, seedlings are often started in pots in frames or greenhouses and transplanted into the field after 3 or 4 leaves have developed and after danger of frost is

Winter varieties of squash, C. maxima, are long-vining, generally large-fruited, long-season kinds, that can be stored many months if kept dry and well above freezing. The fruit stems are greatly enlarged next to the fruits and the fruits show a wide range of sizes, shapes and colours. They are higher in nutritive value than summer squash or so-called pumpkins, and are cormonly baked or made into pies. They are extensively grown in the United States in home gardens, market gardens, and on a large field scale for canning. (V. R. B.)

SQUASH RACKETS. A game played on exactly the same principle as rackets but in a smaller court and with a ball made of india-rubber. The rules are in most particulars similar to rackets but the scoring is different. In matches in England, hand-in only can win an ace. The rubber is the best of five games of 9 up. If, however, the score becomes 8 all, the player who reached 8 first has the option of a set to two. In America a game consists of 15 points up, and an ace is scored for each rally irrespective of which player is serving, all matches being the best three out of five games. The rotation of service in England is just as in rackets. In the American game, the winner of one rally serves in the next.

The Court and Implements.—Squash rackets can be played in courts of many sizes and descriptions, both covered and uncovered, with three or four walls and made of concrete or wood. The first standardization of a court in England was made by the Tennis and Rackets association in 1911. Shortly after World War I the association issued revised standard dimensions, and the great majority of British courts have been built to these dimensions since. The standard court has four walls and can either be covered or uncovered. In length it is 32 ft. and in breadth 21 ft. The front and side walls are 15 ft. in height and the back wall is 7 ft. in height.

The floor in a closed court should be made of wood; in an open court, of cement. In a closed court the front wall should be of composition.

The markings on the floor and front wall of the court are exactly similar to those in a racket court. On the front wall, the top of the play line is 19 in. from the floor and the service line is 6 ft. from the floor. The short line is 14 ft. from the back wall. The service boxes are 5 ft. 3 in. square. In the space between the play-line and the floor is generally placed a strip of tin or some other metal in order to differentiate clearly in sound when the part of the front wall "in play" or "out of play" is hit. The lines on the wall and floor are painted red. Maple is considered a most suitable wood for the floor. The courts should be lighted from the roof, and nearly all modern courts, in addition to this lighting, are fitted with electric light for evening play.

The American standard court is of different size from the English,

being considerably narrower, 31 ft. by 18 ft. 6 in. The racket is precisely similar to the implement used in the game of rackets, only shorter in the handle. The ball is of black rubber. Many different forms of ball have been tried and formerly, when there

were no standard courts, the ball which seemed best suited to the particular conditions was generally used. For the present standard English court the association has adopted three standard balls. The ball used in America is larger than that in England.

Open competitions at squash rackets were unknown in England before the World War. In the years since, several have been started, the most important being the London inter-club tournament (teams of three) for the Bath Club cup; the amateur championship, the royal navy and army championships, and the ladies championships. The winners of the amateur championship were.—April 1923, Capt. T. O. Jameson; Dec. 1923, Capt Jameson; Dec. 1924, W. D. Macpherson; Jan. 1926, Capt. V. A. Cazalet; Dec. 1926, Capt. J. E. Tomkinson; Dec. 1927, Capt. V. A. Cazalet; Dec. 1928, W. D. Macpherson; 1929 and '30, Capt. V. A. Caza- ENGLISH, BENT ASH let; 1931-33 and 1935-38, F. D. Amr FRAME, SQUASH RACKET Bey; 1934, C. P. Hamilton; 1939, K. C. Gandar-Dower.



The amateur championships are held annually in December at the Bath club. The duke of Windsor is a very keen player and, as prince of Wales, competed several times in the amateur and

army championships.

The British professional champion in 1939 was J. Dear (Prince's club) who defeated D. Butcher (St. John's Wood club) in 1937. Leading lady players were Miss Cicely Fenwick, Miss Nancy Cave, Miss Joyce Cave, Miss S. Huntsman, Miss Susan Noel and Miss Margot Lumb, champion from 1936-39. F. D. Amr Bey, an Egyptian, created a sensation in London in the early '30s and was invincible against the best amateurs and, professionals for some years.

The development of the game in America was even more rapid than in England, achieving a big vogue in the late '20s and '30s. The large cities of the United States, particularly New York, Boston and Philadelphia, are amply supplied with courts; and the game is also played with much keenness in Canada. British teams visited America after 1924, the late Captain V. A. Cazalet, M. P., leading one of them, and United States teams also toured in England. Among the leading amateur champions were Stanley W. Pearson, 1915-17 and 1921-23; W. Palmer Dixon, 1925-26; Myles P. Baker, 1927; Herbert N. Rawlins Jr., 1928 and 1930; Dr. J. Lawrence Pool, 1929 and 1931; Beekman Pool, 1932-33; Neil J. Sullivan, 1934; Donald Strachan, 1935 and 1939; Germain Glidden, 1936-38; A. Willing Patterson, 1940; Charles Brinton, 1941-42.

The French Squash Rackets association was formed in 1926 and four courts were opened in Jan. 1927. Outside Europe and America courts are to be found in several parts of the British empire, especially in India and the far east. There are courts in New Zealand and in South Africa.

See E. H. Miles, Racquets, Squash Tennis (1902); C. Arnold, The Game of Squash Rackets (1926); E. B. Noel, The Field Handbook of Squash Rackets (1926).

(E. B. N.; A. DA.)

SQUIB, a firework bursting with a flash and a clatter; hence a slight satirical composition put forth on an occasion, which should make a noise by its explosion, not by the possession of any permanent importance. Steele says, in the Tatler, that "squibs are those who in the common phrase of the world are call'd libellers, lampooners and pamphleteers," showing that in his time the satirist as well as the satire was called a squib. Swift speaks of the rapidity with which these little literary fireworks flew about, and was himself a proficient in the making of them. A good type of a squib is Gray's Candidate. (See LAMPOON.)

SQUID, the popular name given to a large number of cephalopod molluscs which include (e.g.) the common squids of the Atlantic (Loligo, Ommastrephes), the giant squids (Architeuthis) and the fire squids (Lycoteuthis, Abralia). They are exclusively marine animals of world-wide distribution and form an important part of the population of marine swimming and floating animals.

A typical squid, e.g., Loligo vulgaris, the common squid of the north-east Atlantic and Mediterranean, has an elongate slender body (visceral sac) edged by triangular fins, a short square head provided with well-developed eyes and ten arms. On the undersurface of the latter are arranged rows of suckers which are strengthened by tough horny rings. Two of the arms (tentacles) are longer and more mobile than the other eight (sessile arms) and the suckers are concentrated at the extremity as a "hand." The long tentacles are used for capturing prey, the sessile arms for transferring the latter to the mouth and grasping it while it is being crunched by the horny jaws which are situated around the mouth in the centre of the circlet of arms.

Situated within the muscular tissues of the "mantle" is a long horny structure, the "pen" or gladius. This is the rudiment of a shell and consists actually of a secondary growth (the proostracum) which has replaced the true shell-rudiment. In the genus Ommastrephes there is a vestige of the original shell.

The majority of the squids are active, highly mobile animals of aggressive habits and are probably all carnivorous.

Originally the squids were distributed among the two "tribes," Oigopsida and Myopsida, of the ten-armed Cephalopoda (Decapoda). Recently, however, Naef and other students have proposed a more suitable classification of the Decapoda according to which the squids are all placed in a single sub-order, the Teuthoidea.

These forms are divisible into two groups originally called by C. Chun the Oigopsida libera and Oigopsida consuta. The first include the large, active and freely swimming forms (Architeuthis, Loligo, Ommastrephes, etc.). The second comprise a smaller assemblage of curious and highly modified forms which are less common than the Libera and are very largely planktonic. The distinction between these two groups is based on the mode of attachment of the ventral edge of the mantle to the head. In the Libera this attachment is effected by a stud and socket junction (see Cephalopoda) between the head and the edge of the mantle and can be freed from the head when necessary. In the Consuta the ventral edge of the mantle is permanently fixed to the head.

The Libera are represented by about 65 genera. Among them Architeuthis is the most striking on account of its size. The genus includes the largest living invertebrate animals, Architeuthis princeps of the north Atlantic attaining a maximum record length of 52 ft. (including the outstretched tentacles). Sthenoteuthis, a group of smaller forms, which attain a size of over seven feet, may be also reckoned as "giant squids."

Another interesting group are the phosphorescent squids, Nematolampas, Thaumatolampas (Lycoteuthis) and Abralia, which bear light-organs in certain regions of the body (on the mantle, arms, inside the mantle-cavity and around the eyes). Certain of these when seen alive are very beautiful. Ommastrephes bartrami, the so-called "flying squid," is found throughout tropical and temperate seas. Its flight is, strictly speaking, a series of leaps across the surface of the sea which are often strong enough to land it on the deck of a ship. This feat is no doubt rendered easier in high seas. The Consuta are mainly small animals. Their fins are largely reduced and the mantle is swollen and tun-like in Cranchia, Bathothauma, etc. In the latter, and in Sandalops, and Corynomma the arms are much reduced and the eyes are situated on stalks. Unlike the larger swimming squids these animals probably float largely at the mercy of the currents and are thus to be reckoned as "plankton." (See CEPHALOPODA.)

reckoned as plantoun (co. See G. Pieffer, Die Cephalopoden der Plankton-Expedition (1912); C. Chun, Wiss. Ergebn. d. Deutsche Tiefsee Expedn. Bd. xviii. (1910); G. C. Robson, A monograph of the recent Cephalopoda, vol. 1 (1929) (G. C. R.)

SQUILL, the name under which the bulbous root of Urginea Scilla (family, Liliaceae) is used in medicine. The medicinal squill is a native of the countries bordering the Mediterranean,

and grows from the sea-level up to an elevation of 3,000ft. The bulbs are globular and often weigh more than 4lb. Two varieties are met with, the one having white and the other pink scales. They are collected in August, when leafless, the membranous outer scales being removed and the fleshy portion cut transversely into slices and dried in the sun.

Three pharmacopoeial preparations of this powerful drug are of importance: the syrup, composed of one part of squill, eight of dulute acetic acid and four of sugar; the Philus Ipecacuanhae cum Scilla, in which ipecacuanha and opium are the chef constituents; and the In which pectangual and open art of squill with five of alcohol. The drug is a cardiac stimulant. Even in small doses it is a powerful expectorant and a fairly active diuretic. The drug must not be given alone, owing to its irritant action.

An allied species, Urginea indica, is used in India in the same manner as the European species. The true squills are represented in Great Britain by two species, Scilla autumnalis and S. verna. These are confined to the sea-shore. There are 80 species or more in temperate regions of the old world. Several species are grown in gardens, notably S. bifolia and S. sibirica, originating from the Caucasus region and S.W. Asia. S. nonscripta or English bluebell and S. hispanica or Spanish bluebell are also widely cultivated.

SQUINCH, in architecture, a general term for several means by which a square or polygonal room has its upper corners filled in to form a support for a dome: by corbelling out the courses of masonry, each course projecting slightly beyond the one below: by building one or more arches diagonally across the corner; by building in the corner a niche with a half dome at its head, or by filling the corner with a little conical vault which has an arch on its outer diagonal face and its apex in the corner. The arched squinch seems to have been developed almost simultaneously by the Roman builders of the late imperial period and the Sassanians in Persia.

Squinches are often found both in Romanesque and Mohammedan work. In Italy the form is either the conical type as in the church of S. Ambrogio at Milan (crossing 11th or 12th century) or as a succession of arched rings as in the 13th century central tower of the abbey church at Chiaravalle Milanese; more complex forms, with niches and colonnettes are characteristic of the French Romanesque of Auvergne, as in the cathedral of Le Puy en Velay (late 11th and early 12th century); the allied churches of the south-west coast, such as St. Hilaire at Poitiers, use conical squinches of the Italian type. Mohammedan architecture, borrowing from the Sassanian precedent, makes great use of squinch forms, particularly in the Syrian, Egyptian and Moorish phases; the stalactite work, which is so marked a feature of later Muslim architecture, is, in essence, merely a decorative development of a combination of niche squinch forms. In Gothic architecture squinch arches are frequently used on the insides of square towers to support octagonal spires. (See Byzantine and ROMANESQUE ARCHITECTURE; DOME; PENDENTIVE.)

SQUIRREL, the name of a red, bushy-tailed arboreal rodent, but also extended to include allied species. Typical squirrels are found throughout the tropical and temperate regions except

in Madagascar and Australia.

The common squirrel (Sciurus vulgaris) is found over the whole of Europe and North Asia, though showing great range of colouring in the various parts of its habitat. The ears are tufted, and the animal feeds largely on vegetables and fruits, varied with mice, small birds and eggs. In North America this species is replaced by the gray S. carolinensis, a larger and more powerful form, that has been introduced into Great Britain, where it has

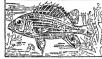


GRAY SQUIRREL (SCIURUS CAROLI-NENSIS), EASTERN NORTH AMERICA

exterminated the native species in many places. Squirrels vary in size from that of a mouse, as Nannosciurus minutus of West Africa, to that of a cat, as the black and yellow Ratufa bicolor of Malay. In India the commonest species are the little striped

palm squirrels, Funambulus palmarum and F. pennanti, the latter being the more northern species. One oriental squirrel (S. caniceps) assumes a definite breeding dress. Squirrels form the family Sciuridae of the order Rodentia (q.v.). (See also Ground Squir-REL, SPINY SQUIRREL, GROOVE-TOOTHED SQUIRREL, FLYING SQUIR-

SQUIRREL FISHES (Holocentrus), a genus of small (less than a foot long), tropical, marine fishes, numerous about coral



SOUIPPE FISH CHOLOCENTRUS DIADEMA). ONE OF THE COMMONEST IN THE INDO-PACIFIC, RED IN COL-OUR WITH LENGTHWISE WHITE

reefs. They have notably large eyes, astrong backwardly directed spine at the corner of the preopercle (on the lower side of the head), a long spinous dorsal fin contiguous with a shorter one of soft rays behind it, a short anal fin with one of its initial spines notably long and strong, a forked caudal (or tail) fin, and the body covered with firm scales of moderate size. Their colours are

bright-red and yellow-and lengthwise stripes on the body predominate. Those with larger mouths (Flammeo) are sometimes separated generically from those with smaller mouths (Holocent-

Some 12 species of squirrel fishes inhabit the waters of the East Indies: 9, some of which are the same, those of the Hawaiian Islands; about 7 (of which Holocentrus adscensionis is the commonest), the West Indian region. (J. T. N.)

SQUIRREL MONKEY, a small golden-haired South American monkey, Saimiri sciurea; the name is also applied to the two other species of the genus, whose collective range extends from Costa Rica to Bolivia and Brazil. The squirrel monkeys belong to the Cebinae (see CAPUCHIN MONKEY), from the other members of which they differ by their practically non-prehensile tails, smaller size, their large eyes and the backward prolongation

of the hinder part of the head. (See PRIMATES.)



SQUIRREL-TAIL GRASS

SQUIRREL-TAIL GRASS (Hordeum jubatum), a name widely given in the United States to a species of wild barley, native to Europe, Asia and western North America and naturalized extensively in the eastern States and Canada, often becoming a troublesome weed, especially in alfalfa fields. It is a perennial, with slender stems usually from I to 21 ft. high, bearing nodding, soft, brushlike, long-awned flowering spikes, from 2 to 4 in. long and about as thick, whence the common name. It is also known, locally as barleygrass, foxtail and tickle-grass.

SRINAGAR, capital of the state of Kashmir, in Northern India, 5,250 ft. above sea-level, on both banks of the river Jhelum, which winds through the city with an average width of 80 yds, and is crossed by seven wooden bridges. The houses occupy a length of about 3 m. and a breadth of about 1 m. No two buildings are alike. The curious grouping of the houses, the frail tenements of the poor, the substantial mansions of the wealthier, the curious carving of some, the balconies of others, the irregular embankment and the mountains in the background form a quaint and picturesque spectacle. Pop. (1941) 207,787. The city is exposed to both fire and flood. The artisans of Srinagar enjoy a high reputation. Unfortunately, the historic industry of shawl-weaving has been replaced by carpet manufacture. Other industries are paper, leather, silver and copper ware, and wood-carving.

SRIRANGAM, a town of British India, in Trichinopoly district. Madras presidency, 2 m. N. of Trichinopoly city. Pop. (1941), 26,676. It stands on an island of the same name, formed by the bifurcation of the river Cauvery and by the channel of the Colesoon The town is celebrated for its great temple, dedicated to Vishnu, composed of seven square enclosures, one within another, and 350 ft distant from each other. Each enclosure has four gates with high towers, placed one in the centre of each side opposite to the four cardinal points. The outer wall of the temple is not less than 4 m in circumference. It is a great place of pilgrimage.

STAAL, MARGUERITE JEANNE CORDIER DE-LAUNAY, Baionne de (1684-1750), French author, was born in Paris on Aug 30, 1684, the daughter of a painter named Cordier She adopted her mother's maiden name, Delaunay. She was educated at a convent at Evreux, later accompanying Madame de Gricu to the convent of St Louis where the latter was anpointed abbess Mile. Delaunay held a little salon there until 1710, and after the death of Mme de Grieu entered the household of the duchesse du Maine at Sceaux. She helped her mistress to draw up the Mémoire des princes légitimes, demanding the meeting of the states-general. After a short imprisonment in the Bastille, on account of her implication in the Cellamare conspnacy (1718), she returned to the service of the duchess. She had had many admners, and some serious passions, when, in 1735, being then over fifty, the duchess arranged her marriage with the Baron de Staal. She remained a member of the duchess's household, and became the friend and correspondent of Mme. du Deffant. She died at Gennevilhers on June 15, 1750.

Her Mémoires appeared about five years later, and have often been reprinted. In these memoirs the humours of the "court of Sceaux" are depicted as hardly any other society of the kind has ever been. "Dans cet art enjoué de raconter," ' says Sainte-Beuve, "Madame de Staal est classique."

Her Mémoires were edited (1877) by M. de Lescure, and translated by S. Bathurst (1877) and by C. H. Bell (1892). Mme. de Staal also left two excellent short comedies, performed at the court of Sceaux, and some letters.

STABAT MATER, famous mediaeval Latin hymn on the Crucifixion, which has enjoyed unexampled esteem throughout the ages, believed to have been written by Jacopone, a Franciscan monk of the 13th century. Though not originally intended for this purpose, it was early introduced into liturgical use and was adopted as one of the Sequences of the Roman missal in the 18th century Among the many settings of the poem by eminent composers may be mentioned those of Josquin des Prés, Pales-trina, Pergolesi, Haydn, Rossini, Verdi and Dvořák

STABIAE, an ancient town of Campania, Italy, on the coast at the east extremity of the Gulf of Naples (mod. Castellammare di Stabia). It was dependent upon Nuceria Alfaterna. In 80 B.C. it was taken and destroyed by Sulla, and its territory given to Nuceria as a reward for fidelity to Rome

STADE, a town of Germany in the Prussian province of Hanover, situated on the navigable Schwinge, 32 m. above its confluence with the Elbe, 20 m. W of Hamburg on the railway to Cuxhaven Pop. (1939) 19,592. The rise of Harburg has deposed it from its former position as the chief port of Hanover

STADION, JOHANN PHILIPP KARL JOSEPH (1763-1824), Austrian statesman, was ambassador in London (1790-93). After some years of retirement he was entrusted (1800) with a mission to the Prussian court, where he endeavoured in vain to effect an alliance with Austria. He had greater success as envoy at St. Petersburg (Leningrad), where he played a large part in the formation of the third coalition against Napoleon (1805). Notwithstanding the failure of this alliance he was made foreign minister, when he helped to prepare archduke Charles for a fresh trial of strength with France. In 1808 he abandoned the policy of procrastination, and with the help of Metternich hastened the outbreak of a new war. The unfortunate results of the campaign of 1809 compelled his resignation, but in 1813 he was commissioned to negotiate the convention which finally overthrew Napoleon.

See A. Beer, Zehn Jahre österreichischer Politik, 1801–1810 (Leipzig, 1877); Die Finanzen Ossterreichs im 19 Jahrhundert (Prague, 1877). See also Austria, Empire of.

STADIUM, the Latin form of a Greek word for a standard of length. A stade = roo δργυιαί (about 6 ft or one fathom) = 6 πλάθρα (100 Greek or about 101 English feet) = about 606 English feet, or about one-eighth of a Roman mile. The course for the foot race at Olympia was exactly a stade in length, and thus the word for measurement became transferred first to the race and then to the place in which it was run. In modern usage stadium is one of several words applied to a large construction which combines space for games and seats for spectators, such as those erected for football. The Greeks built one of the first at Olympia, for the famous games held there The Romans built several types of structures for similar purposes: circuses, amplitheatres, also called arenas; and naumachia, which could be flooded for naval engagements The most famous of the Roman amphitheatres was the Colosseum at Rome (See Amphitheatre: ARENA )

Sports played a minor role in men's lives for many centuries after the fall of Rome, and it was not until modern times that permanent stadia were again needed. In the interim temporary stands such as those built from time to time in the Place des Vosges in Paris for jousting sufficed. An exception should be made of the court of the Belvedere in the Vatican, built in 7500 by Bramante. There the terraces were arranged to accommodate spectators when tournaments were held.

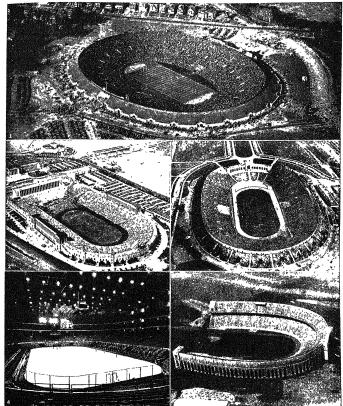
During the 19th century systematic physical exercise was revived. This led to organized athletics, which became as popular as in ancient Greece. Hence the building of large permanent stadia was also revived The first important stadium of modein times was the reconstruction, in Athens in 1896, of an ancient marble one built about AD. 170 by Herodes Atticus on the site of a still earlier Greek circus. It seated 66,000 persons, and was undertaken for the first of the modern series of Olympic games.

Although a few other stadia were built before 1900, such as arenas for bullfighting in Spain and Mexico, the great era of modern stadia building was the early 20th century, which by 1930 had seen the construction of more stadia than in any other equal period. In the United States alone more than 100 large stadia had been built. The early 20th century also witnessed the development of a new type of stadia, unknown to the ancients and made possible by modern building techniques, the indoor stadium. This type, completely enclosed and lighted by electricity, could be used night and day the year around The first important one was the old Madison Square Garden, built in New York city in 1800. It was replaced in 1925 by another of the same name seatmg 18,000. Others were built in London and Chicago. The Chicago stadium was the largest indoor stadium in the world in 1944. This type was flexible enough to be used for all court sports including those held on ice, and also for public meetings such as conventions, circuses and even concerts.

After 1930 fewer large stadia were built, not only because of the economic depression, but because there were so many in existence, and also because the era of spectator sports had apparently reached a peak, while the popularity of participating sports was increasing. The fascist countries were an exception, however, as great sports fields, of which a large stadium was a feature, were

built there during the 1930s.

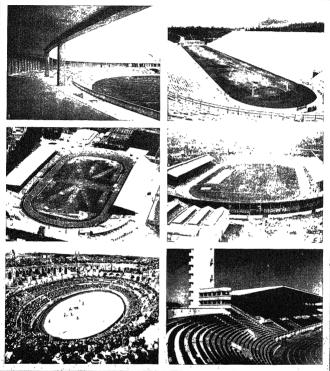
The following data illustrate the phenomenal increase in stadium building after 1900. Whereas in 1913 there were only 5 large stadia in the United States, by 1930 there were more than 100 During the decade of the 1920s alone 18 huge stadia, each seating more than 50,000 spectators, were erected Most of these were built for college athletic contests, particularly football. Others were built by private or municipal funds. Four of the largest stadia in the world were built in the United States. The Los Angeles Colosseum, built in 1923, was enlarged in 1932 to accommodate 125,000 persons and renamed the Los Angeles Olympic stadium. The Philadelphia Municipal stadium, built in 1926 for the Sesquicentennial exposition, held 130,000. The Cleveland Public stadium, built in 1931, held over 100,000. In Chicago, Soldier Field, opened in 1926, had permanent seating for 125,000 and could be extended to accommodate more than 200,000. Thus Chicago had the largest permanent stadium of modern times.



COMMERCE, PHOTOCRAPHS (2, 4) ACME, (5) COPE RINGHART WEAVER

# STADIUMS IN THE UNITED STATES

- 1 The Yale Bowl, first used in 1914, covers 25 acres, has 30 entrances and sects approximately 80,000. Photograph taken just before the start of a Yale-Army game
- 2 Sate of a Yale-Army game
  Soldier field, Chiesgo, with a teating capacity of about 200,000, built
  as a result of the enormoutly increasing public interest in sports
  of various types Operation in 1926
  3. Olympic stadium, Los Angelet, enlarged in 1932 to hold 125,000
  speciators. Used for sports contestly concerts and productions of
- various kinds Chicago stadium, Chicago, largest indoor stadium in the world. The stadium, built in 1928, has a seating capacity of approximately 20,000
- Ohio State University stadium at Columbus, Ohio, accommodating about 75,000 spectators. The horsestee shape is a distinctive feature of this stadium. Auchitect, Howard Dwight Smith; engineer, Clyde T. Moris, built in 1922.



ST COURTEST OF (1) TONT CARMIER, ARCHITECT, (6) FINNISH HIRIETRY OF FOREIGN AFFAIRS, PROTOGRAPHS (2, 5) & N A , (2) CENTRAL ASSOPHOTO COMPANY, (4) TOPICAL PRESS ASSIST

#### STADIUMS OF EUROPE

The construction of the huge stadium at Athens in 1896 for the revival of the Olympic games, and the subsequent increase of interest in sports throughout Europe, have resulted in the building of many large stadiums and the reconstruction of others

- 1. Lyon stadium in the old city of Lyon, France, built in 1920
- Stadium completed in Athens in 1896 for the holding of the Olympic games. There are seats for more than 66,000 spectators
- games. Colombes standium, structly practical design, constructed for the Olympic games of 1924
- 4 Stadium at White City, Shepherd's Bush, London, erected in 1908 for Olympic games
- 5 "Les Arènes," ancient amphitheatre at Nîmes, France About 2,000 persons were living within its walls in 1809 when it was cleared by order of the prefect. It is now restored and used as a stedium. Photograph shows a builfight in progress.
- 6 Helsinki stadium built for the XIIth Olympiad which was to be held in 1940 and was cancelled by the outbreak of World War II A dramatic expression of modern construction

STAËL

273

Olympic Stadia have been among the most impressive of stadia. Nearly every country in which the games were held exceted a great permanent stadium for the event. The first stadium of the modern type providing for the full range of the moden program of Olympic events, which is much expanded over its classic prototype, was that built in London, at Shepherd's Bush, in 1996 for the IVth Olympiad.

It provided a conder track, one-third of a mile long, which bounded a turn fare for field events 243 yell by 90 yd. There was for a pool for swimming events, with sufficient depth for drung, and a cycle track. The stands, part of which were rofeel, accommodated 50000 seats. Other Olympic stadia of interest were the Stockholm one of 1912, the severely simple one at Colombes, near Paris, built in 1924, the handsome brick one built at Amsterdam in 1928, and most elaborate of all, that built in Berlin in 1936, for the Xith and last Olympiad to be held before war broke out in 1939.

The nazi government erected the most extensive facilities for sport the world had ever seen. The large stadium, seating roo,coo, was only one of several stadia in the group. The group as a whole was of a sombie, brutal massiveness.

The Berhn sports field just described was but one of many great sports fields each with one or more stadia built by the nazis and fascists during the 1930s. These were part of the program to develop strong youth for the future armies. In this respect they were unlike the stada of the 1930s which had no ulterior purpose. The fascist stadia were elso adaptable for party congresses.

The Deutsche Stadion, Nürnberg, 1937, was the most colossal. Its large scale and enormous extent, almost double the capacity of the Roman Circus Maximus (reputed to be 225,000), gave a solemn dignity to the ceremomes staged in it.

Plans.-The shapes of stadia have varied widely, reflecting the variety of uses for which they have been built. Some were designed for one sport only, such as the Yale Bowl, built in 1014. with a capacity of 80,000, the first modern one to surpass the canacity of the Colosseum. Like its Roman predecessor it is a closed ellipse in plan The Harvard stadium, built in 1012 was U-shape, open at one end to permit both football and track events Others have been built to permit baseball as well. Those built for Olympic games have generally been rectangular to enclose a large playing field, and with rounded corners for the track, as in Berlin, 1036. The horseshoe shape has also been used as at Ohio State university in 1922. The most flexible shape was that providing two parallel stands, opposite each other, with the narrow ends open. Some of this type have been built with superimposed tiers of seats, others with crescent-shaped stands (Northwestern university, 1926) so that as many seats as possible were opposite the centre of the field Still other types have been used for special purposes, such as the Yankee stadium, New York city, 1923, built primarily for baseball, and Forest Hills, Long Island, built for tennis.

Structure.- The building of large stadia in the early 20th century was stimulated by the invention of the automobile and the new material-reinforced concrete. This material is relatively cheap for large structures, but has not proved entirely satisfactory in temperate climates as it weathers badly. Nevertheless, in the hands of skilful engineers and careful workmen, especially in Europe, magnificent stadia have been built in reinforced concrete which daringly exploited the potentialities of the material. Some of the fine examples follow. Lyon, built in 1920 by Tony Garnier Florence, the Giovanni Berta stadium, built in 1933 with fantastic external stair towers expressionistic in style. Bordeaux, built in 1939, remarkable for a roof of graceful arched sections. Helsinki, built for the XIIth Olympiad which was cancelled by the outbreak of war in 1939. The bold tower there was a striking feature. Projects have been designed, though not executed, making use of other structural forms, such as one by Le Corbusier with a roof constructed as the wings of aeroplanes are constructed. Eventually, making use of war-inspired scientific advances, it may be possible to build large stadia completely weatherproof.

(C. L. V. M.)

STARL, MADAME DE. ANNE LOUISE GERMAINE NICKER, BARONNE DE SIAFL-HOLSTFIN (1766-1817), French novelist and miscellaneous writer, was born at Paris on April 22, 1766 Her father was the famous financier Necker, her mother Suzanne Curched almost conally famous as the early love of Gibbon, as the wife of Necker himself, and as the mistress of one of the most popular salons of Paris The future Mme de Stael was from her earliest years a romp, a coquette and passionately desirous of prominence and attention She was a plain child and a plainer woman, whose sole attractions were large eyes and a buxom figure. She is said to have written her father a letter on his famous Compte-Rendu and other matters when she was not fifteen, and to have injured her health by excessive study and intellectual evoltement. There is no doubt that her father's dismissal, and the consequent removal of the family from the busy life of Paris, were beneficial to her During part of the next few years they resided at Coppet, her father's estate on the Lake of Geneva, which she herself made famous They returned to Paris. or at least to its neighbourhood, in 1785, and Mile Necker resumed literary work of a miscellaneous kind, including a novel, Sophie, printed in 1786, and a tragedy, Jeanne Grey, published in 1790. She married Eric Magnus, Baron of Stael-Holstein, who was first an attaché of the Swedish legation, and then minister, For a great heiress and a very ambitious girl the marriage scarcely seemed brilliant, but the king of Sweden promised the ambassadorship for twelve years and a pension in case of its withdrawal, and the marriage took place on Jan. 14, 1786. The husband was thirty-seven, the wife twenty Mme. de Stael was accused of extravagance, and after 11 years (1797) an amicable separation of goods was arranged There was no scandal between them; the baron obtained money and the lady obtained, as a guaranteed ambassadress of a foreign power of consideration, an established position. In 1788 she appeared as an author under her own name (Sophie had been already published, but anonymously) with some Lettres sur J J. Rousseau She stood at this time for a mixture of Rousseauism and constitutionalism in politics. She visited Coppet once or twice, but for the most part in the early days of the revolutionary period she was in Paris taking an interest and, as she thought, a part in the councils and efforts of the Moderates At last, the day before the September massacres, she fled from France, befriended at this critical juncture by Manuel and Tallien.

She betook herself to Coppet, and there gathered round her a considerable number of friends and fellow-refugees In 1793 she visited England, and established herself at Mickleham in Surrey as the centre of the Moderate Liberal emigrants-Talleyrand. Narbonne, Jaucourt and others. In the summer she returned to Coppet and wrote a pamphlet (Réflexions sur le procès de la reine) on the queen's execution. The next year her mother died, and the fall of Robespierre opened the way back to Paris. M de Stael (whose mission had been in abevance and himself in Holland for three years) was accredited to the French republic by the regent of Sweden; his wife reopened her salon and for a time was conspicuous in the motley and eccentric society of the Directory She also published several small works, the chief being an essay De l'Influence des passions (1796), and another De la Littérature considérée dans ses rapports avec les institutions sociales (1800) It was during these years that Mme. de Staël was of chief political importance Benjamin Constant, whom she first met at Coppet in 1794, had a very great influence over her, as in return she had over him Both personal and political reasons threw her into opposition to Bonaparte. Her own preference for a moderate 1epublic or a constitutional monarchy was quite sincere, and, even if it had not been so, her own character and Napoleon's were too much alike in some points to admit of their getting on together For some years, however, she was able to alternate between Coppet and Paris without difficulty, though not without knowing that the First Consul disliked her In 1797 she, as above mentioned, separated formally from her husband. In 1799 he was recalled by the king of Sweden, and in 1802 he died, duly attended by her. They had three children: Auguste-Louis, Albert and Albertine, who married Victor, duc de Broglie.

The exact date of the beginning of what Mme de Stael's admirers call her duel with Napoleon is not easy to determine Judging from the title of her book Dix années d'exil, it should be put at 1804, judging from the time at which it became pretty clear that the first man in France and she who wished to be the first woman in France were not likely to get on together, it might

be put several years earlier In 1802 she published the first of her really noteworthy books. the novel Delblane In 1803 she returned to Paus She was directed by order of Napoleon not to reside within so leagues of Paris, and after considerable delay she set out, in company with Constant, by Metz and Frankfurt to Weimar, and arrived there in December There she staved during the winter and then went to Berlin, where she made the acquaintance of August Wilhelm Schlegel, who afterward became one of her intimates

at Coppet Thence she travelled to Vienna, where the news of

her father's death (April 8) reached her

She returned to Coppet and found herself its wealthy and independent mistress, but her sorrow for her father was deep and certainly sincere. She spent the summer at the château with a brilliant company, in the autumn she journeyed to Italy accompanied by Schlegel and Jean de Sismondi, and there gathered the materials of her most famous work, Cornine She returned in the summer of 1805, and spent nearly a year in writing Corunne; in 1806 she broke the decree of exile and lived for a time undisturbed near Paris

In 1807 Cornue, the first aesthetic romance not written in German, appeared It is, in fact, what it was described as being at the time of its appearance, "a picturesque tour couched in the form of a novel" The publication was taken as a reminder of her existence, and the police of the empire sent her back to Coppet. She stayed there as usual for the summer, and then set out once more for Germany She was again at Coppet in the summer of 1808 (in which year Constant broke with her, subsequently marrying a German lady) and set to work at her book, De l'Allemagne, which occupied her for the next two years. She decided to publish the book in Paris The submission to censorship which this entailed was sufficiently inconsistent and Mme de Stael wrote to the emperor one of the unfortunate letters, at once undignified and provoking, of which she had the secret. The reply to her letter was the condemnation of the whole edition of her book (10,000 copies) as "not French," and her own exile from France She retired again to Coppet, where she was not at first interfered with, and she found consolation in a young officer of Swiss origin named Rocca, 23 years her junior, whom she married privately in 1811

The operations of the imperial police in regard to Mime. de Staël are 1ather obscure She was at first left undisturbed, but by degrees the château itself became taboo, and her visitors found themselves punished heavily Mathieu de Montmorency and Mme. Jeanne Françoise Récamier were exiled for the crime of seeing her. On May 23 she left Coppet almost secretly, and sourneved by Bern, Innsbruck and Salzburg to Vienna There she obtained an Austrian passport to the frontier, and, after some trouble, receiving a Russian passport in Galicia, she escaped from

Napoleonic Europe

She journeyed slowly through Russia and Finland to Sweden, making some stay at St. Petersburg, spent the winter in Stockholm and then set out for England. Here she received a brilliant reception and was much lionized during the season of 1813. She published De l'Allemagne in the autumn, was saddened by the death of her second son Albert, who had entered the Swedish army and fell in a duel brought on by gambling, undertook her Considérations sur la révolution française, and, when Louis XVIII had been restored, returned to Paris. She was in Paris when the news of Napoleon's landing arrived and at once fled to Coppet, but a singular story, much discussed, is current of her having approved Napoleon's return. There is no direct evidence of it, but the conduct of her close ally Constant may be quoted in its support, and it is certain that she had no affection for the Bour-

In October, after Waterloo, she set out for Italy, not only for the advantage of her own health but for that of her second

husband, Rocca, who was dying of consumption Her daughter married Duke Victor de Bioghe on Feb 20, 1816, at Pisa whole family returned to Coppet in June, and Byron now frequently visited Mme de Stael there

Despite her increasing ill-health she returned to Paris for the winter of 1816-17, and her salon was much frequented She died

on July 14, 1817.

Baron Auguste de Stael (d 1827) edited the complete works of his mother in 17 volumes (Paris, 1820-21), with a notice by Mme Necker de Saussure, and the edition was afterward republished in a compacter form, and, supplemented by some Oeuvres médites, is still ob-tainable in three volumes, large octavo (Didot) The Considerations tamable in three volumes, large octavo (Didot) The Considerations and the Dr. années d'evil had been published after Mme de Stael's death Some Lettres néedies to H Meister were published in 1903 There is no recent reissue of the whole, and the minor works have not been reprinted, but Corune, Delphine and De PAllemagne are easily accessible in cheap and separate forms of separate works on Mme de Stael, or rather on Coppet and its society, besides those of MM

de Stael, or iather on Coppet and its society, besides those of MM Caro and Othern d'Hausson/tle, may be mentoned the work of A Sorel in the Corands correases françair. In English there are boquephies See also E. Hernot, Urn owneys midst de Mme de Stael (1904), P. Kohler, Mme de Stael et la Susse, Elisde bographique et in-terme (Laussine, 1918), I. Boy-B.G. Germane von Stael (Stuttgart, Caroline, 1918), I. Boy-B.G. Germane von Stael (Stuttgart, 1914); I. Boy-B.G. Germane von Stael (Stuttgart, 1914); I. Br. B. F. G. Celteron, Mm. de Stael et M. Necker, 4daprès leur correspondance midital (1923).

who assist the commander of a military force. The basic meaning of the term is similar in all armies, though staff organizations and

their functioning vary considerably

As armies increased in size and complexity, commanders were unable to win victories without staff assistance Commanders, no matter how capable, could not keep watch on the multitude of details involving recruitment, intelligence, operations and plans, and supply. When numerous divisions and corps were included in armies, the top commander was unable to maintain contact with the subordinate units Assistance was obtained by the creation of staffs, including officers and enlisted men, to handle the numerous details of command. Though assistants gave advice to the commander, they had no authority to give orders, except in the name of the commander Eventually, it became necessary to co-ordinate the activities of the staff through a chief of staff. The procedures of the staff, its rights and responsibilities and its place in the armed forces became known as the "functions of the staff

As a later development, the term "general staff" came into existence. It was first used in 1809 by the Prussians to indicate the staff assisting the general commanding the troops of an entire army. However, when forces became larger and many armies were created, the term "general staff" was used for the highest headquarters. As a further amendment the term "general staff," when followed by the designation "with troops," named the staff officers assigned to major subordinate headquarters There they performed duties similar to those at the highest headquarters

Other terms concerning staff functions developed later, such as 'special staff," "administrative staff" and "technical staff" These experts in supply, ordnance, administration and the like were essentially advisers, having no staff functions of policy and management comparable to the general staff. Normally, special staff officers have two functions, advice in their specialty and command of service or administrative troops

## HISTORY OF MILITARY STAFFS TO 19TH CENTURY

Ancient Armies.-Staffs in the early armies of Persia, Greece and Rome were usually on an informal basis. The commander was in complete charge in battle; his orders were sent to subordinates through messengers or aides de camp and the quaestor or supply officer.

Both Athens and Rome maintained committee commands in their armies. In Athens authority was exercised by ten strategoi, literally generals, under whom were ten taxiarchs who were in charge of subsistence, construction of camps, the orderly conduct of marches and had limited command functions.

When Caesar came to power in Rome he found a curious system of command in the army, each legion being commanded by a committee of six tribunes Divided into sets of two, each pair commanded the legion for a definite period or companya, Laing the lader's position on alternate days. Somewhat similar to the Achenian command by the ten stratego, it was a straige though accessful system. Whether the battles were won despite the command system is a moot point. One advantage was that the tribunes not in command were eligible for staff duty as assistants to the commander. Caesar modified this committee system of command by placing a legate as the leader of the legion, utilizing the two frulness on duty as staff assistants.

During the middle ages when warfare was an individual affair among feudal chiefs, there was practically no development in the staff system and no need for it. However, the crusaders, who lacked a national character and were feudal theirs and set is bound together by a religious mission or spirit of adventure, learned that their operations and movements needed co-ordination. No one looked after their ships or assured supplies of food, weapons, sege equipment and horses. Defeat convinced the crusaders of the need for assistants to control and co-ordinate their supply system.

need for assistants to control and co-ordinate their supply system Military staffs however, showed no significant development until the time of Gustavus Adolphus, when dynastic armies came into prominence

Gustavus to Napoleon.—The Swedish army of the 1620s was the best organized of any army up to that time It brought with it new tactus, an appreciation of held fortifications and a supply system which functioned smoothly. Gustavus Adolphus organized a staff nucleus in his regiments. Each headquarters included a colonel, a lieutenant colonel and a major, a quitermaster four suggeons, four provost marshals, two judge advocates and two chaplams, assasted by a number of clerks. The quartermaster was a vital member of the staft, being responsible for food supply and the movement and quartering of troops. Provisions were distributed to the regiments in bulk, subsequently being issued to the men by the regimental major, who was also called the "sergeant major." In addition to such duty, it was a logical step for the latter to assume administrative and operational functions.

The Swedish army was governed by regulations upheld by contra-martial, a system which endured in all armies. To enforce the regulations, the staff position of provost marshal was created These changes increased the staff duties in armies, but none would have been possible without punted regulations and orders. By Gustavus' time, the printed word for military orders was replacing the verbal orders in practice since the Greek and Roman armies

"Cromwell's New Model army followed on the heels of the Swedish army, giving new impetus to organizational innovations. His staff system, like that of Gustavus, was organized under a captain general, assisted by a chief of staff who was also chief of infantry and sergeant imago general. Connwell, as second in command to Sir Thomas Pariatx, was heutenant general and chief of cavalry. The other staff officers also doubled in brass; the commissary general as an assistant chief of cavalry; the chief of ordance as head of both artillery and engineers. In his insistence that all men be paid for services rendered, Cromwell required another staff officers, a commissary general of musters

Soon afterward, the French munister F-M. Louvois substantially improved the supply of ammes. He persuaded Louis XIV to introduce a staff officer known as the intendant who operated commissaries, pand the troops and procured and distributed supplies. Later the intendant's duties were restricted to finance and procurement, supply being directed by the marchala gladral das logis. Within the French army staff the logistical chief was on the same chelon as the marchala de battille, the chief of operations. Both served the field marshals commanding armies, who in turn reported to the marchala de France.

Subsequently, Louvois replaced the field marshals by a marshal of legistics, who with his assistants formed an army staff. Sébasticn Vauhan, the celebrated slege expert, was the inspector general of engineers, while Jean Martinet served the infanty. The latter demanded such rigid discipline that his name was given to all struct discribinaristics.

During the 18th century, Frederick the Great gave new impor-

tance to staff (unctioning For instance, he was assisted at all times by a quartermaster general whose duties were to survey and lay out camps, bridge streams and plan the defense of villages Frederick as a staff mentor also instructed a number of officer candidates in making reconnaissances, planning operations and using obstacles for flank protection of armies. He also founded in 1765 an academy of nobles for the training of young men in diplomacy and the military art. Subsequently he established a war academy and personally permed its regulations and course of instruction. These were the first schools for the training of staff officers.

Though he had an obvous interest in the education of military staffs, Frederick himself manitaned a very small staff of assistants. Rather than a lack of interest, it indicated that as both king and army commander he incorporated in his person many of the staff tunctions which might well have been delegated to staff specialist. He was an ardent engineer, paying particular attention to the building of roads, bridges and field fortifications, he was vitality concerned with tactics and supply. In effect, Frederick was list own military staff. Succeeding commanders, other than Napoleon, rarely held his combination of political and military power.

Napoleon.—Because Napoleon was both chief of state and commander of the arrny, and because of his mitiatory abilities no real general staff was required. Marshal Louis Alexandie Berthier was Napoleon's chief of staff, but in name only, since he acted more as an adjutant. Other staff officers were François de Chasseloup-Laubat, the chief of engineers, Nicolas Marie de Chasseloup-Laubat, and Perre Antonion Darut, the chief of the quartermisater department. Each of the latter also had his own personal staff.

Many of the famous French marshals were at one time adjutants general, assisting the cluef of the general staff for the army. The position of adjutant general had been created by the National Convention in 1792, as replacement of the former maréchal général des logis.

Berthier, a student of staff organization and functioning, reduced to writing the principal duties of the general staff. He placed great emphasis on the necessity for speed in staff work. The first real manual on staff procedure was, however, written by an adjutant general, Paul Thiebault. Basic staff theory and technique were included in the manual, insistence being given by the author to the requirement that staff officers responsible for reports make them "pieceies, accurate, and complete". The staff functions sot forth in the manual were based largely on Berthier's instructions to his stafful.

The first section included staff records, legal matters, personnel affairs such as recruitment, prisoner of war records and the like Supply of food, equipment and arms was the principal activity of the second section of the staff, though it also included the medical and military police staffs.

In addition to a division of functions, the staff manual set forth the essentials of staff knowledge and practice based upon army experience. On one occasion when Thebault was serving as a divisional staff officer, he was questioned by Napoleon, who was making an inspection. Thiébault was unable to tell him the supply struction and the enemy intelligence—all of which were embarrassing questions for the young staff ofheer.

The staff manual was the culmination of his resolve to systematics the handling of information so that it would be readily available to the commander. It included data on the functions of each staff officer, organization of the staff, allocation of work and detailed forms for staff reports, even to the number of paragraphs needed. He listed the higher staffs of the period as including the commanding general, chief of staff, aidles to the general, adjuttant general, intendants or finance officers, generals of artillery and engineers, health officers and the wagonmaster general.

In the United States, the duties of the staff were in no way developed as in the Napoleomic armies. Army legislation in 1796 constituted a general staff to include one major general, a brigadier general, an adjutant general, a quartermaster general and a paymaster general.

### DEVELOPMENT OF MILITARY STAFFS TO WORLD WAR II

German Staff System.—Gerhald von Schanhonst's roorganzation of the Prussna army after 1820 included a staff system During the succeeding years through World Wai I, the German general staff exeited the greatest influence on the development of modern military staffs. Men like Schamhorst, and Count August von Gensenau and Count Helmuth von Moltke after him, built upon the staff system of Frederick the Great Its prestage was overawing, mainly because of the German social system which gave the military a position of great influence The Japanese and Russans based their staff systems on the German model, in many cases German officers actually training their staff candidates

While it is true that the German general staff was built upon Geman ideas under Fredenck and Scharnborst, it was undoubtedly influenced by Napoleomic methods. Certain terms in staff procedure were taken directly from the French and even tetained their French spelling. Moreover, French ideas were brought into the Pressans staff system by French instructors at the war academy.

It was the Genmans who first began assigning general staff officers to subordnate headquarters. However, in being thus assigned they were not attached to the local general in command but to the organization so that in effect the ideas of the general staff at the highest headquarters permeated all the major subordinate commands. In Jost the highest staff became known as the great general staff and the other portion which was distributed to the army commands was known as the army general staff. In time the great general staff in Berlin became known for its dictatorial methods, its arrogance and its dominant role over the entire army A military caste was created which considered war as a national enterprise and their monopoly. The great general staff became permanent, independent and specialized.

The Prussan general staff through more than a century of war and peace gave to the term a connotation of arbitrary, militaristic and anstocatic power. Despite these handicaps, under Moltke in the latter part of the 19th century it was an extremely efficient organization. Its plans were complete and worked out to the last detail.

The staff organization had five sections, of which the first section was the general staff with responsibility for operations, intelligence, supply and administration and training. The other four sections were in sequence the adjuntat general, the pudge advocate, special services such as medical, pay, quartermaster and the like, and the chaplain service. The particula work of the staff was accomplished by three groups drawn from the five sections a tactical group consisting of operations and intelligence from the general staff in the first section, a supply group consisting of the supply branch of the general staff and the fourth section with attacked the pudge advocate and the chaplain from the second, third and fifth sections, respectively. The training function was exercised by the general staff without assistance from any of the other staff sections.

One other feature of the German general staff was rotation of officers for periods of general staff and troop duty. Thus the general staff gained complete control of the army by assuring that higher troop commanders were selected members of the general staff.

French Staff System.—In contrast to the development of the German general staff during the 19th century, the French staff system was moribund Cestain graduates of the French military schools of St Cyr and Ecole Polytechnique entered the Ecole Gittat-Major, stabhished in 18t8, where they learned the routine of staff procedure. For the remainder of their service they were members of a weak staff bureau, separated from the troops.

After the French defeat in the France-Frassian War, a true staffrollege, the Ecole de Guerre, was established in 1880. Its attention to strategy and higher staff training awakened the French staff system, so that by 1914 France had a well-trained staff on a par with that of Germany. Impetus in the French staff system also came from legislation in 1894 which set forth the basic regulations for staff organization and procedures.

Staff responsibilities were made specific, and staff channels were later fixed within an organization of three sections or bureaus

The first bureau was charged with organization, promotions, secruting and other personnel matters. Enemy information was the concern of the second bureau, while the third prepared orders and institutions for imitiary operations. A peculiarity of the French system was the decentralization of a fourth bureau, for supply, to the subordmate field commands. Thus the theory and technique of the French staff had gone through an evolutionary process before World War I, rising from its low point after the success of the Napoleomic era to a capable organization at the close

of the century

British Staff System.—By World Was I, the British general
staff was well trained, though too few in numbers to meet the war's
demands Staff development during the 19th century had been
extremely slow, little cognizance being taken of Prussian and
French methods H Spenser Wilkinson's The Brain of an Army
published in 1963, awakened Britan to the need for rehabilitation
of its staff system Its author purported to give the secret of
Moltke's success.

Fortunately, a staff college had been established in 1858, and though it had not produced the desired improvement in Brists staff practice it had provided a basis for development. In the Boer War the British command and staff system had exhibited many deficiencies. A report of inquiry by Lord Esher in 1904 resulted in a reform of the British staff.

Basacally, the British staff depended greatly upon committee efforts and upon co-ordination. Below the highest command there was no chief of staff, the functions of that office being divided among the general staff, the administrative ("A") staff and the quartermaster ("Q") staff. Prussan influence was evident in the system of having the senior general staff officer act as commander in the latter's absence. Furthermore, division of the administrative and service functions of the staff was reminiscent of the Cerman method.

Operations and intelligence were general staff functions, while the "A" and "Q" staffs were responsible for personnel and supply, respectively The British organization differed, however, from the German in that supply was a function of both the general staff and the "Q" section

The fact that the British staff varied from those of France and the United States (the latter based on the French organization\text{resulted in many complications in both World Wars I and II The Allied armies had to learn one another's staff procedure and terminology in order to function smoothly as combined forces

U.S. Staff System.—There was no general staff in the army of the United State during the right century. The adjusting temperal, quartermaster and other technical and administrative service chiefs were a law unto themselves. The commanding general had no direct authority over the various bureaus in the staff. When Gen William Tecumseh Sherman was commanding general after the Crul War, he threatened to move his office from Washington, D.C., because he had no control of the independent staff bureaus

Prevously, during the Civil War, the field commanders developed their own staffs, but there was no comparable development in the war department. Gen George B McClellan, when commander of the union army in 1861, complained of the lack of a staff system, probably forgetting that six years or before he had made no note of European staff methods when on an inspection committee. However, he improvised a staff, utilizing his inspector general as chef of staff

The creation of a general staff was not seriously proposed until after command failures in the Spanish-American War brought action by the secretary of was, Elihu Root He established a command and general staff school in 1902 and the next year obtained from congress authorization to organize a general staff. The list of its duties was borrowed from the Pressan, Paul Bronsart von Schellendorf, and its organization from the French. Staffs were formed in all headquarters, to include the infantry division, in World War I Five sections were organized under a chief of staff; personnel (G-1); intelligence (G-2); operations and plans (G-3); supply and transportation (G-4); and training (G-5).

### WORLD WAR II STAFFS

Changes in Staff Organization .- The social nature of war was well illustrated during World War II with two developments m military staffs The first requirement was for more specialists and therefore resulted in an increase in the size and complexity of military staffs The second development was the unified command of two or more forces or nations, testimony to the interlocking nature of modern war

The German, Japanese and soviet armies employed substantially the organization of the German general staff explained above The French and British systems were little changed from those of World War I but the U S general staff shifted war plans from G-3 to G-5, delegating training to the field forces

In all armies, World War II brought about certain changes designed to improve the efficiency of staff operation. For instance, the soviet general staff, which had always included topographical engineers, a historical division, security police and political commissars found that it had to eliminate the political commissars for a time because the troop commanders complained of divided command The Red army's historical division was charged with keeping an account of military operations of the higher ranking generals If unsatisfactory, commanders were summarily removed.

The U S war department staff was reorganized to include an air force and a service force staff in addition to the general staff. The latter underwent a change in that G-5, war plans, developed into the command post of the chief of staff and was designated the operations division This move, in practice, placed the operations division on a higher level than the other general staff divisions

Prewar staffs were found to be much too small both in function and number to handle the multitude of problems which arose in World War II. In most aimies, policy matters were the prerogative of the general staffs, technical functions and operational matters being delegated to subordinate headquarters which organized staffs along conventional lines. Administrative services of this kind were drawn together in a separate command known as rear area services in the Red army and communications zone headquarters in the U.S. army

Unified Staffs.-The second development, formation of joint and combined staffs, was peculiar to the total and global warfare of World War II. Blitzkrieg tactics, requiring the utmost cooperation between land forces and the air fighter support, underlined the necessity for commands containing both army and air force officers Similarly, amphibious operations brought in the navy as well, so that there was close staff co-operation among the three combat forces This union of the staffs of two or more services of one nationality was called a joint staff. The phenomenon was restricted to the central headquarters at home and to the theatre or highest overseas command headquarters. For instance both the U.S. and Great Britain formed supreme commands. known as the joint chiefs of staff in the United States, and the chiefs of staff committee in Great Britain. In both cases the joint staff at the seat of government was concerned with war plans, logistics support, intelligence, munitions production and other requirements of waifare, and included army, navy and air force staff officers In the field, the joint staffs were not co-ordinated to such a high degree since the commander of each dimension of warfare had his own staff and made arrangements for co-operation through committees or liaison, to assure co-ordinated accomplishment of the joint objective.

Co-ordination among Allies was effected through a combined staff of officers from two or more nations. The best demonstration of this type of staff were the two commanded by Gen. Dwight D. Eisenhower in his armed forces headquarters in Africa (AFHQ.), and in his supreme headquarters Alhed expeditionary forces (S.H A.E.F.) in Europe. In the latter staff, army, navy and air force officers and enlisted personnel, men and women, from Britain and the U S were formed into a true combined headquarters Under Eisenhower were field commanders for the army, navy and air force, the latter two being British and the first an American. His staff was organized on the basis that alternate staff

divisions, branches and sections were to be headed by alternate nationals British or American. The chief of staff was an American supported by two British deputy chiefs of staff, one for operations and intelligence and the other for administration and supply This was a merger of the British and US staff systems with a deputy for operations and intelligence, controlling the complete general staff in the British system, and the combined G-2, G-3 and G-5 in the U.S. system. The other deputy was both the "A" and the "Q" cluef in the British system and the G-1 and G-4 in the American In the staff divisions the G-1, G-3 and G-4 staff chiefs were American, and the G-2 and G-5 (the latter having become civil affairs and military government) were British

The functioning of such combined and joint staffs was complicated by differences in nomenclature and in staff channels. However, because of the educational processes of the previous century which were common to the staffs of all major nations, the preparation of policies and plans and the position of the staff as assistants to the commander were well accepted by all staft officers Furthermore, staff officers were acquainted universally with the co-ordination of their efforts by a chief of staff Also the relationship with tactical, technical and special staffs was similar in all armies In most cases, the ordnance, engineer, quartermaster and other technical specialists reported to the supply thief, the chaplams, adjutant general, finance officer and provost marshal reported to the personnel chief There was a slight difference in staff placement of signal communications, it being a part of the general staff in the British and soviet systems, but a technical service in the US and German staff systems

### TRENDS AFTER WORLD WAR II

The postwar trend in staffs was toward greater unification of effort and a reduction in the number of agencies reporting to a commander or chief of staff. The Soviet Union in 1046 followed Britain's lead of ten years before in the establishment of an armed forces general staff, and the United States tollowed suit in 1947 In both cases, this establishment of a unified staff was legal recognition of a system which had developed during World War II The soviet armed forces staff was largely controlled by army officers since the army had been the primary service in that country, the navy being rather small, and the air force a tactical group assigned for close support of the field armies. In Britain and the US there was increased use of the joint or unified staffs, and a further development of combined staffs under the North Atlantic treaty defense committee

The 12 nations signatory to the North Atlantic treaty agreed to set up regional military committees which required the combination on one staff of as many as five nationalities 
It was recognized that the language difficulty had to be hurdled first, then training and tactics had to be standardized. A precedent was set for the staff combination of more than two nations since S.H.A.E.F. included British and U.S. staff officers with French, Polish, Belgian and other nationalities in a haison capacity.

Standardization as well as more complex staffs in keeping with the progressive scientific nature of war had become the trend in organization of military staffs.

The progressive source that the Co was and Decorate trees the Bratton of military staffs.

Brattonoanty - Grayano I. Kirk and Rohnd P Stabilus. We and Bratton P Stabilus. We and Bratton P Stabilus. We are stated in the Control of the Control Staff (1976). It Spense the Stabilus of the General Staff (1976). It Spense twinkinson, The Bratton of an Army, rev ed (1895). We R. Robertson, Solders and Statesmens of an Army, rev ed (1895). We R. Robertson, Solders and Statesmens, 1974—1975. The State Control of the Con

cers delegated to advise and assist a flag officer in the administration and operation of his command In the sailing-ship era simplicity of operations, cramped quarters and short range of communications restricted staffs to one or two officers. The technological revolution of the 19th century, progressively magnifying and complicating the problems of naval command, enlarged the size and functions of staffs so that in the Civil War as many as eight staff officers were detailed to an admiral, in World War I Adm William S Sims, the commander of US naval forces in Europe, recruited a shore-based staff numbering in the hundreds, and in World War II Adm Chester W Nimitz, naval commander in the Pacific, counted his staft in the thousands Radio facilitated the staff growth in World War I by permitting concentration of authority In World War II the necessity of co-ordinating land, sea and air forces swelled staffs still further

Naval staffs today are grouped in two categories, operational and administrative A single staff may fall in both categories but separation promotes standarduction of administration and relieves combat officers of petty details. Operational staffs, small and mobile, accompany task force commanders into battle assisting with the planning and eaceution of combat missions. Administrative staffs usually base ashore or in large auxiliary ships supervising maintenance, alteration, supply and training of a particular type of ship within a fleet. As an example, in World War II the commander of destroyers of the Pacific fleet never commanded destroyers in battle but he and hus staff did check destroyers for readiness of me and material. Similar administrative commands and staffs specialized in such types as cruisers, battleships, amphibous vessels, carriers and their aircraft.

A typical seagoing operational staff in 1950 comprised about 20 officers with at least as many enlisted cliental assistants and technicians. The enlisted men were not staff members but constituted the "enlisted flag complement." The staff was compartment onto five functional divisions administration, intelligence, operations, logistics and communications. These divisions were sectioned into such diverse technical fields as guinnery, aviation, supply, medicine, public information and amphibious operations. The staff officers were not always specialists in the particular fields to which they were assigned.

Three officers were assigned as the flag officer's ardes and each were a distinguishing agualletic One of these, the chief of staff, always the senior staff officer, co-ordinated all staff activities A second, the flag secretary, was the administrative officer in charge of correspondence and office routine. A third, the flag laustenant, was personal ande and staff signal officer. A these, staff offices of the line stood watch on the flag bridge or in the operations centre, transmitting the admiral's orders to the shines of his command.

An administrative staft ashore was organized along similar lines to an operational staff but naturally placed emphasis on normothet fields such as logistics, training and administration. Normally flag officers ashore had but two aides, one the chief of staff, the other called simply the "aide".

Staff organization at the top of the mavy, a product of long overvolution, din ot conform to the pattern of the lower exclusion nor to the army's general staff system. After 1798 a civilian secretary of the navy reheaved the presendent of the details of his task as commander in chief of the navy From 1842 the secretary was advised and assisted by professional officers, each the chief of a technical bineau (such as ordance or ships). Subsequent to 1915 there was a chief of naval operations who as commander of operating forces required a staff and as adviser to the president was a member of a staff.

The chief of haval operations, appointed by the president from among line flag officers, commanded the operating forces and was responsible to the secretary of the navy for their use, including but not limited to training, readness and preparation for war and war plans. Stationed in Washington, D.C., he also acted as the principal naval adviser to the president and the secretary of the may on the conduct of war. At the outbreak of World War II the president appointed Adm. Ernest J. King as commander in chef of the United States fleet to control and distribute naval power in

STAFF, NAVAL. A naval staff consists of a group of offist delegated to advise and assist a flag officer in the administrain March 1942 when Admiral King became both fleet commander
in and operation of his command. In the saling-ship or and object of naval operation of his commander.

Admiral King, by virtue of his office was a member of the joint cheefs of staff together with multary heads of the army, the joint multary heads of the army, the was responsible for the strategic planning and direction of multary effort Admiral King sat also on the combined chiefs of staff, an organization composed of the US president, US joint chiefs of staff, British pume minister and British multary leaders. This body was designed to unify the war effort of the two Allies

Latson among Vatious commands, an essential function of World War II staffs, was easily maintained between the joint and combined chiefs of staff since the same US leaders sat on both In subordhate echolises there were frequent interstaff exchanges of views by radio, letter and personal meetings. Theatre leaders and their staffs made recommendations based on knowledge dear tived from proximity to the scene of action. Thus, in 1943 when Admiral Nimitz's staff discovered that amphiboious assault against Narru Island in the Pacific was physically impracticable he suggested that the joint chiefs of staff substitute Makin. This was done. Similarly, when US commandes in Philippine waters in 1944 found unexpected enemy weakness and asked authorization or an immediate seizure of Leyte, permission was at once granted

After World War II the title commander in chief United States fleet was abolished, the chief of navial operations retaining the functions of that office. In July 1947 congress passed the National Security act providing for unification of the armed forces under a single civilina secretary of defense. Under this act the joint chief of staff comprised a charman, the chief of staff of the army and are force and the chief of navial operations. In addition there was an Armed Forces Policy council which included the secretaries of defense, army, navy and air and the joint chief of staff. This council advised the secretary of defense on matters of hoad policy relatine to the armed forces.

The staff (although not called such) of the chief of naval operations consisted of a vice-chief of naval operations, an inspector general and five deputy chiefs of naval operations, one each for the fields of personnel, administration, operations, logistics and an

The traditional technical bureaus were retained, the secretary of the navy, assistant secretaries and the chief of navial operators sharing jurisdiction over the bureau chiefs and receiving from them technical advice and logistic assistance. These bureaus were ships, aeronautics, ordanace, supplies and accounts, navial personnel, medicine and surgery, yaids and docks, judge advocate general and headouratres marine corbs

To summarze, the chief of naval operations was a member of the president's military staff. As operational chief of the navy, he was advised and assisted by his staff of vice-chiefs. The bureau chiefs, primarily responsible to the secretary of the navy, were not a staff in the strict sense.

The term naval staff is not to be confused with naval staff corps which are organizations of specialists. In the U.S. navy in 1790 the staff corps were, medical, supply, chapian, civil engineer, dental, medical service and nurse corps Staff corps officers exercised administrative jurusdiction within their specially but only in exceptional instances succeeded to combat command which was the province of the executive or "fine corps" of the navy

the province of the executive of me to object to the province of the executive of me to object to the executive of the execut

Great Britain.—In the British navy the naval staff at the admiratly consists of the chief of the naval staff, who is also the first see lord, the vice-chief of naval staff, the deputy chief of naval staff (art), who is also the fifth see lord, and the assistant chief of naval staff. These officers together with the second, third and fourth sea lords are the naval members of the board of admiralty. These officers are assisted in their duties by the directors and officers of the various staft divisions which include. Inteligence, plans, signal, operation, trade, naval air warfare, naval

air organization and training, gunnery and antiaircraft, torpedo, antisubmanne and mine warfare, navigation and direction, tactual and staff duties and training. The naval staff was organized and embodied within the board of admirally on May 14, 1917

Maval officers serve on the naval staff of the admirally for a period of about two years, after which time they rejoin the fleet. There is, however, a large permanent civil staff which handles the office administration and advises on technical, legal, financial and secretarial matters. By this means a destrable degree of continuity is maintained despite the frequent changes in naval personnel. At the same time the organization is kept up to date with new ideas:

and opmons from sea Outside the admiratly each commander in chief, squadron, division, floulla or base commander is allocated a staff commensurate with the size and importance of the command. Thus a commander in chief of a main fleet or station will probably have appointed to his staff officers designated to perform the duties of chief of staff, captain of the fleet, operations, plans, intelligence, guinery, torpedo and antisubmarine, communications, aft, royal mannes,

eigineering, accountancy, medical, electrical and educational On foreign stations this staff may be augmented by officers appointed to carry out the duties concerned with the logistic support of the fleet. This duty would normally be performed by the admirity on a home station. In addition, it is a custom to allow every admiral in command a personal staff consisting of a secretary and a flag leutenant (A D.C.) who is usually a specialist in communication of the control of the cont

cations duties

The flag officer in command of a squadron of ships is provided with a smaller staff. The staff officers in many instances perform ship's duties in addition to their staff function. For example, the gunnery officer of the flagship is frequently squadron gunnery.

officer on the flag officer's staff

The captam in command of a destroys flotilla or escort group has a staif of specialist officers (i.e., gunner, torpedo and antisubmarine, communications, engineering, avantion, electrical) to assist him in deciding the policies to be employed within the flotilla under various circumstances. The duties of the staff also include assisting individual commanding officers in technical matters regarding repair and maintenance and also in weipon training and practices.

After World Wai I a need was felt for proper training in staff duties so that all officers on staffs would be thinking, planning and

writing on more standardized lines

By 1938 the Naval Staff college at Greenwich was engaged in buning out a number of officers who were trained to be stiff officers and who were possibly capable of reaching the higher ranks of the navy since they would then be able to appreciate more readily the functions of their staffs. The Greenwich course had the added advantage of giving officers an adult education which was designed to assist them in carrying out their duties on an admiral's staff. This staff training was continued, with a short break during World War II, and extended. The royal navy, together with its sister services the army and the royal air force, sends its officers to higher staff colleges where training is given on a higher and more unified level.

To train the best officers the royal navy has always been averse to any idea of a general naval staff corps. Naval staff officers when embarked in an admiral's flagship are considered in excess of complement and do not fall into the chain of command of the ship in which they are embarked. This does not, however, interfere

with their chance of promotion.

STAFFA (Norse for staff, column, or pillar island), uninabited island of the Inner Hebrides, Argylishire, Scotland, 54 m. W. of Oban by steamer, about 7 m. from the nearest point of Mull, and 6 m. N. by E. of Ions. It lies almost due north and south, is \$4 m. long by about \$4 m. wide, and its highest point is 135 ft. above sea-level In the north-seat it shelves to a shore, but otherwise the coast is rugged and much indented with numerous caves. During the tourist season it is visited regularly by steamer from Oban. In section the isle has first a basement of tufa, from which rise, secondly, colomades of basait in pillars forming the faces and walls of the principal caves, and these in turn are

overlaid, thirdly, by a mass of amorphous basalt. On the southeast coast is the Clam-shell or Scallop cave. It is some 130 ft long, and on one side of it the ridges of basalt stand out like the ribs of a ship. Near this cave is the rock of Buuchaille "Her Herdsman," from a supposed likeness to a shepherd's cap), a pile of columns, fully seen only at the water On the south-west sales are the Boat cave and Mackumon's or the Comorants' cave. Fingal's cave, the most famous, situated in the southern cof of the isle, is 227 ft. long On its western side the pillars are 36 ft. high The cave is the haunt of seals and sea burds

STAFFORD (FAMILY) This famous English house was founded in Englind by Robert, a younger brothet of Ralf de Tosiny (Toeni), of a noble Norman house, who was standard-bearr of the duchy Robert received at the Conquest a great fiel extending into seven counties and became known as Robert de Estafford from his is issidence at Stafford castle. With his son the male line became extinct, and his sister's husband, Hervey Bagot, one of his knightly treants, succeeded to the fier in her right (1194), their descendant Edmund de Stafford (that surrame having been assumed) was summoned as a baron in 1299. His son, RALPH, conducted the brilliant defence of Auguillon against the host of France, fought at Creey and in the stage of Calais Chosen a Knight of the Garter at the foundation of the order, he was created earl of Stafford in 355.

His son Huori, who succeeded as and earl in 1372, served in the French wars. From 1376 he became promument in politics, probably through his marriage to a daughter of the earl of Warwick, being one of the four lords on the committee in the Good Parlament, and also serving on the committee that controlled Richard II. (1378-86), whom he accompanied on his Scottish expedition in 1385. He dead next year on playimage at Rhodes. His son, Thomas, the of Buckingham (son of Edward III.), who, on Thomas's death, married in 1398 his brother Edward, but of the 1814 his properties of the State of the State of the State of the State of Suckingham, was placed by his descent and his possessions in the front rank of the English nobitly.

HENRY, the 2nd duke, was attainted in 1483, but on the triumph of Henry VII. in 1485 EDWARD, the 3rd duke (1478-1521), regained the title and estates, and recovered the ancestral office of lord high constable in 1509. He was accused of treason and, after a nominal trial by his peers, was beheaded on May 17, 1521, a

subsequent act (1523) confirming his attainder

HENRY (1501-1563), the son of the last duke, was granted by the Crown some of his father's manous for his support, and, espousing the Protestant cause (though married to a daughter of Margaret, countess of Salisbury and sister of Cardinal Pole). was restored in blood on Edward VI's accession and declared Lord Stafford, as a new creation, by act of parliament. His second surviving son, Thomas, eventually assumed the royal arms, sailed from Dieppe with two ships in April 1557, landed at Scarborough, seized the castle, and proclaimed himself protector. He was captured and executed for high treason. His father's new barony, in 1637, passed to a cadet in humble circumstances, who was called on, as a pauper, to surrender it to the king, which he did (illegally, it is now held) in 1639. The king thereupon bestowed it on Mary Stafford (the heir general of the line) and her husband, William Howard, in whose descendants it is now vested. Roger, who had surrendered the title, died in 1640, the last heir male, apparently, of the main line of this historic house.

of the main line of this historic house.

See Dugdals, Beromage (1675), vul. i; G. E. C(ckayne), Complete
Bernage, Wrottedley, History of the Fromity of Bagot (1995) and
Bernage, Wrottedley, History of the Fromity of Bagot (1995) and
Bernage, Wrottedley, History of the Fromity of Bagot (1995)
Bernage (199

STAFFORD, market town, county town, municipal borough, Stafford parliamentary division, Staffordshire, England, on the river Sowe, a tributary of the Trent. Pop. (1938) 32,190. Area

7 or sq mi. An important junction on the L M.S. railway and 1321 mi. NW. from London, it is also served by the LNE and GW railways. While largely modernized, it contains a number of picturesque half-timbered houses. The church of St. Mary, once collegiate, with its canons mentioned in Domesday, shows transitional Norman, Early English and Decorated styles. The complete foundation is attributed to King John It contains a memorial to Izaak Walton (q v.), a native. The older St. Chad's (much restored) has good Norman details Since 1909 Stafford has been the seat of a bishopric suffragan in the diocese of Lichfield. The William Salt library, presented in 1872, has many local books and mss.
Stallord (Stadford, Stafford, Stafforde) is said to have originally

been called Betheney from Berthelin, a hermit who lived there In later Anglo-Saxon times Stafford contained a royal mint. It is a borough in Domesday Book, and the chief place in the county The king received all dues, two-thirds as king, the other third as earl of Stafford From the Domesday Survey it appears that the Conqueror built a castle at Stafford; this was destroyed in the wars of the 17th century. The existing ruin of Stafford Castle is that of an unfinished mansion (1810), which replaced the old stronghold. Beyond it is an early encampment, Bury Ring, A charter from John (1206) constituted Stafford a free borough. The staple industries are the manufacture of boots and shoes and

engineering. The town was extended in 1934

STAFFORDSHIRE, a midland county of England, bounded by Derbyshire, Leicestershire, Warwickshire, Worcestershire, Shropshire and Cheshire The area is 1,154 sq ml. The county may be divided into three geographical divisions, north, middle and south Staffordshire, depending on the geological structure. The highest land is in the north Here the southern ends of the Peak folds bring up Lower Carboniferous rocks, with limestones in the north-east and the Pendleside shales and Coal-Measures forming four basins in the north-west and centre The district is drained by the headwaters of the Trent and its tributaries the Dove, Hamps, Manufold and Churnet and shows a diversity of scenery, the limestone hills being domed and treeless, whilst the Pendleside shales form heather-covered moors, and the grit bands have bold scarp faces Axe Edge (1,756 ft ), and the Roaches are the highest hills, being formed by Millstone Grit The four coal-basins are the Pottery, Cheadle, Shaffalong and Goldsitch Moss coalfields. The last two are small and contain only the lowest coal-measures and are no longer worked. The Pottery and the Cheadle basins are more important and contain valuable seams of coal The Bunter sandstones of the Cheshire plain overlap the coal-measures in the west of the Pottery basin.

Middle Staffordshire is a broad undulating plain, occupied by various members of the Trussic series and drained by the Trent The plain is divided into an eastern and a western portion by Cannock Chase, formerly a royal preserve, now an important coalfield concealed beneath a cover of glacial sands and gravel which rest upon Bunter sandstone. The high ground rises to about 500 feet The "Black Country" occupies the greater part of South Staffordshire. Here again the country is low and undulating covered on its margins by the Trias whilst in the middle lies the South Staffordshire coalfield, in which there are several small inliers of Silurian rocks which stand up above the surrounding country to a height of 800 feet. Most of the county is drained by the river Trent, a few streams drain into the Dane which flows into the Mersey, whilst a small area in the west and south-west forms part of the Severn drainage system The only considerable sheet of water is Aqualate Mere on the Shropshire boundary

Staffordshire is an important coal-mining county The Southern coalfield has an estimated reserve of 1,415 million tons and the northern coalfields 4,460 million tons. The latter contains the valuable black-band ironstones which are of commercial importance, and a smaller amount of iron is mined in the south where, however, there are important quarries for road metal.

History and Early Settlement .- Although remains of Palaeolithic man have been found in the Derbyshire caves over the border, no finds are known from Staffordshire itself. Neolithic implements, especially round barrows and Beaker pots of later date are found almost entirely and in fairly large numbers in the

north-east section of the county. In early times this remon must be considered as part of the Peak district of Derbyshire. In the remainder of the county there are isolated finds of Bronze, notably palstayes at Brewood, Biddulph, Rushbury and Stretton, a bronze sword at Alton Castle and a leaf-shaped spear-head at Yarlet. These isolated finds serve to indicate the beginnings of movement along the valley ways and the importance of the roads around the hills into Wales and the west In Roman times Letocetum just south of Lichfield was the most important settlement

In the 6th century a tribe of Angles settled about Tamworth. afterwards famous as a residence of the Mercian kings. Later the invaders advanced beyond Cannock Chase The district was frequently overrun by the Danes, and it was after Edward the Elder had finally expelled the Northmen from Mercia that the land of the south Mercians was formed into a shire around the fortified burgh which he had made in ora at Stafford. The county is first mentioned by name in the Anglo-Saxon Chronicle in 1016

The resistance which Staffordshire opposed to the Conqueror was punished by ruthless harrying and confiscation, and the Domesday Survey supplies evidence of the depopulated and impoverished state of the county The five hundreds of Staffordshire have existed since the Domesday Survey, and the boundaries have remained practically unchanged The shire court for Staffordshire was held at Stafford, and the assizes at Wolverhampton, Stafford and Lichfield, until by act of parliament of 1558 the assizes and sessions were fixed at Stafford

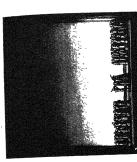
In the wars of the reign of Henry III most of the great families of Staffordshire, including those of Basset and Ferrers, supported Simon de Montfort, and in 1263 Prince Edward ravaged the lands of Earl Robert Ferrers and destroyed Tutbury Castle During the Wars of the Roses, Eccleshall was for a time the headquarters of Queen Margaret, and in 1459 the Lancastrians were defeated at Blore Heath. In the Civil War of the 17th century Staffordshire supported the parliamentary cause, but Tamworth, Lichfield and Stafford were garrisoned for Charles, and Lichfield Cathedral withstood a stege in 1643

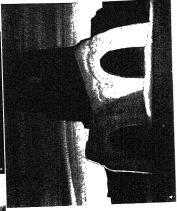
Much of Staffordshire in Norman times was waste land, but the moorlands of the north afforded pasturage for sheep, and in the 14th century Wolverhampton was a staple town for wool. In the 13th century mines of coal and iron are mentioned at Walsall, and ironstone was procured at Sedgeley and Eccleshall In the 17th century the north of the county yielded coal, lead, copper, marble and millstones, while the rich meadows maintained great dairies; the woodlands of the south supplied timber, salt, black marble and alabaster; the clothing trade flourished about Tamworth. Burton, and Newcastle-under-Lyme, and hemp and flax were grown in the county The Staffordshire pottery industry is of early origin, but was improved in the 17th century. It has been greatly extended in modern times

Architecture.-The most important churches are the beautiful cathedral of Lichfield, and the churches of Eccleshall, Leek, Penkridge, St. Mary's at Stafford, Tamworth, Tutbury and St. Peter's at Wolverhampton all of which are described elsewhere. Checkley. 4 m. south of Cheadle, shows good Norman and Early English details Armitage south-east of Rugeley, has a church showing good Norman work Brewood church, 4 m. south-west of Penkridge, is Early English Audley church, north-west of Newcastleunder-Lyme, is a good example of Early Decorated work remains of the Cistercian abbey of Croxden, north-west of Uttoxeter, are fine Early English, and at Ranton, west of Stafford, the Perpendicular tower and other portions of an Augustinian foundation remain Among mediaeval domestic remains are the castles of Stafford, Tamworth, Tutbury and Chartley Beaudesert, south of Rugeley, is a fine Elizabethan mansion in a beautiful undulating demesne In the south-west, near Stourbridge, are Enville, a Tudor mansion, and Stourton Castle.

Agriculture and Industries.—About 75% of the total area of the county is under cultivation, and of this three-quarters is in permanent pasture, cattle being largely kept, and especially cows for the supply of milk to the towns. Staffordshire is well wooded; the National Trust owned 1,964 ac in 1942.

The southern industrial district, the Black Country (q.v.), is





3 Setting for "Panio" designed by Jo Mielziner 4. A runed eastle In "The Old Foolishness," design by Robert Edmond Jones

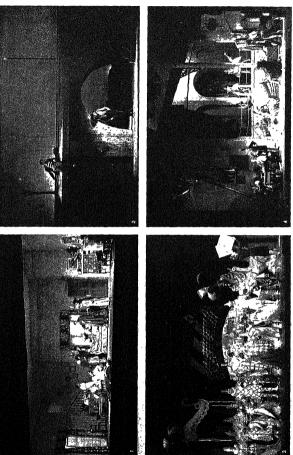


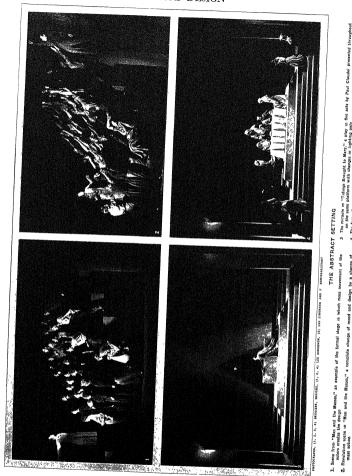


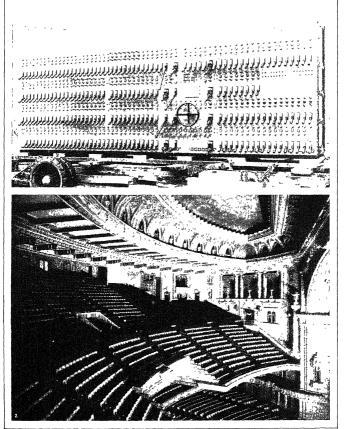
Despite by Maliner for "Emperor Jones"

2. The pract of Messe zene from 'Green Pastures " designed by Robert Edmond Jones

2. The pract of Messe zene from 'Green Pastures "

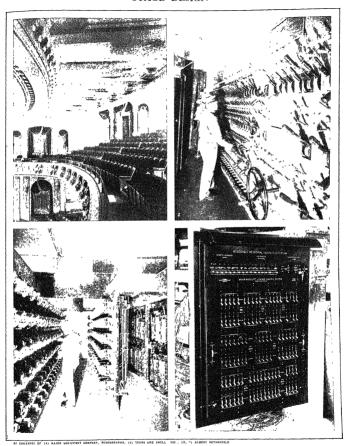






A LIGHTING SWITCHBOARD AND THEATRE AUDITORIUM

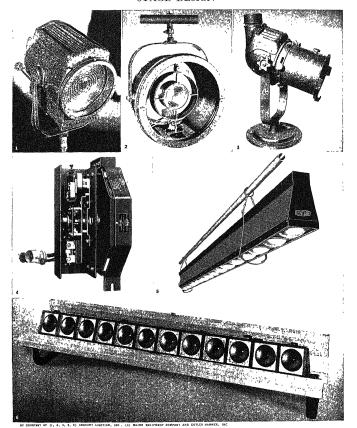
1. Hays containant of the type recent in large and the table seeks and the seeks and t



MODERN LIGHTING APPARATUS

 Mezzanine in Roxy theatre with lighting effects that are used to reflect the mood of the stage presentation.
 Roxy theatre switchboard, 8ft high and 22ft long, with over 1,000 switching levers and 500 diamets.
 The meastor room of the Roxy theatre where reacter dimmers and contactor

switches are placed. The reactor plates run up to a capacity of 15,000 watts each. 4 Compact lighting control board for the Wisconsin Memorial Union auditorium. Two matter faders, one on each side, enable the operator to shift at any desired speed from one pre-set to the other.



LIGHTING EQUIPMENT FOR THEATRES

- 1 Spotlight with widely variable spread and soft-edged beam

- 4 Motor-driven autotransformer dimmer, modulite type
- 2 Manual text projector, which there a behave from there to four times as legislat said of an endinary solution and the said of the said and said of the said and said the said and said text of the said text 5 Borderlights are used for tone and blending rather than for sharp definition

the main seat in England of iron and steel manufacture in all its branches It covers an area, between Birmingham and Wolverhampton, resembling one great town, and includes such famous centres as Walsall, Wednesbury, Dudley (in Staffordshire) and West Bromwich The northern industrial district forms the Potteries (q v ), Cheadle east of the Potteries, is the centre of a smaller coalfield; Burton-upon-Tient is famous for its breweries. Chemical works are found in the Black Country and at Tunstall, glassworks at Tutbury, there are also a considerable textile industry, as at Newcastle-under-Lyme, paper mills in that town and at Tamworth, manufactures of boots and shoes at Stafford and Stone, silk and artificial silk at Leek and other manufactures in the county include rubber goods, and motor cars

Communications,-The main line of the L M S railway runs from southeast to northwest by Tamworth, Lichfield (Trent Valley), Rugeley and Stafford This company and the GWR. serve the Black Country by many branches from Birmingham and jointly work the Stafford-Shrewsbury line The L.M S has branches from Trent Valley to Burton-upon-Trent, and from Rugeley through the Cannock Chase coalfields, from Stafford and from Burton-upon-Trent northward through the Potteries, with a line from Uttoxeter through Leek to Macclesfield

The west and north line of the L M S (Bristol-Derby) crosses the southeastern part of the county from Birmingham by Tamworth and Burton with a branch to Wolverhampton The LNE serves Uttoxeter, Burton and Stafford. A considerable amount of coal transport takes place along the canals of the Black Country

Population and Administration.-The area of the geographical county is 1,154 sq mi, with a population in 1938 of 1,483,650 The area of the administrative county is 1,071 sq mi.; population (1938) 749,900 Staffordshire contains five hundreds, each having two divisions. It contains 6 county boroughs and 8 municipal boroughs. The county boroughs are:— Stoke-on-Trent, Wolverhampton, Walsall, Smethwick, Burton-on-Trent and West Bromwich; and the municipal boroughs are .-Lichfield, Newcastle-under-Lyme, Stafford (county town), Tamworth, Wednesbury, Bilston, Rowley Regis and Tipton There were 17 urban districts in 1943, as follows, given in alphabetical order —Aldridge, Amblecote, Biddulph; Berrley Hill; Brownhills; Cannock, Coselev Darlacton Vilamento hills; Cannock, Coseley; Darlaston, Kidsgrove; Leek; Rugeley; Sedgley; Stone, Tettenhall, Uttoxeter; Wednesfield; and Willenhall Other towns are Abbots Bromley, Brewood, Cheadle, and Eccleshall There are two cities in the county, Stoke-on-Trent and Lichfield. The county is in the Oxford circuit, and assizes are held at Stafford. It has one court of quarter sessions and there are 20 petty sessional divisions. The county boroughs have separate courts of quarter sessions and commissions of the peace. The county is in the diocese of Lichfield

Staffordshire is divided into seven parliamentary divisions each returning one member, Burton, Cannock, Kingswinford, Leek, Lichfield, Stafford and Stone The parliamentary boroughs of Stoke-on-Trent and Wolverhampton return one member for each of three divisions, and the boroughs of Newcastle-under-Lyme, Smethwick, Walsall, Wednesbury and West Bromwich each return one member The county and parliamentary boroughs return m all 18 members.

BBRIOGRAPHY.—J. C. Wedgwood, Staffordshire Parliamentary History (1910), C. J. B. Mascheld, Staffordshire (1918); M. Hugbes, The Story of Staffordshire (1924), W. B. Smith, Staffordshire (1915); and the Vectoria County History, Staffordshire.

STAGE, in architecture, an elevated floor, particularly the various storeys of a bell-tower, etc. The term is also applied to the plain parts of buttresses between cap and cap where they set back, or where they are divided by horizontal strings and panelling. It is, too, the floor or platform on which plays are acted, whence the term has come to signify both the theatre (q v.) and the drama (q.v). See also STAGE DESIGN, below. From its etymological meaning of a station comes the sense of a place for rest on a journey, the distance between such places, etc.

STAGE DESIGN. Until about 1900 the pictures created on

to 1900 had made a common possession. The picture of the world within the theatre was invariably dull, without illusion and rigidly painted,-painted, in fact, with the same merciless and metallic precision which led Manet to exclaim before one of Meissonier's paintings of charging currassiers, "Everything is of steel except their breast-plates" Trees stood invariably in regimental rows and their foliage hung in separate parallel layers above their trunks. The walls of hovels or palaces reminded the most careless eye that they were merely painted canvas; the sky flapped, an obviously painted sheet. The ugliness of the total result was all the more glaring because, in an age of realistic playwriting, actors were using every artifice they possessed to make an audience feel that they were Russian or Silesian peasants, Norwegian town councillors, or English clergymen and poets. Every word in the theatre was trying to convince its hearers that what they saw was not actors, but human beings in a world as real as the one they had just left to enter the theatre, that people "were like that"; that life had this significance and that meaning. But everything on the stage reminded the audience that, after all, what they were seeing was a play in a thoroughly artificial place, the theatre, that had no relation to life Even when a poet held the stage the result was equally ludicrous. It was difficult for the singers of Wagner to transport an audience to the beginning of the world, where the gods were deciding the destiny of men, when everything about them seemed an enlarged landscape done in chromolithograph Mary Garden wandered in a park that had neither magic nor mystery, in the supposed gloom of palace halls as bland as lithographs of English country houses, current in the '50s Any symbolism that might have lurked in Maeterlinck's fairy tale of the terror and foreboding of young love was dissipated; and Mélisande's cry "I am not happy" seemed less a comment on the state of her soul than on the preposterous stage settings that surrounded her.

The inadequacy of this type of scenic background, so prevalent at the turn of the century, did not lie alone in its artificiality nor in the fact that it was an obvious and flimsy convention. Artificiality and the conventions of formally painted designs, as proved by the work of Inigo Jones, Bérain and the Bibienas, can breed beauty in the theatre just as easily as the same tradition in the 19th century bred ugliness. The reason for the change which makes painted scenery in one epoch enhance the meaning of the play and in another detract from it, is our changed attitude towards the theatre The creative dramatists of the past 40 or 50 years, whom for convenience sake we may call modern, such as Ibsen, Shaw, Hauptmann, Chekov and Strindberg, Synge and O'Neill, are modern in the sense that one and all they do not regard the theatre as a place of pure entertainment. And they have succeeded so well that though we may still go to the theatre merely to be amused, we also go to watch a play with the same expectation with which we open a novel treating of modern life-in the hope of seeing more clearly into the springs of character, of getting a fresh sense of human destiny

The Modern Scenic Movement.-The blatant dissonance between modern plays that were attempting to reconceive a world and scenic backgrounds that merely reflected the conventions of a purely theatrical theatre, was so preposterous that it could not endure. For that reason, directors of modern theatres in every country in Europe, beginning with Germany, and finally in the United States, enlisted painters or designers to make the world on the stage the world of the play. This is the genesis of the so-called modern scenic movement. It arose, not because modern art already existed, but because it became essential to the theatre in order to quicken the reactions of the audience until the world the dramatist asked them to believe in had the plastic reality of a world before their eyes or the imaginative quality of a poet's dream. The source of modern scenery has not been dogma. It did not arise because Gordon Craig prophesied that only screens could back a stage; modern scenery would have occurred whether or not Craig had ever existed or penned a line. He, however, was one of those who prophesied that a change must come and any stage, generally known as scenery, had no relation to the that stage settings must be designed to interpret the play they feeling for form, colour, composition or light which art from 1850 housed. Every manner and method of modern painting, has, with the aid of some mechanical device, been put to work in the theatre. the plaster dome, in conjunction with the flexibility of incandescent lamps which made the painted sky seem a heaven and filled the stage with all the ambient light of day; the spot-light, manipulated to create the chiaroscuro of Daumier, light mixed with colour in the manner of Monet and Seurat making colour vibrate, and achieving the atmosphere of the impressionists, or enmeshed in gauze, giving the atmosphere of Whistler's nocturnes. Every technique of modern art has been exploited, whether of impressionism, post-impressionism, cubism or futurism However, from the point of view of pictures constructed within the proscenium frame of the theatre, almost every method at one time or another, in the hands of a particular director and in conjunction with the methods of his actors, has succeeded in convincing an audience and projecting the interpretation of a dramatist's ideas

The point needs stressing because the history of modern scenery is usually regarded from the point of view of a mere chronology of begetting, and is continued in the strain of prophecy' A designer reading any of the current histories of his art would feel that the entire problem before him was the choice of a style And the value to him, as a craftsman, of almost all discussions of the subject, is hereby rendered nil The theatre, it is supposed, is about to be re-created, purged of evil, saved and given its final form if he, the designer, only makes the right choice, screens, a stage without curtains, scenery made of nothing but curtains, a circus theatre where the actor can mingle with the audience, scenery that is only light, scenery that is merely symbolic colour, scenery that is wooden trestles, and so on, depending upon which method at the moment has had the latest critical success in Europe. It is essential for the scene designer to avoid this critical approach if he wishes to analyse the basis of his craft For whatever his preferences may be as a painter, he will find that the moment he sets out to design stage settings his problem is everywhere the same He will find the problem of relating a particular play to a particular audience, the problem, as conceived by the director, of how the meaning of that play can be put over the footlights, and dramatized for that audience. His methods will be deduced not from any abstract aesthetics of the theatre but from the exigencies of that particular situation. For not all his convictions as to why imitation and realism was a defunct method prevented George Bernard Shaw from continuing to write plays so provocative that they must be acted in country-house gardens, Salvation Army barracks and physicians' consulting rooms, for which the designer has to build the walls, find the furniture and even evoke the flowers. On the other hand, not all the dogmas in the world as to the value of realism prevented Shaw, or any other playwright, from reconstructing Antony's adventure in Egypt or Adam's adventure in the Garden of Eden, for which there is an equally avid audience, and the designer will have to find a decorative equivalent for the sphinx, or some symbolic equivalent of the tree of knowledge And whether theatre audiences are those of London, Prague, Berlin or Warsaw, the designer will find that they came to the theatre to share experiences that are not their own, so that in the course of a single season the designer may have to help in making plausible the romantic scruples of a Hungarian schoolboy or a Hungarian servant, the feudal scruples of Japanese noblemen, the political dogmas of Slavonic revolutionists, the moral codes of American revolutionists and Russian peasants.

Staging of "The Fathful,"—Some of the problems of semic design as worked out by the present writer at the Guild theatre of New York, although not final in any sense as examples of theatre art, are tyrical of the problems which every stage designer must face in order to evolve design, whatever the pattern he may ultimately adopt. "The Fathful, by Dho Massfeidel, tells the story of 47 Ronin, retailers and henchmen of a Japanese nobleman, tricked by a rival into committing an affront to the emperor's person for which the only explation was suicide; of the voluntary call of these Ronin as partials, and their final triumph over their dead master's enemy It is a poet's celebration of the nobleness of loyalty What is the producer's problem? Obviously something more

than to demand poetic background for a poetic play, because the tale of the 47 Ronin, as much of a household story in Japan as Washington and the cherry-tree in America, is totally unfamilial to Western audiences He can count on no background in the audience's mind But Japan is the background which he must create decisively five minutes after the curtain is up, for the reason is that the unforgivable act committed was nothing more than a mistake in ritual, a failure of ceremonial observance, not to the emperor himself, but vicariously to the emperor's person as personified by his envoy The rigid code of Japanese feudalism is a tradition difficult for Westerners to conceive The danger is that they will find it, if not preposterous, at least not plausible, so that they cannot identify themselves with the hero. The problem here is that to an audience not composed of orientals or members of Japanese societies, the normal reaction would be "Stab oneself because of a mistake in court etiquette? How preposterous! What a trivial people!"

The playwright cannot solve this problem in the many ways that are offered to the novelist, he has no preliminary chapters or incidental comment to prepare the mind of his audience, as his story proceeds, to make them understand the rigid Samuiai code of honour and accept the tragic alternatives imposed on its adherents Aware of this problem, the designer finds, in making his first researches into the field of Japanese costume and architecture, that ritual ruled not only court etiquette but all Japanese life of the period, to the most trivial detail. Everything is prescribed and ordered, the degree to which the head is shaved, and the degree to which the hair is looped forward on the head, the precise way the obs or white silk belt is tied that holds the pleated skirt in place, the length of the sleeves, as well as the cut of the gown. Everything is ordered ceremonial, even the squares of the matting, the placing of the sword in its rack, the one picture niche where the solitary landscape scroll is shown and the way the single group of flowers is arranged under it. There are in the simplest acts, of receiving a friend and taking tea in his presence, countless opportunities of outraging him by breach of etiquette.

In a world of this sort, it begins to be comprehensible that a mistake in court efiquette could involve the death penalty. Hence every effort—and here the producer co-operates—is made to convey the ceremonucusness of the Japanese feudal world, in the gait of the actors, their gestures, their genuflections, the mode of entering or leaving a room. A Japanese is found to train them, he ties every obi, adjusts every costime, este every that and wig The room which is the opening scene of the play is almost archaeling the second of th

On the other hand, once the world of the Samurai is realized, and the tragedy is enacted, there is no further need of such realistic devices. The ragged Ronin wander in the snow, but the snow may be the snow gorges of Japan, painted upon a six-fold Japanese screen, without diminishing either the reality or the suffering of these outlaws Here a deliberately decorative method seems the inevitable choice Japanese landscape is known to Western audiences through the popularization of Japanese prints. A screen setting evokes this purely decorative pictorial tradition and suggests the countryside of Japan far more effectively than any attempt to reconstruct it realistically Thus meticulous realism and deliberate decoration can be employed simultaneously in the same play, and for the same purpose. As pictures the snow scenes are far more effective. But in the theatre the palace scene was far the more important of the two. For if that scene succeeded in conveying Japan effectively to the audience, the world of the Japanese could be taken for granted for the rest of the evening. A white sheet and the shadowgraph of a few pine boughs might have done just as well for the winter hills. This instance reveals how superficial it is to codify stage sets according to

purely pictorial principles

Staging of "Liliom."—Molnar's Liliom presents an analogous problem of transplantation, not from one century to an

other but from one country to another at the same period. The producer's problem in Liliom was, in essence, that his story deals with the creed of a gangster and a "tough" who is fundamentally romantic Liliom falls genuinely in love with the servant, Julie, and evinces a belief in "the eternal feminine" worthy of a latterday Faust. He is transported by the prospect of fatherhood When he stabs himself rather than be captured by the police in an attempted hold-up that fails, his last cry is. "Julie my little girl my little cricket." When, after facing the judgment of heaven and ten years' probation, he returns to earth as a beggar for an opportunity to win redemption, he steals a star to give to his daughter, and then in a moment of evasperation beats her, as he formerly beat her mother The child cries "he hit me but I didn't feel anything—as though someone had stoked my hand . . ." "Nothing has happened" her mother assures her, divining who the beggar is, "it is possible, my child, for someone to hit you-so that you don't feel any pain " Liliom is not forgiven in heaven, he is redeemed on earth by the persistence of human compassion. The beauty of the final scene made the play at the Guild theatre an allegory, the vindication of a romantic faith, and dictated the scenery. The play was some-thing more than the story of a foreign underworld; its realism was made an ironic cloak for poetic truth. Thus the amusement park where Liliom flourished as a bully was made as authentically Hungarian as possible, so that the audience might accept the reality of a romantic gangster and not reject him as a maudlin invention On the other hand, precisely because the play seemed important as an allegory because of its poetic truth, the tawdry squalor of Liliom's surroundings had to be invested with beauty, even the tumbledown shack in which he lived And the railroad embankment, where he attempted his hold-up and met his death, was composed with some of the dignity and severity appropriate to tragedy

Scene 2 represents the park where Lilom falls in love. The point is that, bully, seducer and braggart though he is, he does fall genunely in love. He is transfigured and the moment becomes as beautiful for this Hungaran hoolgan and a kitchen mad as it does for all lovers. Therefore, the park where they meet must be made beautiful. The hour is dusk, when, as Whistler reminded us, "the evening mist clothes the riverside with poetry as a veil, and the tall chimancys become campaniles, and the warehouses are palaces in the might and the whole city hangs in the heavens", the "exquisite hour" as Verlaime calls it. Therefore the problem for a designer was to clothe that park with poetry as with a veil; with tree silhouettes which are hung on transparent gausses; and putting into those tree silhouettes all the grace and timed to arch over young lovers. Had the scene been one of cynical seduction, this quality of tenderness and brooding would have been irrelevant.

Scene 6 represents heaven Liliom sees heaven in terms of the police courts with which he is familiar. He can conceive of no other bar of judgment; heaven is merely the last police court presided over by a police-court judge; the attendant angels are to his eyes only detectives and policemen. The stage directions emphasize the fact by stating that their costume is the usual police uniform Nevertheless, Liliom has died, he is in heaven awaiting eternal judgment. If the play is to be properly interpreted this seat of judgment cannot be the proverbial heaven with a celestial throne. On the other hand, if the allegory of the play is to be made plain it cannot be shown simply as a police court. This dilemma was solved by making the scene as far as Lihom's eye ranged a drab room, with the ordinary judge's bench at one end; but the solid walls ended at the wainscoting and window frames. Beyond that was emptiness; the room sat without walls or roof under a blue sky as illimitable as stage light could make it. By this combination of realism and fantasy, the reality of heaven was established for the audience, and at the same time the fact was made clear that to Liliom its judgments were no different from what he had experienced on earth. These four scenes from two plays entirely different in type demonstrate how contradictions of realism and decoration in stage pictures are determined by

problems of dramatic interpretation and not primarily by pictorial considerations. The picture is a result of a conviction as to what the meaning of a play is and how it can be reflected in pictorial form

The Method of Abstraction .- Settings that eliminate the stage picture entirely are designed for the same reason and by the same process The Tidings Brought to Mary, by Paul Claudel, was played on the same platform for its entire five acts, which according to the stage directions take place in a barn, a farm kitchen, an orchard and a road at the edge of a forest. Fedor Komisarjevsky, the director, chose the unit platform because he felt that the play was mediaeval not only in its story but in its quality It was a mystery, couched in the mystic faith of a truly mediaeval catholicism. A single square block served as a hench and, when it was covered with a formal cloth, as a suppertable and an altar. The orchard became eight nuns clothed in Byzantine splendout, each holding a branch of silver flowers, who stood in a remote semi-circle. The sky behind them at this moment became green to suggest the foliage of out of doors. For the road-side scene at night, the same backdrop became the inky blue of a wintry night spangled with a few stars. And a cold steel-blue light thrown over the platform gave the illusion of winter snow For the miracle the sky blazed forth gold, like the background of a 14th century mosaic, and aureoled the actors The same intention was carried through the costumes many were mediaeval French, but others-those of the father and motherwere clad in the traditional robes of early religious paintings, so that the mother had a suggestion of the Mother of Christ, the father, of one of Christ's disciples, and in its formal grouping, the supper of farewell suggested an apostolic meal

In Man and the Masses, by Ernst Toller, the formal platforms became almost invisible. The settings were made wholly by the massing and the movement of the actors. The human beings on the stage provided all the scenery that was needed, for the play was conceived as an abstract allegory. One leader who tries to limit the workers to the bloodless methods of a general strike, is called simply The Woman. The agitator who incites them to revo-lution is called The Man Though the workers are supposedly in their union hall, their angry indictments of capitalistic society are chanted in unison as a formal chorus. How could this meeting be placed in a realistic setting of an actual union headquarters, without making such formal choruses seem ridiculous? The title literally translated is "mass-man." The force of Toller's conception is his vision of mass-man. The working-men are a single stubborn unit, welded together in resentment and anger, from which only voices of the young and the old emerge to cry, threaten and lament If a group of 30 or 40 actors on the stage are to give this feeling of mass power, they cannot be scattered, they cannot move about much; they must be welded. Hence a stage setting was devised for the drama that was a literal crosssection of an amphitheatre, the players never moved from the spot where they were wedged; they rose with waving arms and clenched fists to face The Woman, who pleaded with them, they towered over her; she was below them, supplicating When this compact mass of 30 actors stood they seemed to represent "the masses", it seemed that they could sweep down on The Woman and overwhelm her. Then The Man sprang out of their midst and slowly backed up step by step to the top of the amphitheatre. As his eloquence grew they swung slowly round, looking up towards him, turning their backs on The Woman as they ignored her pleas. Finally, at the moment when they were won over to a doctrine of violence, they were a solid mass, crouching under him waiting to spring; as he cried "revolution" they took one step up, the only step they took in the entire act, and lunged together like a huge beast, echoing his cry "revolution." Each one had turned completely round during the scene without once moving from the spot on which he or she stood. They remained a mass, and by a single mass movement expressed their change of faith.

Varieties of Interpretation.—The designing of scenery is thus never a purely pictorial problem, it is part and parcel of the act of interpreting a play. Whether a designer chooses abstraction or realism, a picture-stage which imitates the world as we see it in rooms with the fourth wall knocked out into which we peep, modern stage the spectators are looking into a space so shallow or a formal stage which symbolizes the world, is in itself a relative thing The method of design chosen is only good even from a pictorial point of view provided it touches the imagination of an audience, and really convinces it of the truth and reality of the play Setting the play is only part of the process of acting it so as to give it dramatic force, no method, however beautiful it is as a picture, is the right method if it fails to convince an audience; and there are as many types of audience as there are kinds of play No play has only one meaning, it can mean all things to all men The imagination of the director must decide and the pictorial imagination of the scene designer must second him. If you can make your audience accept Liliom's story as a modernistic fairytale, an allegory from the outset, Pitoev's method of presenting it in clear hard formal outline is the right one If the play means more as a story in which the allegory is implicit, then the more realistic method of the Theatie Guild is better; similarly with He Who Gets Slapped. To compare the two, one would have to sit through the two productions as played by two different casts.

There is no one way of producing any play, even classic masterpieces In fact every one, whether Euripides or Shakespeare, has to be constantly re-interpreted, in order to become relevant and remain living. If Shakespeare's characters seem important as figures rescued from an actual historic past then the elaborate and exact costuming of the Duke of Saxe-Meiningen or Henry Irving is not only necessary but effective. To one audience, which conceives them primarily as creatures of Shakespeare's time, the bare boards of the Elizabethan stage will make them live more completely. To another audience, particularly sensitive to Shakespeare's word-magic, formal scenery, even a single curtain, is enough To a German audience, for whom much of the poetry is lost in translation, more pictorial backgrounds are necessary, into which that lost glamour must be projected But to both German and American audiences for whom Shakespeare's protagonists are imaginative figures living in the world of the imagination, they become most real when part of an unreal world, a forest of dyed strips of tapestry or gauze (Barker's production of A Midsummer Night's Dream and Reinhardt's production of the same), or a blood red stairway (Jessner's production of Richard III ), or among golden screens (Craig's production of Hamlet with Stanislavski at the Moscow Art theatre) And if the tragedy of Hamlet begins to seem too remote and archaic to us, we can make him a human being, for certain audiences, by putting him in modern dress. The art of scene designing is a living art because it can find no final formula. It will live precisely as long as it can discover new meanings in every play of every epoch. Scenery is the background of a play, and as such is part of the continuous adventure of projecting the meaning of a play across the footlights, finding, firing, and then fusing the imagination of an audience. And that adventure will always be a different one in every country and every epoch

Structural Innovations.—The technical and structural changes which determine the design of modern scenery are two: first, the modern theatre, in contrast to the 18th century theatre, has become an extremely shallow box, second, that black box can be completely flooded with electric light, modulated and controlled. The theatres of the late 17th and 18th century fixed the architectural type of theatres, which with changes of ornament and the depth and arrangement of balconies is the type still prevalent to-day But there is one vital difference; the proportion of the space occupied by the stage in relation to the space occupied by the audience in the auditorium. The 18th century stage averaged in depth 1 to 11 times the depth of the auditorium pit, and was rarely less than 75 feet. The modern stage, except in opera houses and European state theatres, is rarely more than 1 the depth of the auditorium, and averages at the best 25 to 30 feet.

Moreover the 18th century stage was carefully calculated to enhance painting in perspective. The stage floor sloped up. The side flats receded until the rear of the stage was very near the true vanishing point, so that an alley of trees or an avenue of that any illusion of depth is difficult to attain. In an average production there is raiely more than 8 to 10 ft from the garden wall to the distant mountains, often there can be only 4 or 5 ft from a window to the sky

The early technique of shifting scenery was done by having the side flats on grooved slots, set in pairs, tied to a rod which connected with a series of windlasses in the cellar. At a given moment one turn of these windlasses would shoot the rear flats out like a shutter, and withdraw the front flats out of sight, achieving a complete change of scene with great precision. A beamed gridiron under the ceiling, with another series of windlasses, hoisted and lowered the clouds and the platforms on which gods and goddesses descended Owing to the shallow space of the modern theatse and the suppression of the apron in front of the curtain, the front rows of spectators can see clear to the roof and to the side walls. The modern stage settings therefore have had to become a three-sided box with a lid over the top, when interiors are called for, for exteriors a curved sky, either of canvas or of plaster is used, instead of a sky in flounces as seen in the 18th century theatres There is so little room on the stage for stackmg scenery that most of it has to be broken apart, or unlashed, for each change of scene, and hoisted into the air where it hangs until it is needed again, and as certain sets may be 24 and sometimes 30 ft high they have to be hoisted high enough to be out of sight when not in use Hence the gridiron from which scenery is hung-handling is facilitated by having the lines that haul it attached to counterweights grouped at one side of the stage,-is the most important part of standard stage equipment The opening which the audience sees, the proscenium frame, is in reality a mouse-trap shutter at the bottom of a tall shaft. The average proscenium opening is 24 to 30 feet. The curtain in actual use is rarely drawn higher than 20 ft for exteriors, and 12 to 14 ft. for interiors, the remaining space is occupied by flounces and draperies. And the gridiron must be a minimum of 65 ft. in height; for hauling scenery out of sight, 80 to 85 ft. is better At the Century theatre, New York, it was about 100 ft above the stage floor.

In any case the space behind the stage opening is mainly storage space for hanging scenery in mid-air The place occupied by the largest scene is approximately one-seventh of the total stage space, and the proportion will not vary greatly in American theatres or most commercial theatres of Europe

The system outlined above is not by any means the best either mechanically or aesthetically. It is, in method, as archaic as hoisting sails; indeed the workmen on the stage who shift scenery are known as the crew to this day. The revolving stage introduced by Lautenschläger from Japan was used extensively, and did away with the necessity of a gridiron almost entirely. At Dresden, Linnebach at the State theatre and Hasait at the Opera constructed elevator stages worked by hydraulic power, so that heaviest sets could be set in the cellar, hoisted to stage level and slid into place with extraordinary speed. The cellar being two or three storeys deep, the settings for two or three entire productions could be kept intact indefinitely.

These mechanical marvels have never developed because the economic trend of the time is against them. Land has become too expensive to allow the amount of space and excavation required; rising costs everywhere in Europe make the duplication of any such installation prohibitive. In the United States where a single elevator platform 12 by 30 costs approximately \$25,000 to install, an entire stage so equipped would represent a capital investment that only the very wealthiest theatrical producer could carry. Thus theatres tend to become smaller and shallower and the theatre everywhere approximates to American conditions where everything has to be crowded into a standard building site of 100 ft

Important architectural experiments have been made which aim at changing the conventional "peep-show theatre," as its critics have called it, where we look into a stage picture through a more or less gilded frame Theatres have been projected with the stage columns receded very much as they would in nature. But on the as a formal platform, where the actor emphasized in space, picked

surrounded by them, a sort of electric contact being the goal sought The most notable theatres of this sort have been the projects of the American Geddes, the Dutchman Vanderwelde and the Austrian Stranad Jouvet's platform stage designed for Copeau existed in Paris for a number of years; a circus theatre by Poelzig. "the theatre of the 10,000," was actually built in Berlin, but like Coneau's theatre it was abandoned Quite apart from economic problems, what thwarts the development of these playhouses is the fact that modern playwrights will not write enough plays that can be given in any such manner O'Neill and Shaw, Toller, or Werfel, revert to realism quite as often as they depart from it and write plays which require the three-sided box room or the illusion of distance in an actual world which can only be achieved. in the theatre, by looking through a frame Until modern playwriting achieves some unity of tradition, these formal stages must remain isolated experiments or dreams on paper

Lighting.-The most important effect that the shallow-box stage has had on designing is the fact that perspective planning and painting become preposterous, anything that leads the eye from the front of the stage directly across it to the back wall, makes the eye realize that the picture is only 20 ft. deep. Hence the kind of composition modern scene design employs is not the Renaissance composition of distance into which the eye is led by receding parallel perspective, but distance suggested in the Japanese manner by planes cutting one another like the distant peak of Funyama appearing directly over the brink of a hill The eye, leaping from one to the other, imagines the distance and gets the suggestion of space. Thus a space in modern settings is suggested rather than revealed the base of one column will suggest an entire temple, one pillar in a gloom pierced by a stained glass window will convey an entire cathedral, and because there is no intermediate form between the pillar and the window, the blackness will seem as deep as the nave of a church. Even the window may not be shown but a shaft of light may be thrown from a point out of the spectator's range of vision in order to increase the scale by the same process of suggestion

Light is the scene-painter of the modern theatre; light, not paint, draws the scene, and by varying planes of intensity, models it, and makes the corner of a building solid, a hill remote, a sky infinite though it be only two arms' length from the garden wall If a stage 25 or 30 ft deep is flooded with even radiance, nothing will persuade the eye that it is anything but a shallow box, however suggestive the arrangement of the setting itself may be. Settings are constructed now as in the Renaissance period, of canvases stretched on wooden frames and hinged or lashed together, but the paint on them is a mere preparation for the light to be thrown on. No setting can be designed until one is certain how one is going to light it; the colour painted is conceived as an undertone of what it will seem when lighted on the stage

The railway viaduct in Lilson, for example, if it is to seem massive and menacing must have the light thrown across it, not at it, otherwise it will become flimsy canvas. Thrown from right to left the single pier casts a sharp shadow which gives a sense of solid masonry The whole forepart of this scene must have a different quality and intensity of light from the distant silhouette of factory chimneys. With the right balance of light they will recede and seem distant even though they are actually only 8 ft. behind the arch culvert. And both foreground and background must be properly related to the sky if they are not both to fall

So much for the scene; but there are the actors They must be modelled and emphasized in the areas in which they move; sharply picked out at certain moments, where the action calls for it, at others almost blotted into half shadow, for this scene is one of ambush, of two thieves waiting to rob a cashier, and a rim of shadow into which they can retreat is part of the process of creating the atmosphere of terror and suspense when the crisis comes. Every scene has pools of light waiting for the actors, light which we do not see or know is there until the actor walks into it at a given moment.

out by light, can mingle freely with the audience and is partially other medium in the theatre. We react to it even more quickly than to the actor's voice. In fact it sets the key of our emotions, and determines what effect the actor's voice will have on us. Lights not only paint and model the setting, emphasize its planes, and define its form, light also sustains the mood of a scene, and dramatizes its meaning. Crude or blatant lighting can war against the emotions an actor is trying to convey, and often destroy them entirely, all the more so because the lighting of any scene often does not remain static, but is dimmed or heightened, pulses and fluctuates with the action, like an orchestral score

Change of light alone created every difference essential to the five acts of the Tidings Brought to Mary The park scene of Lilion consisted of two gauzes on which the silhouettes of trees were pasted The entire mood of the scene's poetic dusk was created by a balance of lights In Man and the Masses, the contrast between the mystic dream scenes (not shown) and the sculpturesque force of the mob scenes is entirely a matter of lighting. In the course of the play there were several hundred subtle shifts of lighting timed to coincide with the action of the play. The tree of knowledge in Back to Methuselah was entirely made with light, projected from the tear The sphinx in Peer Gynt became a towering form by the same process. The sacred tree on the rim of the Persian desert in Marco Millions was merely a silhouette on a semi-transparent back-drop But it towered in mysterious majesty because of the way light was thrown upon it, from both front and rear.

The technical basis of this important phase of modern theatre art is the spot-light-in contrast to the flood light-which can be controlled and focussed accurately upon one particular spot. To be effective these spot-lights must be separately controlled so that each can be set at any point of intensity from full to dim and fluctuated back and forth if need be during the progress of the play. Hence the rheostats, or dimmer board, that controls these lights, is to the designer's conception what the central nervous system is to the ideas in the brain. Increased subtlety both in design and control of electric light, and particularly the colour of light, is the key to theatrical design of the future. That must wait not only on the playwright and stage designer, but on the lighting engineer, who, more than anyone, holds the key to the modern

engineer, who, most unit anyone, roots are key to the moura-theatre's destiny (See Theatre Modern Fundacies).

Binancoraver—E. Ordono, Ching, Friedric of the day (with bill, 1975, 37 et al., 1975, 1976, 1924); 1. Fichel, On Budding a Inestre, Ineatre Arts and Shonographs No. I (1920) revised and reprinted as Modern Theatres (1925), O M Sayler, The Russian Theatre under the Revolution (1920, 2nd et 1923), and Inside the Moscow Art Theatre (1925), L B. Campbell, Scenes and Machines on the English Stage during the Renaissance bell, Seems and Machines on the English Stage during the Renaissance (1933), K MacGowan, Constanted Stageroft (1931), R. E. Jones, "Drawings for the Theatre" and Norman Bel Geddes, "A Project for the Theatre Treemitation of the Divan Comoció of Dante." "Theatre Art Inc. (1932), W. R. Fuerst and S. J. Humes XX. Crossing Stage and the Constant C

## STAGE EQUIPMENT

The technical equipment of a modern stage consists of two types of machinery. (1) the mechanical equipment used to facilitate "setting and striking," ie shifting of scenery; and (2) electrical equipment to control the lighting of the stage

A house has been described by one modern architect as a machine for hying. A stage has always been a machine for giving plays. Even the Greek stage, usually supposed to be indifferent to scenic changes and scenic effects, was equipped, by the 4th century B.C. and probably earlier, with three standard pieces of machinery. (1) the crane used to lower the deus ex machina (the god out of the machine) from the roof of the palace façade, (2) the periaktoi, triangular prisms placed in the façade of the palace wall, Emotionally we react to light far more quickly than to any revolving on wooden pins and turned in unison, each face painted to indicate a different milieu so that three successive indications of place might be achieved, and (3) the eccyclema, or rolling platform which emerged from the palace doors after the tragic catastrophe, on which the murdered victim and often the aggressor were shown as a tableau

The chef mechanical devices of the theatres in the Middle Ages, the Renassince both in Italy and Blinabethan England, and the European theatres of the 17th and 18th centuries were the trup through which actors appeared and disappeared, often to the accompaniment of effects of smoke and flame, the moving platforms on which Christ was assumpted to the ballowy heaven of an open air mediaeval mystery, or the classic gods descended 20 an open air mediaeval mystery, or the classic gods descended 20 or 20 strong in the glorie that concluded so many 17th and 18th century spectacles and opera, and, when mobile scenery was adopted as part of the technique both of playwriting and play production, the windissess and ropes which hosted scenery out of the way or drooped it into blace.

Until the latter part of the joth century very little had been added to these base tage mechanics. The revolving stage of the Japanese popular theatre of the 18th century was copied by Lautenschlager in Munch in 1898; the State and muncipal theatres of Germany built in the early 1900s operated the traps mechanically, making them elevator stages which rose from a cellar level as needed in addition sliding platforms, each carrying a complete setting, known as wagon stages, were utilized and often operated electrically.

In the United States none of these mechanical improvements was generally adopted, the reason being that the conditions of production remained radically different in the American theatre from those that prevailed in Europe On the Continent theatrical production, particularly in Russia, Germany and the Scandinavian countries, was mainly in the hands of permanent resident companies operating endowed municipal or State theatres which gave a wide repertory of plays ranging from intimate realistic comedies or tragedies to large-scale spectacles and opera. The productions were built on the premises so that workshops as well as a large storehouse were an integral part of the architectural plan, as can be seen in the municipal theatre at Stuttgart with its large theatre at one end, a smaller theatre at the other, and the long façade of the storehouse serving as a connecting link between the two. The complete mechanization of such stages was considered worth the very large investment required in order to facilitate the giving of a different play every night of the week. This type of elaborately mechanized theatre is still standard in Europe,

as exemplified by the theatres recently built in Goteborg and

Malmo, Sweden In the United States, particularly after the decline of the local stock company at the end of the 10th century, the individual company, usually assembled for the occasion, was the producing unit, and much of its income was derived from touring on "the road" through all the principal cities and many of the smaller ones of the entire country For this reason the mechanical arrangements of the stage remained primitive. Until late in the 10th century the rigging of most stages was exactly like that of a ship. The ropes needed to hoist the scenery up and down were attached to a fly gallery and tied to the belaying-pins on a pin rail, which was an almost exact counterpart of the pin rail of a frigate. Massive or solid scenery was not often built, the entire system of scenic construction consisting of breaking the sets into units not more than 5ft. oin, wide so that when the settings were dismantled they could be slid through a baggage car door, its standard height being about 6 feet. The American theatre remains very largely an itinerant theatre to this day, the production being assembled usually in New York, then taken for a "tryout" on "the road," then brought back to New York, and, after a New York run, if it is a success, taken on tour again Instead of being designed and built for the dimensions of a permanent playhouse, it must fit the variable stage dimensions, often exiguous, of any number of theatres.

American theatres have therefore generally been built to rent to travelling productions, either for a percentage of the boxoffice gross or for a fixed guarantee per week, and it has been

the rule to provide as limited mechanical equipment as possible in order to reduce the landlord's overhead expense. The lighting system in these theatres is usually old-fashioned and even primitive, and controls the minimum of apparatus, a few overhead borders and footlights. The company must bung in all its lamps cables and "dimmer boards," or rheostats, needed to control them. The only mechanical improvement that became common is the substitution of the counterweighted lines operated from the floor. which replace the dead pull of the old rope sets worked from the fly gallery. The houses built in the last century usually had a single trap, known as the Hamlet trap, placed so that Ophelia could be conveniently buried. The trapping of commercial stages is not uniform, and it is under these conditions that even the most modern scenic productions have been made, and to meet these conditions that they have had to be designed and devised Where revolving stages or sliding stages are needed and used, as is occasionally the case, they also have to be carried on tour and assembled for each opening performance

Before the deflation of 1929 very few technically adequate theatres had been built, the Century Playhouse, since torn down, a few theatres such as the Martin Beck theatre and the Guild theatre in New York being the exceptions, and a few new opera houses such as those in Chicago and San Francisco. In the main, however, the professional theatres in the United States have either rudimentary or madequate in equipment, and except for the houses on "the road" large enough to house musical comedete on tour the stages are too shallow and lack the off-stage space needed to manipulate efficiently and without great waste of time and labour the scenery and properties used during a typical performance.

The technical equipment of American theatres has recently improved due to the fact that they are now being built on college and university campuses for a continued repertory of student productions, and so begin to approximate the rational layout of the repertory houses of Europe Notable examples are the new theatre at Stanford university, the Wisconsin Union theatre at Madison. Wisconsin, opened in 1939, and the auditorium at the University of Indiana, Bloomington, Indiana, opened in 1940, as well as such small theatres as the recently opened theatre at Amherst and the large playhouse projected for Dartmouth college In these theatres, not restricted by the size of a conventional city lot, and where the cost of land is not an item of initial expense, stage dimensions are ample, the stage running from 35ft to 40ft in depth and 70ft to 80ft in width from wall to wall, they are provided with an adequately high gridiron, approximately 70ft, and a complete counterweight system as well as a stage floor that can be trapped over a third of its area. In addition there are workshops where an entire production can be fabricated and painted At Stanford, at Wisconsin and at Bloomington two auditoriums are provided a large auditorium with a seating capacity running from 1,300 to 3,000 which can be sub-divided by curtains for smaller audiences, and a smaller theatre for more intimate or experimental productions At Bloomington and Wisconsin an electrically operated forestage has been provided which can at the touch of a push button be dropped below auditorium level to become an orchestra pit, raised above auditorium level for formal productions, making a forestage for an Elizabethan production if needed or dropped to auditorium level to hold additional seats

The funds available for the building of these theatres, running from approximately \$50,000 to wer \$75,000 are, even so, not ample enough to provide for any further mechanization of the stage equipment, such as electrically driven revolvings stage to wagon stages; even on a college campus the additional offstage space is rarely available which would be required to house these wagon stages when not in use The plans for the Dartmouth theatre, however, call for two such reserve wagon stage spaces, and the prize winning design of the William and Mary competition (see Theatre Arts for June 1393) also indicate their use

The more important technical equipment of the modern theatre remains the lighting control system, and the distinguishing feature of a modern production is the subtle variations of light which accompany and dramatize the dramatic action of the play. The need for these changes, known as "dims," was felt centuries before the mechanical means for their effective use had been invented The dialogues of Leone di Somi, a Mantuan stage director, written shout 1565 (see Appendix B, Allardyce Nicoll's The Development of the Theatre, and edition, Harcourt, Brace and Company, 1937) contain the following indications of how variations of light emphasize the mood of the scene

"Now it has been a custom, both in ancient and modern times, to hight bonfiles and torches in the streets, on the housetops and on towers, as a sign of Joy, and hence arises this theatical convention— the mutating of such festive occasions. The lights are put there for no other purpose but to imitate, in the very first scene, this mood of

garety"
"I suppose, then, that these lights would not appear in a tragedy"
"Perhaps they would not be so wholly out of place even in such a play Oute apail from the fact that there are tragedies with happy endings, we note that nearly all tragedies open in a happy strain, and consequently it will not be unfitting to arouse the mind, so far as we may, to this happiness, although disasters and deaths are to ensue later I remember once I had to produce a tragedy of this kind During all the time when the episodes were happy in mood I had the stage brightly illuminated, but so soon as the first unhappy incident occurred—the unexpected death of a queen—while the chorus was engaged in lamenting that the sun could bear to look down on such evil, I contrived (by prearrangement, of course) that at that very instant most of the stage lights not used for the perspective were darkened or extinguished. This created a profound impression of horror among the spectators and won universal praise

A device for dimming the candlelight of the period can be found in Nicola Sabbattini's well-known treatise. The Practice of Making Scenes and Machines in Theatres, printed in 1638

Di Somi continues

"It is a natural fact-as no doubt you are aware-that a man who stands in the shade sees much more distinctly an object illuminated from afar, the reason being that the sight proceeds more directly and without any distraction toward this object, or, according to the and without any distraction toward this object, or, according to me peripately theory, the object impinges itself more directly upon the eve. Wherefore I place only a few lamps in the auditorium, while at the same time I lender the stage as blight as I possibly can

Thus the general scheme and balance of our stage and auditorium lighting was anticipated by nearly 400 years. But the subtleties of modern stage lighting were not finally outlined until Adolphe Appia wrote his epoch making work, Die Musik und die Inscentering (1899), and described in detail a typical light plot for a production, never made, of Tristan und Isolde, in the appendix to the volume.

"Fitture of the stage at the rise of the curtain A great torch at stage centre. The somewhat narrow stage space is filled with enough the stage centre. The somewhat narrow stage space is filled with enough beliance of the torch and above all without dimming the shadows which this source of light casts. The forms which demarate the stage setting are seen only harply. The quality of the light veils them in an atmospheric blur. A few barely visible lines in the stage setting machact the forms of trees. Gradually the eye becomes accusiomed to

this, above, it becomes aware of the mass of a building in front of which one perceives a terrace. "During the entire first scene Isolde and Brangaene stay on this terrace and between them and the foreground one senses a declivity, the forms of which one cannot identify clearly When Isolde exthe torms of which one cannot identify clearly When Isolde ex-tinguishes the torich the entire setting is enveloped in a monotonous half-light in which the eye losse itself without being arrested by a single definite shape Isolde, as she flies towards Tristan, is enveloped in mysterious shadow which intensifies the impression of death that in mysterious saacow wanch intensines the impression of ceata that the right haid of the stage has already induced in us. During the first existacy of them encounter both remain on the terrace. At its cidinax (page tray, plano 8°, 10° and oron Menn's perceive that they come toward us imperceptibly from the upper terrace and by means of a barely noticeable ramp reads a lower platform further in the foreground ramp of the platform, the ramp leading from the terrace to it and another incline which leads to the foregrant of the Stage trainfy. make an uneven terrain on which the glowing dialogue of the scene that follows takes place

Then, when their desire is sufficiently appeased, when a single idea possesses them and when we become increasingly aware of the death of time, only then do they reach the foreground of the stage death of time, only then do they reach the foreground of the stage where (pp 336-37) we percave for the first time a lench that avants where the property of the property of the state of the stage still more uniform in that. The structural forms are blotted out in the shadow of the background and even the different planes of the stage floor are no longer visible. The stage floor are no longer visible. The stage floor are no longer visible. The stage floor are no longer visible of the stage floor are no longer visible. The stage floor are no longer visible and the stage of the stage floor are no longer visible. The stage is the stage of 
eniolded by the world about them During Brangaene's song the light grows still dimmer. Even the figures of the actors not made the property of the actors not made and the actors are more recorded and the actors are more recorded and the actors of the actors and the actors are more recorded and the actors are more than a superior and the actors are actors and actors and actors are actors and actors actors and actors and actors actors actors actors and actors a contact with the world once again, challenging Melot, who betrayed him, to a duel

pot is veiled from the dawning day and remains soft and shadowy

the bench at the foot of the terrace

These ideas again anticipated the technical means of accomplishing them It is only in recent years that lighting control systems have been perfected to the point where such fluctuations of atmosphere and light on the stage, to the accompaniment of the changes of dramatic mood and dramatic movement of the script, can be accomplished

In order to understand this it is important to realize the elaboration of the lighting apparatus needed to light a play and its disposition. The footlights and borders which used to be the principal source of illumination are now unimportant adjuncts of lighting equipment. The focusing lens' spot light with coloured mediums of either glass or gelatin is the essential unit. They are usually assembled on two upright pipe battens on either side of the stage, known as the "light tormentors," and are also hung from one or more pipes overhead, the total often reaching 60 or more spot lights. In addition, in order to illuminate the actors without relying on bright foots which, if used with sufficient strength to light the actors' faces invariably cast distracting shadows on the scenery back of them, spot lights are located in the ceiling beam of the auditorium so that the angle of throw is approximately 60° and hits the actor head-high from the front of the forestage to a point within 6 or 8ft upstage of the proscenium where the overhead and tormentor lights can illuminate him These lights are focused in groups to cover various acting areas. and their colour is determined by the nature of the scene whether daylight or night, whether they are projected to illuminate the actors or give colour and tone to the scenery They are then successively brought up to a given point of intensity, ie "dimmed up," or "dimmed down" to a lower point of intensity in overlapping groups, making a light plot which approximates in general scheme and intention Appia's light plot quoted above

The greatest flexibility of control is therefore essential, and the control hoard-commonly called the switchboard-temains the nerve centre and the most important single piece of apparatus on the modern stage. Up to recent years the standard rheostat or dimmer consisted of a wound core of resistance wire through which the current was shunted. Thus, when the light was dimmed a major portion of the current was turned into heat The control was entirely mechanical, each dimmer having a dimmer handle which operated the dimmer from full to out. A certain number of these dimmers could be geared together on a shaft and worked by a master handle. However, as there was a limit to the number that could be geared together without creating too much friction or making the mechanical control extremely difficult to operate, it was usually impossible to select all the lights needed for a particular change and operate them together in a mechanically efficient

way One either needed several operators or often, on a large switchboard, an operator with the reach of an orang-utan For it must be remembered that in the dimming changes of a modern light plot the light changes start with 50 or more lamps each set at different degrees of intensity-some may be full, some only half bright, others only a quarter up, etc. The change does not take them uniformly either to full or out. Those half-way up may only come down a few points in intensity; others may go to full out. others may come up in the opposite direction from nearly dim to nearly bright And it is the drawback of the mechanical gearing of dimmer handles on a single shaft that it is impossible to gear them until they are all brought to the same level, so that the task of stopping some when they reach the various predetermined levels of intensity is an almost impossible one to achieve accurately by hand

This has been made possible recently by several improvements in the lighting control system. The first is a reactance dimmer in the form of a thyratron tube which directly regulates the voltage of each citcuit. The second is a theostat known as an auto-transformer which automatically transforms the voltage of the lamp to correspond with the desired intensity, the contact being a carbon or copper brush actuated by a motor. Both these dimmers have a variable capacity, the auto-transformer having a wider variable load. The old-fashioned resistance dimmer of 1,000 watts had to be connected with a lamp on lamps of a cold 1,000 watte capacity of a lamp of 10 with 1000 transformer dimmers will take a lamp or circuit of 4,000 watts reacting the production of the connected at the product of the connected at the product of the pr

The reactance type of dimming control, though it is in process of being simplified, is much more complicated in wiring layout. more expensive both in initial and installation costs, and occupies more on-stage space than the auto-transformer type. The operating mechanism on the auto-transformer control board consists of a series of potentiometers which actuate, on a 24-volt circuit, the motors attached to the auto-transformers. The control is through a series of small handles over a graduated semi-circular arc which set each circuit at any point between full and out. Without affecting the set-up of the lights then on, a second set of handles controlling these same circuits is pre-set at any number of other points of predetermined intensity from full to out, and the change from the first pie-set to the second is made electrically, each circuit stopping at the point indicated and pre-set. Two master handles are provided which are electrical master controls so that. as on the board at the Wisconsin Union theatre, any of 56 circuits can be connected with one master, the remainder with the other master, and the light change be made on these two sets of selected circuits simultaneously at different speeds either in the same or opposite directions, ie either from full to out or from out to full, or to any number of pre-selected intermediate points of intensity for each circuit. The system thus gives complete control of any number of lighting units in any number of possible combinations in a way that no mechanical system of dimmer control is able to achieve This lighting control system in one type or another will undoubtedly become standard in the near future

It has the further advantage that the control wires can be extended to a point in the auditorium or in the projection booth at the rear of the auditorium, and a portable dimmer board be connected there so that the lights can be as effectively controlled from the auditorium as from backstage if the occasion requires.

An additional feature of modern lighting equipment is the lighting of the cyclorama. The illusion of depth and space in an open air sky is best achieved by a plaster dome, but as this is a heavy and elaborate piece of construction, and requires a great deal of off-stage space if it is not to interfere with the exigencies of scene shifting-more space than can usually be given to it or paid for-a cyclorama made of a textile is the usual substitute. This is a cylinder of cloth or canvas laced to a semicircular pipe above and below, and lighted from overhead and below by lights in parabolic reflectors with glass mediums that are spectroscopically accurate to act as light primaries-red, blue and green. By combinations of these at various intensities in conjunction with the proper painting of the cyclorama itself the colour of the cyclorama can be changed through almost the entire range of the spectrum. As painted canvas is very much affected by changes in humidity and can rarely be made to hang properly, the better practice is to use dyed cotton velour; and in order to facilitate changes of setting during scene intermissions, the up- and down-stage arms are made in the form of travellers, the velour being heavy enough to be drawn back without settling into wrinkles.

The mechanization of the stage for scene shifting seems to offer no further possibilities of practical development differing from what has already been achieved. Future technical developments

will undoubtedly be in the electrical field, the development of low voltage high wattage lamps, increased flevibility of focusing lens units, increase in the range of variable load of rheostats and added flexibility of electric master and sub-master control

BBILIODRAFIV —These devices can be studied in ditail in Gustave Chen's Historie de is mue on sche dass le biddier retigues; françoi du moyen age (1995) and Le hove de conduste du régisseur et le 1997 (1995). White the conduste du régisseur et le 1997 (1995). White the conduste du régisseur et le 1997 (1995). White the conduste de l'apparent de l'historie (Second Seites, 1913), the section of Diderot's Encyclopeade devoted to stage machinery, as well as m G Bapt's Essai ur PHistorie du Thédire, and the rinchy illustrated portfolios of 18th century (Swedish Architectural Historical Society) (Swedish Architectural Historical Society) (Swedish Architectural Historical Society)

## DEVELOPMENT OF STAGE LIGHTING EQUIPMENT

The first authentic description of artificial light as an integral part of a stage presentation is by the Italian Seito who placed candles and torches behind flasks of coloured water, the light being projected through holes in the scenery. He also used pans and trays as reflectors to intensify the light, but one can magnie that the resulting illumination was never objectionably bright. Even in the early covered theatres the chief light sources were torches or pine knots, open lamps with floating wicks browning vegetable or animal oils, and candles of wax or tailow. "Paid-do's theatre" in Italy and "Black Frais Tim" were the first of these indoor theatres and the first indoor productions in England did not take back cell 11 × 50.

The removal of the theatre from the open air into buildings was the first active force to bring about better artificial illumiation. Ingo Jones brought the Italian theatre influence to England and used the proscenium arch. Gold decorations were applied to the theatre inteneors reflecting light from huge clusters of candles. These were hung from the ceiling in a corona above the stage, and supplied all the general illumination. Even with candles, all the writers of the time referred to the highting as "brilliant".

In 1628 Joseph Furtenbach described the use of oil lamps and candles as "floats" or "footlights," as well as "wing lights he latter being now known as "borders." In 1775 when David Garrick placed a row of candles below and in font of the stage, masked from the audience by metal screens, they were an innovation in stage lighting. Not till the 18th century did oil lamps generally replace candles The John Street theatre in New York, erected in 1767, was illumnated by candles for 30 years

The invention of the Argand lamp in 1783 and the use of camphine, kerosene oil and other higher grade illumnants brought a fat superior light to the theatre. The new lamp, which was a simple oil and wick combination provided with a glass chimney, was the first important scientific advance in light sources in 4coo years. For the first time the illuminant was enclosed rather than being an open flame.

These lamps gradually supplanted the candles Lamps hung in clusters from the ceilings and projected from walls, balcomes and boxes. They were used as footlights, borderlights and wing lights Despite the improvements, there was still only sufficient illumination to make the actors and scenery recognizable

Then came gas. In 1781 William Murdock of England claimed a patent for its manufacture, and in 1803 F A Windsor completed the first theatre installation in the Lyceum theatre in London. In 1796 it was used in Philadelphia for exterior illumination, and in 1816 a complete gas lighting system was placed in operation in the Chestnut Street Opera house of the same city Gas was manufactured on the theatre premises for the theatre only An installation was, therefore, an expensive affair, and gas did not come into general use before 1850.

All of the original gas burners were open farmes or flames burning in open glass chimneys But in 1886 the Welsbach incandescent mantle was invented which increased the efficiency many times. They were used in borders, foots, wings, and bunch lights continuing the old conventions

Gas for the first time permitted the control of all the lights on the stage from one central location Elaborate systems were devised with mains sometimes more than ra" in diameter, and thousands of feet of feeder pipe, both flexible and rigid The Lyceum theatre in London and the Boston theatre in America were two of the first to be equipped with these new controls which were called "gas tables" The first electric control boards were fashioned after these gas tables. They were located near the prompter who could reach a master valve controlling the entire layout In addition to the master there were series of individual dimmer valves, and on some boards flash buttons by means of which spurts of flame could be made to give quick bursts of light

Chief among the defects of this system was the 118k of fire Many theatre fires of this time were started by the blazing spirit wads on long poles used for lighting gas jets among the scenic pieces Dancers with their thin costumes were sometimes set afire by the footlights Because of these dangers, code regulations were established which fixed the position and number of burners in various locations, and made compulsory the use of guards and

scieens over open flames

It became the custom at this time to dim the lights in the auditorium during the play, for at last the theatre had discovered that contrast between light and darkness was as important as light alone for visibility and maintaining interest

Gas lights also left their impression on the scenic design and painting for many years to come The light source was not small nor bright enough for small individual units, and the old-fashtoned borderlights, footlights, and wing lights were retained, altered only to accommodate the burners replacing the oil floats, chimneys and candles

Henry Irving experimented with effects of realism, using individual lights to achieve a more plastic illumination and devising an arrangement for drawing thin coloured silks or screens in front of others. He also started the use of sectionalized strips and borders-later employing spot lights-and thus increased the flexibility of existing apparatus. At this time also the cyclorama made its appearance, a piece of equipment still most useful on the stage

In 1816 the calcium light or "lime light" was invented by Thomas Drummond, and by 1860 had come into general use in the theatre From this unit came the common expression, "in the limelight" which is frequently used today This light source was extremely white and concentrated and therefore could be used behind a lens or in front of a parabolic reflector as a spot light. The apparatus was used to "follow" characters about the set and in a few instances for general illumination of the stage. It required the constant attention of an operator

The beginning of electricity in the theatre was the invention in 1808 of the arc by Sir Humphry Davy, who had also experimented with incandescent lamps as early as 1802 However, this apparatus, although invented before the "lime" lights, did not come into use till many years later. Frequent adjustment was necessary as the carbon was consumed, but the arc was a great advance over the calcium light. Two types of units were built around this source. One used a parabolic reflector behind the carbons, the other was equipped merely with hand operated shutters. The first device was designed in 1846 and used by M J. Duboseq and M. Foncault in the production of The Prophet at the Paris Opera Five years later M Duboseq also developed a lightning machine of a type still used today, a rainbow projector, and a luminous fountain-all built about the arc as a light source,

In 1878 Paul Jablochkov introduced his Jablochkov candle, two vertical parallel sticks of carbon separated by a layer of insulating compound. In 1879 the Bellecour theatre in Lyons, France, installed 52 of them But this method never came into general use for it could not compete with the incandescent lamp invented

by Edison in 1879

This invention brought to the theatre for the first time a clear, relatively high powered, easily controlled light source. For the first time there was light which could be used as a plastic medium, coloured, varied in form and intensity, used in ways which had never before been possible. Wagner in his operas had suggested possibilities in the use of light which stimulated the minds of the producers. He created a demand for technical developments which now began to look possible. Qualities of light were avail-

able to those who would use them, and theatre lighting as an art had arnyed

But the invention of the incandescent lamp alone did not immediately bring modern stage lighting to the theatre. However, its advantages over the older types of illuminants were recognized almost at once, and the change-over was more rapid than it had been with any other type of lamp. In 1880 and 1881 a series of experiments in the Paris Grand Opera resulted in the first theatrical installation of incandescent lamps. The greatest impetus was received from a theatre at the Electrotechnische Ausstellung at Munich in 1882 Incandescent and aic lights were used for audito turn as well as stage lighting, and units on the latter were equipped with remotely controlled colour screens. The tracker wire mechanical method was used for this colour changing and still is

The first completely electrified theatres in Germany were the Landestheater in Stuttgart, the Residenztheater in Munich, the Staatsoper in Vienna, and the Staattheater in Brunn-all in 1883. The Savoy theatre in London and Bijou theatre in Boston installed electric lighting in 1882 The first New York theatre to be equipped was the People's theatre on the Bowery, in 1885 In 1882 a congress of theatrical managers assembled and issued a formal report tayouring the illumination of halls and theatres by means of electricity In 1871 this new method was so well established that a law was passed prohibiting the use of gas in all theatres of Prussia

The original electric incandescent lighting units were footlights, borderlights, and wing lights, following the old conventions Arcs were still used wherever concentrated light sources were necessary. The only bulbs available were of the carbon filament type which gave a relatively dull glow of a definitely orange colour.

Gradually, however, materials other than carbon were discovered and osmium, tantalum, moulded tungsten and finally drawn tungsten were used in filament constructions. The use of nitrogen and later nitrogen and argon in the bulbs further increased the efficiency and decreased the size of the lamps Today, with coiled and coiled-coil filaments, gas filled bulbs, and heat resisting glass jackets, 500-watt lamps only 13in, in diameter are in general spotlight service, and 5,000-watt lamps, although much larger are not uncommon

With new light sources available, equipment was developed to use them more effectively Steel MacKaye, a producer and actor, designed the modern effect machine as well as many other mechanical contrivances for the theatre Mario Fortuny developed the Kuppelhorizont or dome, still the most perfect means of simulating natural or spectacular sky and background effects. He also developed a system of lighting named after him which utilized reflectors of coloured silk placed behind the lamps to tint and diffuse the light. These silk panels were movable so that the colours could be changed and the illumination softened

David Belasco and his electrician, Louis Hartmann, abolished footlights—a suggestion made years before by Henry Irving and began the use of individual sources from the auditorium and above the proscenium for acting area lighting. By means of these instruments as well as special reflector borders and baby lens spots they developed a standard of realism now in general practice in theatres throughout the United States In Germany Lennebach, Hasait and many others made more contributions to the technical development of the theatre. They invented the rolling cyclorama and made up elaborate systems of light control. The Fortuny system was discarded and used only in rare instances

Today the development of smaller lamps with hard glass jackets and concentrated filaments, and new types of reflecting surfaces have made possible the design of two new types of spotlights. By reducing the diameter of the lamp bulb and using a Fresnel or stepped lens, an instrument having a high efficiency and giving an even field with soft edges, useful for acting area lighting and easy to blend into a general effect, has been developed. The second type of spotlight differs entirely from this, the light from the lamp being gathered and redirected by a reflector rather than a lens

An ellipsoidal reflector has the valuable characteristic of re-

directing light which is generated at one of its conjugate focithrough the other This is the principle of the ellipsoidal reflector spotlight. A lamp with tubular glass tacket and concentrated filament, generally of the base-up burning type, is placed with its filament near the focal point within a reflector. A gate or aperture is placed between the reflector and the conjugate focal point and "filled" with the reflected light. One or two lenses acting as an objective then project an image of the aperture on the field to be illuminated. In this way fields of even intensity are produced, the beam may be shaped by means of shutters, iris, or other controls at the aperture, hard or soft edges are possible through focusing of the objectives, and efficiencies comparable to those of the Fresnel lens spotlight are obtained

spotlight are obtained.

The two above properties of spotlights have to a large extent. The two above present groups of the properties of the spotlights, and the spotlights, three other types of lighting equipment are widely used in stage presentations. First are the striplights—really the first form of apparatus as the old wing or borderlights were stips. The latest development in striplights is, the individual were strips. The latest development in stringings is the individual reflector spin which each lamp is placed in a spin reflector equipped with either a coloured glass roundel or a gelatin, or glass colour frame. Floodlights are specially shaped reflectors for individual lamps. They are made in narrow beam or wide beam types and accommodate.

Into are made in marrow beam or worde beam types aim accommonates a small or large lamps. Wide angle floodlights are used for illuminating back drops and cycloramas, and, in the US, are matte finished ellipsoidal refectors Banks of them equipped with three or more filters can give effects which simulate any degree of sky colour from midday to midinght including the brilliant hours of sunset and dawn

Special effects, the fourth class of lighting equipment, often are built about the spotlight as a base, but they may include anything from painted ranbows and moving clouds to water inplies of cut glass strips, a burst of fireworks, or a waving flag The effects are generally painted on mica discs enclosed in a sheet metal protective housing and driven by electric or clockwork motors. These "effects" are placed in front of spothghts, an additional lens being added to each to further concentrate the light, and objective lenses project

each to further concentrate the mages of the moving discs.

As opposed to the complicated design of these "projection effects"

As opposed to the complicated design of these "projection effects"

This apparatus is very old is the simplicity of the shadow projector. This apparatus is very old in principle but the form now used in stage work is the Linnebach lantern—named after Adolph Linnebach, the designer. It consists of a deep box painted black inside and surrounding a concentrated filament lamp or arc One side of the box is open, and over this is placed the slide carrying the design to be projected. Because the lamp filament since carrying the design to be projected. Because the lamp nament on arc has a definite size, sharp projections such as are obtained with lens units are impossible. But very wide areas can be covered at relatively short projection distances, and, especially for silhouettes of skylines and crude outlines, this method has no equal

of sylms and crude outlines, this method has no equal.

In step with improvements in equipment has been the development of new colour medias. Fortuny and other of his contemporaries used coloured sliks and reflectors for tuning the light. I tump dip appeared after the invention of incandessent lamps. Today sheet gelatin is still probably the most videly used colour medium. If is a svallable in large sizes, a great variety of colours, is mesupeare, and most of the colours are relatively last. Horst are constantly being made to in-

crease their permanence

crease time permanence wery unsatisfactory in damp chimates as it also below the readily and proceeds to "melt". In any climate after being subjected to heat from lamps for several hours it becomes very buttle and tends to shrived Acetates, such as celluloid, are much the fire hazad precludes their use Gelatin may be ignitted but supports combustion only with difficulty, and tends to smoulder statier. than burst into an open flame

Cellophane has been used with a great degree of success in recent years. It is available in 11 colours besides clear, black, and two de-grees of clear diffused It is thinner than gelatin, is not greatly affected grees of clear diruses. It is immer than glean, is not greatly succeed by dampness, and supports combustion only with difficulty. Some of the colours are quite fast, but others rather unstable, and the limited colour selection is, of course, a great disadvantage.

From many standpoints glass is the ideal theatrical colour medium

From many standpoints glass is the fideal theatrical colour medium despite its weight, intuital cost and fragility. It has come into use only recently and more because new equipment required it than because it was developed to a new degree of perfection. "Gelatina" burned out with alarmare rapidity when used in front of high powered hight came into use with their greater light outputs and concentrated beams, new colour filters had to be found at once. Coloured sheet glass in both "flashed" and "type" forms was available, but non eit reaked glass in both "flashed" and "type" forms was available, but non eit reaked in the standard of the standard o

ditions Glass is not the perfect colour medium. It is fragile, heavy and expensive. Its colour range is limited, and sheets of glass often and expensive its colour range is imitted, and sheets of gass often vary in colour and transmission by as much as 50% from one end to the other. The field of plastics at present seems to promise a great advance in colour control in the theatre. But as yet there are no transparent materials which are available in heat resisting quality But one day in the not too distant future we may expect a material which can be used without a stiffening frame to support it, one which is impervious to heat or moisture, available in a multitude of fast colours It will be light yet sturdy, and less expensive than glass filters It is not too much to expect

For the remote control of all the old gas lighting equipment, the gas table had proved very satisfactory. In the first switchboards only intensity control was thought necessary, although colour controls had already been included in many of the previous gas installations nada already been included in many of the previous gas invaluations. The first electric dimmers were water barries with two metal plates put in a weak solution of brine. One plate rested at the bottom of the barriel, the other could be reased or lowered, thus varying the restance of the circuit by varying the amount of brine between the plates through which the current had to flow. These units were expenses the country of plates through which the current had to flow. These units were ex-tremely unsatisfactory as the water evaporated rapidly, the heat, if the barrels were overloaded, produced a vile smelling vapour, and the settings for any particular lamp intensity were never twice the same

settings for any particular lamp intensity were never two crites are resistance wire tapped at a number of points, these taps hency connected by wires to the points of a todary switch. By turning the switch the resistance in the circuit could be varied at will. The reswitches were located on the stage floor. Because the resistance to current flow uses energy which, is transioning into heat, the coals content flow uses energy which, is transioning into heat, the coals current flow uses energy which is transformed into heat, the coils became hot, especially when overloaded—and for that reason were dangerous. A large number of wires leading from the control switches to the coils were also necessary, and this was eliminated by the re-sistance plate dimmers next developed.

In this type the resistance wire was laid out on a plate, either itself in this type the resistance wire was fact out on a place, enter rises an insulator or coated with an insulator, and heat resisting compound. The switchpoints were connected with the wine. The entire assembly was coated with more heat resisting material until only the contact surfaces of the switchpoints were visible. The tapping arms were provided directly to the resistance block. This type of control unit is

The most obvious fault of the resistance control has already been mentioned—that energy is used in reducing the current flow and is then dissipated in heat. This fault was recognized as early as 1890 and in 1896 a reactance type of dimmer bank was installed in the Earl's Court theatre in London. Here a double reactance with one

Earl's Court theatre in London Here a double reactance with one oil slipping in and out of the scond was used to contiol each circuit, alternating current being used rather than direct. The plan worked Court of the country of the c

and not current regulators

The most modern types of alternating current controls are the auto-transformer dummer, and the electronic tube and reactance circuit The first is manufactured in sizes up to 5,000 watts for single phase loads and up to 10,000 watts for three phase loads

The latest development in theatrical intensity control equipment is

the electronic tube and reactor circuit, and, still more recently, electhe electronic tube and reactor circuit, and, still more recently, elec-tionic tubes which themselves carry a considerable load current by means of these devices switchboard sizes have been tremendously re-duced, and a panel the size of a moderately large radio receives is now sufficient to control the lights in an entire theatre.

sumerent to control the ignits in an order treature.

Swotching and dimming equipment have been improved and reSwotching and dimming equipment have been developed which permit the instant switching of a large number of controls by means of a single master lever, or allow an operator grad-ually to change the lighting from one predetermined setting to another, some units dimming, some brightnems, but all in proportion to the

individual readings

As has been mentioned previously, tracker wires and mechanical line movements are still the standard means of remote colour control in Europe In the U.S., self-synchronous motors and electromagnetic in Europe. In the US, self-americaness motors and control gentlem that such as the control gentlem that same service. The former permit an operator at the central control panel to move colour frames or lighting units themselves in exactly the same way in which he manupulates levers and dais. Only electric circuits connect the control and the highting equipment—there are in moying cables or pulleys. Electromagnets control and with the control show movements.

BIRLIOGRAPHY.—S. R. McCandless, Syllabus of Stage Lighting: Nard Lonards Electric Co., Phater Lighting Past and Periner; Friedrich Kranch, Bulmentechnik de Gegenwarf; Slemen-Schuckert, Friedrich Kranch, Bulmentechnik and Gegenwarf; Slemen-Schuckert, Elghting; Louis Hattmann, Thesire Lighting; Selden and Sellman,

Stage Scenery and Lighting, Westinghouse Lamp Division, Artificial Light and Its Application, Theatre Fuchs, Stage Lighting, Lighting by Century (E KK)

STAHL, FRIEDRICH JULIUS (1802-1861), German ecclessastaal lawyer and polituian, was boin at Munich on Jan 16, 1802, of Jewish parentage At the age of 19 he entered the Lutheran Church He was professor of law at Wurzburg, and of ecclessastacal law and polity at Berlin

Stabl early fell under the influence of Friedrich von Schelling, and at the latter's mussience, began in 1827 his great work the Philosophie des Rechts mach escalachtlicher Anualta (an historical view of the philosophy of law), in which he breas all law and political science upon Christian revelation, denies rationalistic doctrines, and as a deduction from this puniciple, maintains that a state church must be strictly confessional. This position Stabl further elucidated in his Der chistiliche Stade und seru Verhalinss sum Denimus und Judenthium (The Christian State and Its Relation to Deism and Judaism).

As synodal councillor Stahl made use of his influence to weaken the Evangelical union (i.e., that compromise between the Calvinist and Lutheran doctrines which is the essence of the Praisant Evangelical Church) and to strengthen the influence of the Lutheran Church (cf. De Luthersheck Kurche wide Pulmon, 1859). Frederick William IV supported Stahl in his seclesiastical policy, and the Prussan Evangelical Church would probably have been dissolved had not the regency of Prince William (afterward the emporer William 1) supervened in 18-8

Stahl retired into private life and died at Bruckenau on Aug 10,

1861
STAHL, GEORG ERNST (1660-1734), German chemist and physician, was born on Oct. 21, 1660, at Anspach He was graduated in medicine from Jens in 1684, and became court physician to the duke of Weimar in 1687.

From 1694 to 1716 he held the chair of medicine at Halle, and was then appointed physician to the king of Prussia in Berlin, where he died on May 14, 1734

In chemistry he is known chiefly in connection with his doctrine of philogation (see CIRMSTRY History of Chemistry), the essentials of which, however, he owed to Johann J Bocher (1635-1632) He also propounded a view of fermentation which mosome respects, resembles that supported by Justus von Liebig 150 years later.

He was a firm believer in animism In his youth he believed in alchemy, but later he warned against its frauds. As proof that metals do not "ripen" into gold in the earth, Stahl cated the fact that British in was the same as when exploited by the Phoenicans He observed that acids are of different strengths, that the basic component of common salt differs from that of potash, and he recognized the particular nature of the earthy constituent of alum.

Among his students were Johann H Pott (1692-1777) who improved the manufacture of porcellan, and Andreas S. Margarfi (1709-1782) who discovered sugar in the beet. Stahl was a prolife writer, using an extremely difficult Latth. He edited Becher's Physica Subcieronae in 1702, and added his Specimen Becheronaum, in which he expounded at length his own views of condustion which were first presented in his Zimotechema Industrial (1697). His chief medical treatise was Medica Vera (1708). His principal chemical work was Fundamental Chymine (1723)

See R. Koch, essay in Bugge's Das Buch der grossen Chemiker (1929). (R E. O.)

STAHLBERG, KAARLO JUHO (1865—1923). Fundish statesman, horn on jan. 28, 1856, began his public career by holidis alternately university and administrative posts. He then became a member of the diet in 1904 and of the Finnish government in 1905, but resigned in 1907 and was appointed a professor of administrative jaw in 1908.

At the outbreak of World War I the government was Finnish in name only, being composed entirely of Russian officials. Stablberg was then president of the diet and had to act as the chief public representative of Finnish opinion.

He firmly withstood the increasingly oppressive tendencies of

the imperial Russian government. After the Russian Revolution of 1917, Finland became an independent republic, and in 1919 Stahlberg was elected to the presedency. He withdrew from the candidature for the next presidency after his term of office ended in 1924. He stood as a candidate in 1931 and again in 1937, but he was not it-elected. Stahlberg became prominently known as an expert on administrative law.

He retired from political life in 1937 and died Sept. 22, 1952, in Helsinki. Fin

STAINED GLASS, a term that is generally understood to refer only to glass windows that have been coloured by such methods as the fusion of metallic oxides into the glass, the burning of prement into the surface of white glass, or the joining of white with coloured pieces of glass.

#### ORIGINS

The origin of stained glass is obscure. It probably came from the near east, the home of the glass industry, and mosaic windows of glass set in plaster work, which is known from the 17th century in Egypt and elsewhere, are probably of great antiquity. But it is not likely that the art goes farther back than the glass century, it is doubtful if before that time glass was made in a sufficient variety of colours to suggest and produce coloured designs.

The art would most naturally spread first to Italy, and Venice may have been a centre as early as the 10th century. An Italian panel in the Victoria and Albert museum, tentatively ascribed to the 14th or 14th century, is fully Italian and Romanesque in style.

and suggests a native tradition

Actually the eathest reference to starned glass in the accepted sense of the term (that is, windows not merely coloured, but the control of the term (that is, windows not merely coloured, but he control of the coloured windows that the cathedra and redecented it with windows representing various stories (Richer, vol. ii, lib. 3). An earlier reference, in a givine century life of St. Ludger, certainly relates to coloured windows, but it is not clear that they were pertoonal. Male gives, as the eathest mentions of leading, a reference to the Miracles of Saint Benost where it is related that in the last years of the 10th century the church of Fleury-sur-Loire was set on fire and it was feared that the leads of the windows would be melted.

Which are the earliest windows extant is a matter of dispute, but the evidence, both literary and stylistic, seems to favour certain figures of prophets in Augsburg cathedral, which may date from the middle of the rith century.

### TECHNIQUE

A stained-glass window is a translucent mosaic held together by lead, that is the simplest conception of its technique. Actually other considerations come into play in the design and execution of a window. The lead is not merely a connecting medium, but in all good design plays a part of its own, it outlines the main constituents of the design, giving definition and rhythm to the masses of colour.

From the account given by Theophilus, a very accurate notion can be derived of the technique as practised when the art first came to its perfection in the rath century. The general scheme for the glazing of a church was, of course, the care of the clerce, and it may be assumed that the artists among them, the illuminators, would prepare the first drawings. One such sense of drawings, the Guthlac Roll, is preserved in the British Museum (Harley Roll, Y 6). But the actual cartoon for the glass was drawn on end of a whitewashed board supported on irestles. The vacant space at the other end was used for laying out the glass and for the general business of glazing.

The cartoon was marked to indicate the various colours, and the next step was to shape a piece of glass to the outline required by the design. This was done, firstly and roughly, with a hot iron and then more carefully with a tool known as the "grozing iron," aft piece of iron with a notch at one end, rather like a modem spanner. This must have been a slow and laborious process, but the grozing iron seems to have continued in use until about 1500.

when the modern method of diamond cutting began to be employed The next step, in a fully developed stained-glass window, was to paint the glass with details which the bare design of glass could not give At inst the use of paint was confined to an opaque brown (grisaille, q v), used, not as colour, but as a means of outlining the design in further detail, reinforcing the effect of the leads This pigment consisted of powdered glass mixed with a metallic oxide (probably iron), to which was added sufficient gum to make the mixture adhere. If "high lights" were desired, the whole surface of the particular piece of glass was covered with a thin coating of this paint and the lines scratched through with a pointed stick Shading effects were produced by stippling with a brush The glass, having been painted, was next fired in the kiln, to fuse the enamels to the glass. In mediaeval times the glass was fired in a pan, which was filled to the top with alternate layers of glass and whiting When the glass was fused sufficiently, it was brought out and cooled and then rearranged on the glazing table The next step was the leading This was (and still is) done by means of strips of lead, in section like the letter H, but with a thicker cross-bar to represent the "core" of the lead; the upright strokes represent the "tapes" At first the leads were cast, but in the 17th century the lead vice was introduced This is a kind of mangle, with two toothed wheels like coins with milled edges, between which a strip of lead is squeezed, the soft metal emerging in the form already described Sometimes the wheels had the glazier's name engraved on them, which thus became impressed on the lead as it passed through the machine, and these names are occasionally found on old leading When the leads, cut to the required length and shape, had been inserted between the pieces of grozed glass, they were next soldered together at the points of junction, and cement or putty was rubbed into the crevices between glass and lead. The window was then ready to move into place, where it was fixed by means of leaden strips soldered to the leads and attached to iron saddle-bars let into the masonry, Larger windows were made in smaller units and these units fitted into an iron framework or "armature" which itself often formed a geometric design contributing to the general effect of the window.

From the 12th to the 15th century the technique of stamed glass remained practically unchanged, though one minor innovation had a great effect on the character of design. This was the invention, early in the 14th century, of a yellow stain derived from a solution of silver It formed a very thin film on the glass and was therefore very transparent; on clear glass it varied in tone from pale lemon yellow to deep orange; but it could also be applied to blue glass to produce a brilliant green. Its effect on design was far-reaching and will be noticed when we come to the history of the craft. In the 16th century the technique of glasspainting became more scientific; the glass itself was thinner and smoother and more transparent, two layers of different colours could be put together to produce a third colour; if these layers were fused together, one layer could be ground away or "abraded" (and by a later process "eaten" away by fluoric acid) to give delicate effects beyond the reach of a leaded mosaic. Finally, towards the middle of the 16th century, the art of painting in enamel on glass appeared, perhaps as a result of economic causes which made a scarcity of pot-metal Hitherto glass had been coloured throughout its substance and was known as "pot-metal," though to obtain sufficient translucency in a dark colour like ruby the glass was "flashed," that is to say, clear glass whilst still pliant was dipped into molten coloured glass, and so received a translucent film of the desired colour. But now ground glass was mixed with various metallic oxides (copper for green, cobalt for blue, manganese for purple, and so on) and the design was then painted on to a clear sheet of glass and fused on For some time this technique was continued with the old technique of leaded pot-metal; but in the 17th and 18th centuries the old technique disappeared, and the art of stained glass was virtually dead.

# HISTORY

Eleventh and Twelfth Centuries.—The windows at Augsburg, ascribed by Fischer to the middle of the 11th century, have already been mentioned. To the end of the 11th century belongs

a window at Le Mans (France) painted with the Ascension For the 12th century we have in England a figure from a Tree of Jesse in the minster at York, and at Canterbury there is a magmificent series representing the genealogy of Christ which may be dated about 1180 At Chartres there are more important and extensive examples-in the west window is a Tree of Jesse design which is undoubtedly the best surviving stained glass of this century, also the beautiful figure of the Vugin and Child known as La Belle Verrière Other considerable specimens of 12th century glass exist at Angers, Saint Denis, Châlons-sur-Marne, Bourges, Strasbourg, Potters and Le Champ (Isère) The earliest of these windows, such as those at Augsburg and Chaitres, are strongly Romanesque in character The windows at Canterbury come at the end of the Romanesque tradition. They still preserve the monumentality so characteristic of Romanesque design, but the figures are far removed from the agorously schematic treatment of the Augsburg prophets, there is the first flush of humanism in their bold features. There is a sense of movement in their limbs; a sense of vigour in the formal draperies. The colouring of this Canterbury glass is still typical of the 12th century, the bare flesh is cut in pink glass, whilst the rest of the design is a quet harmony of blues, pale green, white, brown and yellow, arranged in fairly broad masses with no effort towards "jewellike" quality. The architectural settings are rudimentary, in most cases representing a simple column on each side of the figure, with an arch spanning the head

It is probable that most of the early windows were of the singlefigure, monumental character of the Augsburg and Canterbury examples But about the middle of the 12th century a new type of window came into being which consisted, instead of a single representative figure, of a medallion (or several medallions) painted with pictorial subjects, such as incidents from the life of Chust, or from the life of some saint. This change was accompanied by various subsidiary developments. The necessity of telling a story in a series of medallions led to the decorative arrangement of these medallions within an "armature" or iton framework which was itself a subject for pattern, and very beautiful designs were evolved, showing a skilful counterplay of circles, lozenges, quatrefoils and squares, with their appropriate borders and interspaces This development in its turn necessitated larger windows and this necessity had a profound effect on the development of Gothic architecture itself. A third development was in the actual colour of the glass The pictorial treatment called for a more detailed and more varied play of colour, and the technical resources of the glass-maker were equal to this demand. The result was that kaleidoscopic or jewel-like glow of colours with which stained glass is always popularly associated. It is in glass of the early 13th century that this property is supremely evident

Thirteenth Century.-With these early 13th century medallions we first become fully conscious of the part played by the actual painting in stained glass It is true that the earlier figures had a broad effective scheme of drawing, but with the 13th century medallions a fine dramatic sense of line was developed and continued in force throughout the century. And with the sense of line came that superb sense of dramatic composition illustrated in so many of the medallions of this period at Canterbury, Lincoln, Chartres, Sens, Bourges, Le Mans, Rouen, Cologne, Marburg and Klosterneuburg (near Vienna). The highly stylicized motives of the decorative borders of the 12th century were no longer in keeping with this dramatic mode, and as the century advances we accordingly get a naturalizing of these motives. The formal acanthus leaves of classical inspiration give place to more natural plant motives, to scrolls of oak and vine; these coil with a more organic and vigorous movement, until eventually, in the 14th century, the artists begin to copy directly from their own observation-from the ivy and the wild strawberry.

Towards the last quarter of the 13th century, a greyer mood seems to have descended on our glass-panters. It may be that they were required to give more light in the churches, or that the supply of ruby glass, always somewhat precarious, gave out Whatever the reason, there developed in the latter part of the

ight and early 14th centuries the technique generally known as groutle painting. It implies the use of large earses of clear quarties patient in black or brown enamel with simple and unobtrusive patterns of folage. Grissulle work at this period is of two knods it may consist of geometrical patterns of quarries, often outlined in coloured bands, on which are painted designs of folage, often imitation of a trellised plant, or it may be used in combination with subject medallions. The best instance of this latter method is perhaps seen in the wandows of the Chapter House at York, which, though now much decayed and obscured, are supreme examples of grissulle work.

These characteristics of 13th century stained glass are general wherever the main stream of Gothic art (a.v.) flowed. Distinctions of nationality need not, and indeed cannot, be made. In point of time the medallion windows at Canterbury perhaps come first, then, closest in time and style, come the similar windows at Sens, Chartres comes next and is very impressive in its quantity and scale, at Bourges and Rouen there is glass very similar to that of Chartres; the glass at Lincoln and Beverley in England must be placed somewhere before the middle of the century But back again in France we find a more distinctive school developing in Paris during the second half of the century, in connection with the building of the Sainte Chapelle and the extension of Notre Dame. The distinguishing feature of this latter style was the general use of a background of trelliswork in blue and 1ed glass, which, in the mass, has a rather unpleasant purple effect. This style scarcely penetrated to England, though an example may be seen in the east window of the south transent of Christ Church, Oxford,

Fourteenth Century.-Midway in the 14th century comes the Black Death, and this catastrophe marks the end of the pure Gothic tradition, in this as in all other arts. Its most marked effect was perhaps reflected in the break-up of the inter-community of Christian art No doubt other forces, economic or political, were operative too; but the disorganization caused by the Black Death among artists and craftsmen all over Europe resulted in the formation of more limited and more local schools. Onward from 1350 the styles of England, France, Austria and Germany diverge more and more from each other. And within all these countries the local differentiations between various centres are often very marked. The disorganization not only affected traditions, but even more so technique. It seems that the ability to manufacture some of the brilliantly coloured kinds of glass was lost at this time, never fully to be recovered until the 19th century There was also a Cistercian ban on pictorial windows, which no doubt had some influence in this direction, during the 14th century But the glass-painters were not slow to react to the new situation; the invention of yellow stain early in the century had provided them with one new resource; and the growing taste for line design, as witnessed in the grisaille glass already mentioned, led to the full exploitation of clear white glass. When once the use of white glass had been forced on the glass-painters, its aesthetic value was appreciated It may be also that the resultant effect on the lighting of the churches was appreciated, and that the glass-painters began consciously to aim at a clearer effect Architectural developments kept pace with, and even aided, this changing colour-scale. The windows grew higher and wider, the tracery more intricate, demanding of the glass-painter an effect that was not too heavy for the expanse to be filled, or too clumsy for its delicacy.

Further developments were due not so much to economic factors as to a change in spirit. The rath century saw the full emergence of that movement towards humanism which had found its protagonist early in the 21st century in St. Prancis of Assist. The tendency towards naturalism which we have already seen creeping into the decorative motives of stained gass was a far wider phenomenon, and involved all art and literature. The new spirit of Pranciscan naturalism only manifested itself in plasture at by slow degrees, but it culminated in the Renaissance. It involved a transformation of Christan iconography, and the glass-painter, along with other artists, now deserted the fixed types of early Goldic art for the living types before him. Sub-

jects are now given a contemporary setting; for his figures, his costumes and his architecture the painter looked around him and found models before his eyes. A playful freedom of line gradually developed, as the brush-stroke grew lighter, it grew easier. The features are rendered with more grace and verve; there is almost an excess of curve and curl in eyes and lips and locks. An individualization of the features begins to creep in; we begin to feel the presence of real people, friends and contemporaries of the glass-painter, no longer abstracted, no longer idealized The folds of the garments lose their angular restlessness and sweep and sway in graceful curves. We get, too, the entry of fashion The garments in the 12th and 13th centuries are formal and of classical derivation, except in so far as they are ecclesiastical or military. They continue to be somewhat non-committal during the first half of the 14th century, but with the growth of naturalistic treatment and the revival of figure-subjects we get the unmis-takable evidences of contemporary fashions. The representation of costume then becomes a matter of course, and is of great assistance in the precise dating of stained glass

But the most typical and expressive development of ornament is seen in the anony. This form of architectural ornament no double originated in the 12th century, when an architectural unti-generally an architectural control of the co

Fifteenth Century.—With this development of the architectural features of stained glass ornament is perhaps bound up a curious retro-Teatures of stamen glass ornament is permaps bound up a comous retro-gression during the 15th century—the abandomment of natural plant motives for stylicized diapers. Artists forsook the carefully observed tuy, oak and vine, and introduced instead such dreary motives as that usually described as the "scaweed pattern"—an clongated, shapelessly indented leaf, generally painted in reserve on a blue or ruby glass, and seemigly kept as "stock" to be used whenever the design required an indeterminate background. It was a step toward that still more slipindeterminate background. It was a step toward that still more slip shod expedient—the stencilled diaper background of the 16th century The borders, which had always been an integral part of stained glass design, develop in conformity with the general trend. But their aesthetic function becomes less obvious and they gradually loss decorative value.

In the zath century the bodder had been the essential framework of the design, enclosing within its definite pattern the otherwise unconfined design. In the 13th century the border existed as a foil for the sequence of separate designs. Then, in the 14th century, when the subject-panel became solated from its background, the border became a purely decorative feature, contributing a separate unit to the general sthetic effect; in the 12th century the border framed the design assentice sheet; is use tran cantary the border trained use usergue—in the 14th telegraph the frame of stomework, its naturalistic form satting efforts of the contract of the contract of the contract of the efforts of the contract of the contract of the contract of the stonework, and providing, as it week, a transition from one to the other. In this role it naturally tended to become more formal in character. Already in the 14th century the typical border of creeping foliage had been varied with alternations of devices such as crowns, foliage had been varied with afternations of devices such as crowns, chalices, heraldic badges, grotesque annuals, small figures of angels, etc.; an exceptional example is to be seen in the famous Bellfounders' window in the north aisle of the nave, York minster, where the border consists of bells (outer lights) and musical monkeys (centre light). The 15th century saw some recovery of the sense of colour. Coloured life is mentally saw some recovery or the sense of colories of colories glass of a variety of colories, but too even and flat in tone to be quite satisfactory, became available on the continent and was largely imported into England. Alteady in 1408 the east window at York master, made by John Thornton of Coventry, is full of a new vitahly aming it. The covenants for the execution of the glass in the Beni-champ chapel, Wanwick, which are dated 1447, specifically provide for glazing the windows "with Glasse beyond the Seas, and with no Glasse of England; and that in the finest wise, with the best, cleanest and strongest glasse of beyond the Sea that may be had in England" This window was carried out by John Prudde, no of the greatest of English glass painters, and the result is versatile in the extreme, the colours, jewelled and counterchanged to the utmost limits of ingenuity, blazing with the greatest richness imaginable.

In Germany also, the development was in consonance with the richness and complexity of late Gothic art in general, and there the develop-

ment may be particularly associated with the name of Hans Wild, whose principal works date from about 1470 to 1480. His most famous window is in the cathedral at Ulm, and shows great boldness and original lantasy in the use of foliage motives. The window becomes a

original fantasy in the use of foliage motives. The window becomes a futurisant trelliswork of flowering plants and pinnacles in the depths of which the human figures tend almost to disappear. One characteristic of this period is the development of heraldry in glass. We have practically no knowledge or records of the use of heraldry in stance-glass windows previous to the right century, though there are three 13th-century shields in the apse windows of Westminster abbey which serve to indicate an early use of heraldic glass. We know from records that these shields were originally placed in the aisle windows, which were of grissalle. But the particular circumstances which brought heialdic glass into general use are hardly consistent with the spirt of early Gothic art. One of the characteristics of the 14th century is the introduction of the personal element into the windows century is the mitoduction of the personal element into the windows Donois began to desire their potrraits within the design of their window, memorials to the immediate dead began to assume a representation of the mode and technique of plass painting at that time forbade it. The shield of arms had therefore the very definite use of identification but it was soon realized that herathicity and an asthetic value of its own, or rendering of the formal patterns of the shields, and the bullancy doubly attractive in this personal emblem. The ground of the shield, which was suitably filled in with a diaper pattern, gave the glass painter an invention of decourse motives. The technique of Sentiching A design in available of the contraction of the contra opportunity to exercise his stat in utusawork and his returns in invention of decorative motives. The technique of scratching a design with a point through a dense ground of colour, always a pleasant endique in glass painting, was encouraged by this development. The glass palitier kept pace with the heraid, and did not heastate to attempt the utmost elaboration of curved shaled and exuberant mantling With the Renaissance hetaldic glass took on a more restrained appear-With the Renaissance netatine glass took on a more restained appear-ance—at least, in England, where the common use of the garter and the wreath tended to confine the design within sober limits. Elsewhere, the wreath tended to comfine the design within sober limits. Elsewhere, especially in Switzerland, heraldic glass became, during the course of the 15th and 16th centuries, the most typical use of glass painting

the 15th and 16th centures, the most typical use of glass painting. The 15th century saw a great growth and intensification of the 15th and 15th an formed all over Europe, and patitularly in the great ecclesiastical cities. In England, for example, definite schools can be associated with York, Coventry, Canterbury, Winchester, Oxford, Gloucester, Wells, Lincoln, Nowanch and Westmanger. Norwich and Westminster

The different styles are not always easy to distinguish, and the "schools" are rather in the nature of empirical groupings based on the

density of distribution

Toward the end of the 15th century England suffered a general invasion of foreign artists and craftsmen, a growing influx that reached its culmination early in the next century with the arrival of Toringiano and Holbein At this time, in the Netherlands, the art of stained glass had reached a development which, in accomplishment and modernity, was far ahead of the insular style in vogue among English glass painters. The wool and cloth trades flourished in spite of the wars The new wealth to some good purpose, and thus they made the z5th century an age of church building and charatable foundations. And these merage of church budding and charatable foundations. And these inst-hants, moreover, were men of some culture, whose business had characteristic or the contraction of the contraction of the the Netherlands. When, therefore, they required glass for the beau-tiful furnished clumches which they began to construct in various parts of the country, they demanded glass in keeping with their luxinous and the country of the contraction of the contraction of the country that the country of the contraction of the contraction of the answer to the demand these mes enew series and, in accordance with the regulations, established themselves within a recognized stanctury such as the liberty of St. Thomas in Southwarfs, and assumed English names As time went on, they became a menace to the existence of the London company or guild of glazlers, and a continual series of dis-putes between the guild and the foreigners marks the beginning of the 16th century But the proper tradition of glass painting was entirely lost. In the middle ages stained glass thrived as an art subordinate to or in community with, architecture With the Renaissance, and the shifting of the dominant emphasis of artistic effort from architecture smitting of the command, emphasis of artistic earls of an acceptance to painting, the glass spinter found himself in a dilemma. He had to adapt his art to the new conditions, or suffer from the general neglect of arts subordinate to architecture. He attempted to save himself by adopting the aesthetics of painting, and the history of stained glass henceforth is the history of this false steps and of all the disastnous consequences

Sixteenth and Seventeenth Centuries,-But while this false aesthetic was developing, there grew up in France and the Netherlands a full-blooded Renaissance style of glass painting which makes the first half of the 16th century a distinctive epoch in the history of the art. It is a development of the pictorial treatment of the windows on the largest possible scale; the window is regarded as one large canvas;

the intersecting mulhors are ignored. On this canvas the coloured glass the intersecting millions are ignored. On this canvas the colouted glass is spread in generous masses and heightened by all the resources of line and shade. The windows gleam with everything that is rich and oinate in colour, design and subject. The glass is tim, but this fault is counteracted by the breadth of the treatment. The Netherlandish type is well represented in England by the work of imported artists, type is well represented in England by the work of imported artists, of whom Banard Flower is the most important. This artist came, have been supported to the state of the window for Henry Uffis chapel at Westmanster, and was entrusted with the contract for King's College chapel, Cambridge, but deed before he had completed more than four of the windows. It is probable that among completed more than four of the windows. the work which may be attributed to Flower are the windows of Failthe work which may be attributed to Flower are the windows of rain-ford church in Gloucesteshine, perhaps the most complete unit of stained glass remaining intact in England King's College chapel, be-gun by Flower after designs probably by the Flemish artist, Diuck Vellert, was completed by a mixed company of English and Flemish

In France, Rouen was the great centre of glass painting, and that city still offers an incomparable display of the glass of this period, though many other towns, such as Evreux, Châlons-sur-Marne, Dieux, Inougo many other towns, such as Evreux, Chaions-sur-Marine, Dieux, Beauvas, Auch, Troyes and Montimorency, are famous tor their windows. In the Netherlands, the most important windows of this period are found in Antwerp, Hoogstraten, Biussels, Liège and Amsterdam, while the windows at Gouda, panted by the brothers Dirk and Waite Cabeth and their pupils, toward the end of the 16th century, are of extraordinary range and completeness In Germany important schools existed at Strasbourg, Augsburg, Munich, Freiburg-im-Breisgau, Nuremberg, and above all at Cologne, the general character of all of which was not essentially different from that of the dominant Flemish or French type In Italy the period is mainly associated with the name or riench type. In Italy the period is mainly associated with the name of Guglielmo de Marcillat (1467-1529, sometimes erroneously called William of Maiseilles). Windows known to have been made by him exist at Arezzo and Rome, and a very typical example from the cathedral of Cortona, dated 1516, is in the Victoria and Albeit museum cathedral of Lortona, dated 15th, is in the Victoria and Albeit museum At Florence, where there are also important earlier windows in the cathedral which are said to have been designed by Ghiberti and Donattello, other windows in the style of Marcillat may be seen in the church of Santa Croce The building of the cathedral at Milan caused an important school of glass parning to develop there, and the work of Cristoforo de Mottuos and Nicolo da Varallo carried out during the second half of the 15th century is of great beauty. The Milan school continued in full activity during the 16th and 17th centuries In Spain, especially at Seville, León and Avila, magnificent windows of this period exist, but they are in all cases the work of Flemish glass

In the 17th century we find the highest level of glass painting in Switzerland, though actually that level had been surpassed in its own country during the 16th century, when Holbem and Burgkmair were leading designers of the panels typical of that country. But the real leading designers of the panels typical of that country But the real significance of Switzerland in the history of glass painting is that their significance of Switzelland in the history of glass painting is that their alone was evolved an appropriate technique of neamed painting. For various reasons of a social kind, glass painting in that country had further of the people, and a panel for the window of a room was as natural, and even more usual, than a picture for the wall. Glass paintings thus became intimate and portable—a mid of Kleumadare comparable to the development of Kleumplainté in sculpture. Within the limits of this littleness, the art of enameling glass developed an appropriate technique. It was, indeed, the technique of painting translucent painting—but then the Swiss panel was in all essentials a painting. To the same category belong the roundels painted in transucent painting—out then the owiss panel was in an essentials a painting. To the same category belong the roundels painted in grisalle which were produced in large quantities during the first half of the 16th century. In these types of glass painting the specific problems of distance and architectural harmony did not enter into the

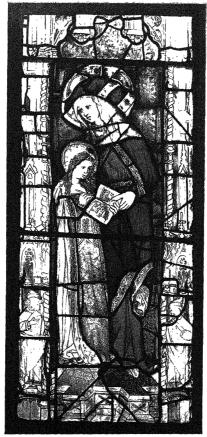
problems of distance and architectural harmony ded not enter into the question; even ything was made for nearness and nutimacy. And on this scale stained glass was imaginopriate, ungainly and without effect glass paintings of the 16th and 17th centures, which illustrate glass paintings of the 16th and 17th centures, which illustrates the enamel technique in both its good and bad aspects, and it was through these, rather than the Swiss, hat the new site penetrated to England. Abraham and Bernard was Linge (who flourished about 1620-49 and painted many windows in Oxford and elsewhere) were the chief of these immigrants, but they were ably imitated by native artists such as Henry Gyles of York (1645-1700), the Price and the Peckitt families of the same city, and by artists like Francis Eginton (1737-1805) and James Pearson (d 1805), who carried the art right on to the threshold of the 10th century. At their best, the achievements of the glass of the 19th century At their best, the achievements of the glass painters in this genre have a miniature delicacy and a perfection of means beyond reproach But it must be realized that we have entered on a new art, with its own aesthetic, and we must beware of any in England (and elsewhere in Europe) it was the glass painters who were guilty of confusion Social custom never called upon them for a domestic art comparable with Swiss glass painting, but nevertheless they attempted to apply the methods of the domestic glass painters (but without their technical skill) to the quite different needs of ec-



ENGLISH STAINED GLASS

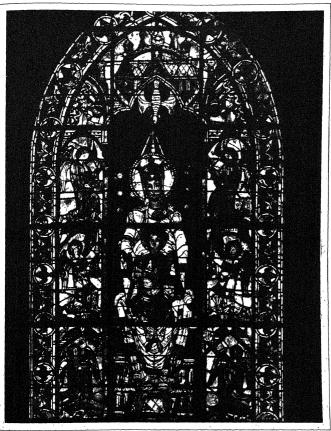
"The Patizeth Jards" 2014 sentury whickow in the south transpot of Centerbury Cathedral. As in much of the mediescry class re Englisher, the have dish is out in plick glass, while the rest of the design is a harmony of blues, pale green, whith, brown set yellow, arrange in thirty broad masser.

# STAINED GLASS



ENGLISH STAINED GLASS

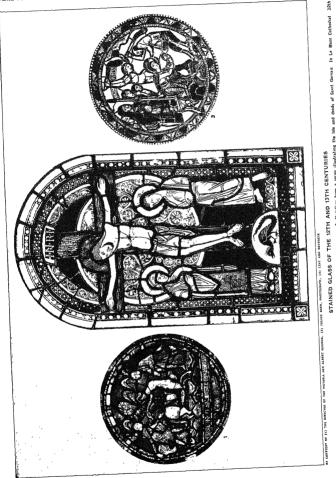
"St. Ann Teaching the Virgin" From the east window of All Saints church, York, dated about 1440. The colouring is imple though rich in qualify, a characteristic of English glass of this period St. Anne swarn a city clock and bonest and a blue gown. The Virgin's dress is white, ornamented with a pate yellow pattern, and the background of figures and canopy is blic covered with a disper. All other parts or white with some yellow statem.



BY COURTEST OF E. HOUVET

STAINED GLASS CATHEDRAL WINDOW

"La Belle Verrière," one of the stained glass windows of Chartres Cathedral, France. The figure of the "Virgin and Child," is strongly Romanesque in character. Work of the 12th century



3 Medallion from a series illustrating the life and deeds of Saint Gerrais cantury, French















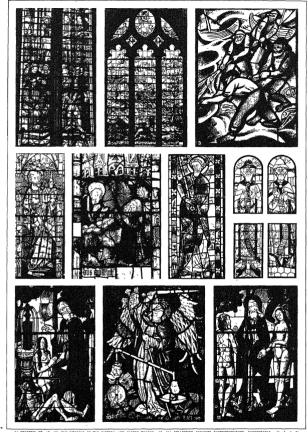
PHOTOGRAPHS, (1, 2, 3) BY GRACIOUS PERMISSION OF HIS MAJESTY KING GEORGE V, BY COURTESY OF (4 5) THE DIREC-TOR OF THE VICTORIA AND ALBERT MUSEUM

EXAMPLES OF 15TH AND 16TH CENTURY STAINED GLASS

- 2, 3 Panels depicting scenes of "The Last Supper" French (Rouen School); dated 1542
- "The Adoration of the Magi," by Guglielmo de Marcellat Italian About 1516, From Cor-tona Cathedral, Italy
- 5 "The Virgin and Child," 15th century, German
- "The Month of March," Roundel, from a series of the Labours of the Month:
  English, 13th century

  8 "Merchant in his Warehouse" An example of Flemith stained glass
  about 1350





E/ COUNTERY OF (6, 10) THE SPECTOR OF THE VICTORIA AND ALBERT MUSEUM, (3, 11) COLLECTION ARCHIVES PROTOGRAPHIQUES, PHOTOGRAPHIS, (1, 2, 4, 5) LYDREY PITCHER, (3, 7, 8) FUHL AND MAGNER

I "The Mocking of Christ," English, early 16th century. In King's College Chapel, Cambridge. 2. "Joenah and the Whale," by Abraham Van Linge in University College Chapel, oxford Dated 1655 3. "Fishing." Example of modern German stained plats, Seewald, executed by 6 Heinardorf 4. "35. Peter," English, middle 14th century. In Gloucetter Cathedral 5. "God Appearing unto Abram". English, middle 15th century in Great century in Great services of the College 
Malvern Priory 6 "St. Peter" French, second half of 13th century From Sées Cathedral, Normandy 7 and 8 "Prophets" German, 11th century in Augubury Cathedral 9 "The Oreation of Eva," in the Cathedral, Chalons-tur-Marne, French, middle 15th century 10 "St. Michael," German, 14th century 11 "The Institution of Matrimony" another stained glass window at Chalons-tur-Marne.

clesiastical buildings. The result was generally ludicious, and always inappropriate The crowning example of this misalliance of two in-consistent arts is to be found in the window designed by Sir Joshua Reynolds for New College chapel, Oxford, which was actually carried

out by a china painter.

The art of glass painting in England during the 17th and 18th centures does not offer sufficient material for any comparative criticism or positive judgment. We see nothing but scattered individuals, each expressing his own wayward fancy, displaying some ingenuity, supply-ing some passing need, but actueving nothing of significance Eighteenth and Nineteenth Centuries.—The Gothic revival

that came as an offspring of the Romantic movement of the late 18th and early 19th centuries was not without its effect on the art of stained glass. The styles and methods of the early Gothic period were reconstructed, but devoid c'all inner reason or inspiring sentiment thus reduced to sterile formulas was easily commercialized, and factories thus reduced to sterile formulas was easily commenculized, and factories for the manufacture of windows, any size, may subject and colours to tasks, sprang up all over Europe, but especial in machine the following the state of the colours of the and, indeed, eventually of Europe We cannot enter here into the general character of Morris's achievements, but the basic fact upon which all his ideals rested was an intense aesthetic appreciation of mediaeval art. As much, perhaps, can be said of the initiators of the Gothic revival, though we may suspect that as an aspect of romanticism Cottine revivat, trough we may suspect that as an aspect or formaticism their enthusiasm spraing from a sense of the temoleness, the strangeness, and the mysterious gloom of this earlier art rather than from any real understanding of its rational basis or religious significance. But Morris had a more logical appreciation of the Gothle, and his attitude Morris had a more logical appreciation of the Gothic, and his attitude was as free from instanctity, as it was devoid of any desire to instate. He realized that without the spirit, the form could not cast, and his real greatness and overwhelming importance in the listory of modern could be an experiment of the listory of modern cycles a style and invent a technique appropriate to the expressions of his age. Burne-Jones designed his first cattorious for staned glass as early as 1857, and the St. Fideswide window in Christ church, Messer Powell of the St. Fideswide window in Christ church, Messer St. Powell of the Whitefrans Glasshouse, but from 1650 insurance Jones worked exclusively for Morris Staned glass was included in the first chultion of the work of Morris, Marshall, Faulkner company in 1650. But the work of this period is weak in design and uncertain function of the leads in the design, and the enamels are either poor in technique. No attempt had been made to work out the proper junction of the lands in the design, and the enamels are either poor in quality or badly fired. But even so, there was a certain freshness of attitude and for statined glass increased, so more thought was given to these matters and the improvement was rapid. In Moiris's fully develoced style, as in the catabedral at Brimingham, there is little to complain of an the technique of his glass. Time has yet to show whether the materials will weather so well as the 15th-century mathe matter with weather so was at the intercept, the did not make his own glass, but obtained the best he could find in the market. In other technical matters Morris need not fear comparison with the could be the could find in the market. with any age. His selection and disposition of colours is adminished with any age. His selection and disposition of colours is adminished and he was not draifed of using new colours to achieve effects unknown to previous ages. In the use of leads to emphasize design he is masterly, and we must go back to the 13th century for an adequate comparison. The best examples of windows by Morris and Burne-Jones are to be found in Chief church, Oxford (the St. Cedina and St. Catherine windows of the Church, Church (the St. Cedina and St. Catherine windows of the Church, Church (the St. Cedina and St. Catherine windows of the Church, Church (the St. Cedina and St. Catherine windows of the Church, Church (1832), the well-known windows and own of the Church (1832), the well-known windows and (perhaps the most important in London) the windows at Holy Trinity. Some after With its repetited to be one of the finest examples of this continuation of the Church (1832), the confined in the main to Biblica subjects, Burne-Jones and Morris and confined in the main to Biblica subjects, Burne-Jones and Morris and with any age. His selection and disposition of colours is admirable, riage at Cana. In addition to all the work designed for churches, and confined in the main to Biblical subjects, Burne-Jones and Morris made a good deal of stained glass for domestic or secular purposes. In their choice of subjects for this profane glass, they perhaps unduly confined themselves to the romantic and literary predilections of their circle; themselves to the romantic and interary predilections of their circle; but here again we cannot criticize their stained glass without entering into a discussion of their whole point of view. It is perhaps sufficient to say that it lacked the immediacy and the reality which we are entitled to expect from any contemporary expression of ideals. The principles which William Morris established and followed give

The principles which William Morris established and followed give us an adequate criterion for the critism of modern stained glass. It is sail to contess how luttle those principles have been followed in the contest of the contest of the day. And it all directions patients and the significant artist of the day. And it all directions there is a relapse mion a service and lifetes mulation of mediaeval man-esting, due to a natural disregard for those self-scarticing ordinances which Morris observed. It seems that only the complete filling of every window in every old church will ever terminate this atrocous vandalism. There might be some satisfaction in the prospect if it were certain that that would put a stop to what is known in the trade as

"penod work", but these pastiches of the ait of other epochs find their way into practically every new church that is built, and the only hop, of any reform would seem to he in the final trumph of those principles of any reform would seem to he in the mail ritimph of those principles for which Wilham Morris stood. For these punciples are not altogether dead, they have merely migrated, and on the continent, especially in Germany, there is a school of glass painting which is not only modern in intention, but is inspired by all that is vital and significant in modern art

modern art Like the stained glass of William Moris, this modern continental stained glass is both religious and secular. The work of Jan Thoin-Prikker and of Karl Schmidt-Rottluff has given to the symbols and images of Christianity a new intensity and realism for which there is no parallel this side of the Renaissance, and the abstract designs in no parallel this side of the Renassance, and the abstact designs in which these glass painteis have experimented seem to open up infinite possibilities for this art of pure coloui and light. These attists work, under the direction of Gottfreid Henersderif for the Beitin firm of Puhl and Wagner. In France, interesting experimental works being done, for example, by MM Maumejean of Pars and Hendaye Stained glass, which dominates all other arts in this matter of colour, would seem to be peculiarly fitted for those experiments in abstract design and harmony which have been distinctive of a certain phase of modern at The difficulty in all contemporary glass-painting of a nonecclesiastical kind, is not so much to extend the possibilities of the art in the duection of design and actuality, but rather to find a function for the art itself. For that we must look, with whatever faith we can summon, to those manifestations of civic and commercial enterprise for which our gas is distinguished. At Hagen, in Germany, the railway attation has age is distinguished. At Hagen, in Germany, the railway attation has newspaper, Littisansignati, have windows with appropriate design by Henn Navarie executed in leaded glass by Geatan Jeanni But these are soluted instances of what seems to be the only chance of a manifestal resource of the art are greater than they have ever been. All that is lacking is the clearing, and the control of th those manifestations of civic and commercial enterprise for which our consciousness of the unique and unrivalled beauties of the art as it has existed in the past

conscounces of the unique and unrivaled beauties of the art as it has existed in the paid, Chemaritie, Interior Decorations, Modach, Heisenstein (Deep Ranting), Chemaritie, Interior Decorations, Modach, Heisenberg, Garley, Garley, Chemaritie, Chemaritie, Chemaritie, Chemaritie, Chemaritie, Chemaritie, Chemaritie, Chemaritie, Decoration, Decoration, Decoration, Chemaritie, Che

STAINES, an urban district in the Spelthorne parliamentary division of Middlesex, England, 17 mi, S.W. of London by road Pop. (1951) 39,983 Area 129 sq mi. A Roman village was situated at the Thames on the main road from London, and the crossing was one of the earliest bridged. The existing bridge, designed by George Rennie, was opened in 1832. Stames (Stanes). first recorded in 969, also appears in Domesday. The London Mark stone was placed there in 1285 at the western limit of the City of London's jurisdiction over the Thames. An annual fair was granted in 1228 The urban district also includes Ashford, Laleham and Stanwell Though chiefly residential, Staines manufactures linoleum among other things and engineering is carried on. STAINLESS STEEL. Stainless steel basically is an alloy

of chromium and iron containing more than 10% chromium. When chromium is added to iron in such quantities, it imparts throughout the entire body of the metal remarkable resistance to corrosion and heat. Other elements may be added to the ironchromium combination to obtain steels with special characteristics. The most important of these is nickel, which is used to produce 18-8 (that is, 18% chromium, 8% nickel, balance iron). Other useful additions are columbium, manganese, molybdenum, phosphorus, selenium, silicon, sulphur, titanium and zirconium, all of which result in modifications for special service or fabrication. As is true of many scientific discoveries no single nation STAIR 29

can claim full credit for the development of stainless steel Between 1903 and 1912 Harry Brealey of England, F M Becket of the United States and Benno Strauss and Edward Maurer of Germany shared in its initial development

Selected scrap which contains only those elements desired in the finished product usually make up the bulk of the furnace charge used for producing stainless steel. If alloy scrap is not available, clean open-hearth scrap may be used, but more alloy is required to meet specifications Pig iron containing 4% carbon. anthracite, or other carbonaceous material may be employed when a high-carbon melt is desired Lime, silica, crushed coke, aluminum, silicon, fluorspar and iron one are materials used for slag constituents and for controlling the composition of the metal bath Because of the high temperatures and precise chemical control requited, all stainless steel is produced in the electric furnace Oxidizing and reducing slags may be used successively in the same heat, depending on the composition of the charge and the analysis of the product. Sulphur is removed from the metal with a reducing slag containing more than 2% calcium carbide, and silicon, phosphorus, manganese, chromium and carbon, with an oxidizing slag However, carbon presents a problem in the presence of chromium, because of the chemical affinity chromium has for carbon. Carbon may be absorbed by the metal at the same time chromium is being oxidized and going into the slag. To oxidize carbon in a charge containing a high percentage of stainless steel scrap requires an excess of oxygen and extremely high temperatures (more than 3,200° F ) Oxygen supplied through a lance into the molten bath is used to a large extent to replace iron ore as a source of this element Considerable chromium is oxidized percentage of chromium oxide. Chromium oxide may be reduced and returned to the metal by the addition of lime and crushed formeilican

The stanless sieels may be grouped according to chemical composition and response to heat treatment as follows: (1) ferritus steels, nonhardenable steels containing 15% to 30% chromium and with low carbon contents (from 0.6% to 0.00%), (2) martenistic steels, hardenable (by quenching) steels containing 10% to 18% chromium with varying calibon contents (5.08% to 1.10%), and (3) austenitic steel containing 15% to 50% chromium and 6% to 25% incide, which is hardenable without quench-incident contents of 1.00% to 2.00% chromium and 6% to 2.00% incident which is hardenable without quench-incidents.

ng.

Ferritic Stainless Steels are better than the martensitic type
and as sood as the austentic type in resistance to cortosion. Howeven, because of their lower ductility they are not used to replace
the austentitic type. Ferritic steels are magnetic and can be hotand cold-worked but sually undergo excessive grain growth during prolonged exposure at elevated temperatures. They have
lower high-temperature strength than the other two types and
may develop brittleness after electricart, resistance or gas welding Machinability is good and can be improved by adding sulphur
or selenium. There is no tendency toward intergranular cortoson.

The production in the United States of ferritic stainless American Iron and Steel Institute (AISI) type 430, widely used for automotive and architectural trim, was approximately a third of the total ingot stainless production in the 1950s.

Martensitic Stainless Steels are magnetic; they can be coldworked without difficulty, especially when the carbon content is low; show satisfactory resistance upon exposure to weather, water and some chemicals; can be machined satisfactorily; have toughness; and are easily forged or otherwise hot-worked. The corrosion resistance is usually increased by hardening, which is accomplished by quenching. Welds made by the electric-are, resistance or gas methods contain some martensite after cooling in air A.I.S.I. type 40 is the most widely used of the martensitig grades. In sheet or strip form, this grade is used extensively in the oil industry for bubble trays, bubble caoss and liners.

Austenitic Stainless Steels are not magnetic unless severely cold-worked. They can be hot-worked, and cold-worked if proper allowance is made for their rapid work hardening. Except for surface hardening, their alloys cannot be hardened by heat treatment. They are extremely shock-resistant and difficult to machine unless

they contain sulphur or selenium. These steels can be welded with difficulty, and, if the welding operation is controlled properly, the resistance to cornoson is not impaired. These steels have the best high-temperature strength and resistance to scaling of the stanless steels. However, they are subject to intergranular corrosion at temperatures between 80°c and 1,60°°F, unless the stucture is stabilized to prevent the presence of carbides at or near grain boundains which are vulnerable to corrosion. Stabilization may be done by the addition of ittainum (4 to 6 times the carbon content) or columbium (8 to 10 times the carbon content), which combine with carbon and prevent the formation of chromium carbides. The corrosion resistance of the austentic stainless steels is usually better than that of the other two groups.

A I SI type 304, a companion grade to types 301 and 302 with somewhat lower carbon (0.08% maximum), is the most widely used of austentic grades. It is well suited to withstand severe forms of corroson encountered in the paper and chemical industries. The austentite grades most resistant to oxidation are types 309 and 310, which are high an incleal and chromium. These steps resist seasts scaling up to 3,100° F, and consequently are used for furnace parts and heat exchangers.

The heat treatment of stainless steels may be carried out with any conventional type of electric, gas-fired, oil-fired, salt-bath or induction furnace. Although all stainless steels are highly resistant to oxidation, they may be expected to scale slightly at high heat-treating temperatures. The scale formed on the stainless steels is tenacious and relatively imporvious and, consequently, is more difficult to remove than scale on ordinary carbon steel. Two basic methods are used mechanical, such as sandblasting and tumbling; and chemical, such as pickling in and solutions.

An important development in the stanless steel industry was the increased use of austentic stanless steels containing manganese instead of inckel as a major alloying element. These were substituted for A.I.S.I. type 907 (18% Cr, 5% Ni), because of the current shortage of nickel. Manganese, like nickel, has the property of producing an austenitic structure in steel, although it takes twice as much to do it. Steel containing 15% Cr minimum, 16 5% Mn, 0 10% carbon maximum, and 1% Ni as a substitute for type 307 stanless is being used

for type 30r stamless is being used
Billionary—Emeric T. Hum (ed), The Book of Stainlers Steels
(Cleveland, 1935); American Iron and Steel Institute, Annual Stattistical Report, pp 45, 716 (New York, 1937). Allegheny Ludding
Steel Corporation, Handbook on Stainlers Steel (Brackeninge, Pa,
Grackeninge, Pa, 1931); Russless Iron and Steel Corporation, Heat
Treatment of Stainlers Steels (Baltimore, 1944); American Society
of Metals, Metals Handbook, pp, 33-2-33, 149-50 (Cleveland, 1948),
J. H. G. Monypanny, Stainlers Iron and Steel, a vol., 3rd et (London,
291 (New York, 1935), J. M. Camp and C. B. Francs, Mahrin,
Sheping and Treating of Steel, United States Steel Corporation, ch. 35,
138 (New York, 1935), J. M. Camp and C. B. Francs, Mahrin,
Sheping and Treating of Steel, United States Steel Corporation, ch. 35,
138 (New York, 1935), J. M. Camp and C. B. Francs, Mahrin,
Sheping and Treating of Steel, United States Steel Corporation, ch. 35,
138 (New York, March 12, 1933), U.S. Dept of the Internomal Refining of Stamiles Steel, no. 24033, S. (N. B. M.)
STAIR, JAMES DALRYMPLE, 184 Viscourt (16191693), Scotilas haveyr and statesman, was born in May 16191693), Scotilas haveyr and statesman,

1695), Scottish lawyer and statesman, was born in May 1619, at Drummurchie in Ayrshire. After seven years as regent of the University of Glasgow he resigned, going to Edinburgh, where he was admitted to the bar on Feb. 17, 1648. In 1649 he was appointed secretary to the unsuccessful commission sent to The Hague to treat with Charles II by the parliament of Scotland, and was sent in the following year to Breda, where the failure of Montrose's expedition forced Charles to change his attitude and to return to Scotland as the covenanted king. Stair met him on his landing in Aberdeenshire He refused in 1654 to take the oath of allegiance to the Commonwealth. Three years later (1657), Stair was appointed a commissioner of justice in Scotland, on the recommendation of Monk. After the Restoration he was received with favour by Charles, knighted, and made a judge in the court of session. He refused to take the declaration that the National Covenant and the Solemn League and Covenant were unlawful oaths, and, forestalling deposition, he resigned. The king, however, summoned him to London and allowed him to take the declaration under an implied reservation. In 1669 a family calamity, the exact facts of which will probably never be ascertained, overtook him. His daughter Janet, who had been betrothed to Lord Rutherford, was married to Dunbar of Baldoon, and some tragic incident occurred on the wedding night, from the effects of which she never recovered.

In 1670 Stair served as one of the Scottish commissioners who went to London to treat of the Union In Jan 1671 he was appointed president of the court of session. In 1672, and again in 1673, he was returned to parliament for Wigtownshire When the Test Act was enforced Stair, dreading a fate similar to that of Argyll (q.v), went to London to seek a personal interview with the king, but the duke of York intercepted his access to the toyal ear, and when he returned to Scotland he found a new commission of judges issued, from which his name was omitted He retired to his wife's estate in Galloway, and occupied himself with preparing for the piess his great work, The Institutions of the Law of Scotland, which he published in the autumn of 1681. with a dedication to the king He repaired to Holland in Oct. 1684, and took up his residence, along with his wife and some of his younger children, at Leiden, where he published the Decisions of the Court of Session between 1666 and 1671 and a small treatise entitled Physiologia nova experimentalis

In his absence a prosecution for treason was raised against him and others of the existe by Sir G Mackenae, the lord advocate, but it was dropped, owing to the appointment of his son, the master of Stair, who had made his peace with James II, as lord advocate in place of Mackenae. Stair returned from Holand in the suite of William of Orange In 1680 he was again placed at the head of the court of session. He was attacked by an anonymous pamphleteer, perhaps Montgomery or Ferguson the Plotter, in a pamphlet entitled The Late Proceedings of the Parliament of Scalland Stated and Vinducated. He defended

himself by publishing an Apology.

Shortly aften its issue he was created Viscount Stair (1599). The massacre of the Macdonalds of Glenco (Feb 13, 1699), for which his son, the master of Stair, was largely responsible, naturally reflected on him On Nov 29, 1699 Stair died in Edmburgh Stair's great legal work, The Institutions of the Law of Scotland deduced from its Origandia, and collated with the Civil, Connon and Faulist Laws and with the Custows of Neighbouring Nations is important to the Control of the Control o

STAIR, a series of steps arranged one above the other, occasionally varied by platforms known as "landings". The total height of a starr is the "rise," the total horizontal distance between the top and bottom steps is the "run". A series of steps without a landing is called a "light." The horizontal surface of a step is called its tread, and the vertical front its riser. The projection of the tread beyond the face of the riser is termed a nosins.

Long use has demonstrated that certain proportions of riser and tread are safe and easy. For interior stairs twice the height of the riser, plus the length of the tread, should be 23, all dimensions being ninches A variant is that the sum of rise and tread should be between 17 and 17½ in; a third rule specifies that the product of rise and tread, in inches, should be not less than 70 nor more than 75. In general, English usage advocates a slightly lower rise for a given tread than American usage, while in Europe the rise is frequently greater. For exterior stairs, the general usage is to keep the rise place of 10 and the tread above 12.

It is uncertain what is the oldest stair in existence. On the sacred road up the mountain of Tai Shan, in Shantung, China, there are many great flights of ancient granite steps. In Egypt stairs in pylons exist which date from the second millennium BLC. Assyria has left massive stairs on the siggurats ( $q \circ v$ ), which date from the 9th and 8th centuries, B c; and the palace terrace at Persepolis has a double flight of steps, of great beauty, which shows the skill of the Persians in the 6th century B.C.

ruther west, stairs play an important part in the Cretan palistr Walter Scott took the plot of his Bride of Lammermoor from this incident, but he disclaimed any intention of making Sir William Ashton a portrait of Lord Stair.

aces, as in the palaces at Knossos and Phaistos (both c 1500 BC). In Helienic Greece the monumental stair was of less importance. due to the Greek love of informal and picturesque approaches Thus in Athens the propylaca of the Acropolis was probably entered by a winding path and the present great flight of stairs, dating from the Roman period, is not part of the original design. In the post Alexandrian period there developed a new love of monumental grandeur, largely Asiatic in origin, which produced such magnificent stairs as those of the altar of Zeus at Pergamon (180 BC) A similar monumental sense distinguished Roman stairs Those of the propylaea at Baalbek (time of Hadrian), over 100 ft wide, are typical, and again and again stails are made essential parts of great architectural conceptions, as in the temple of the Sun on the Quirmal hill at Rome, built by Aurelian (AD 273), some of the steps of which were taken, in 1348, to build the famous stairs of the Aracoeli on the Capitoline hill at Rome

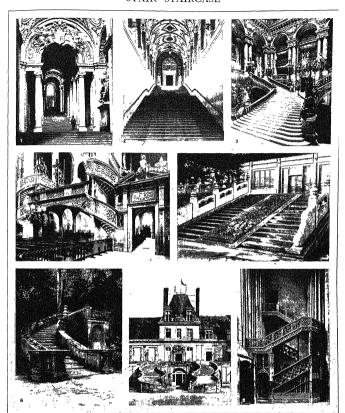
Although during the middle ages stairs were used more for utilitarian than aesthetic purposes, where they were necessary they received adequate treatment, usually more direct and informal and more picturesque than those of the Roman tradition. Thus at Le Puy en Vélay, in France, the 11th century cathedral, which was built on a hillitop, is approached by a magnificent stair that provides a superb foreground to the polychrome façade. The steps that mount up to and past the apse of the 14th century cathedral at Erfort, in Germany, show the direct and beautiful relationships between the building itself and the stairs which is characteristic

of the best Gothic usage

The Renaissance produced a recrudescence of the tradition of Roman formality in stair design Particularly magnificent are the stairs of the Baroque period, such as the so-called Spanish stairs at Rome in the Piazza di Spagna (1723-26), by F de Sanctis, those of the Campidoglio, at Rome (begun 1547), by Michelangelo and the infinitely varied terrace stairs of the Italian villas. The inspiration of these Italian Baroque stairs was felt throughout Europe and is largely the foundation of stair design in modern city and garden planning. Thus the enormous stairs of the gardens of Versailles (1667-88), by A Le Nôtre, owe much to the Italian precedent, and were themselves imitated widely all over Europe. Among modern stairs may be noted the extremely lavish stairs of the monument to Victor Emmanuel II, in Rome (begun 1885), by Giuseppe Sacconi, with the altar of the Patria, the broad flights leading up to the library of Columbia university, New York (1896), by McKim, Mead and White; Waterloo steps in London (1831-34), by Benjamin Wyatt and those of the Lincoln memorial at Washington, D.C. (1924), by Henry Bacon

In the Orient, the stairs leading down to the river at Benares. in India, of various dates, combine monumentality and picturesqueness; a sımılar skill is shown in the design of large numbers of temple and palace steps throughout the peninsula Further east the rums of Angkor use wide flights of steps with magnificent effect in connecting the various levels of the terraced group. The Chinese have always been superb stair designers and builders. and there is hardly a temple or large house or palace which does not owe some of its effect to its stairs, either monumental and formal, like those of the Forbidden City or the Temple of Heaven. both in Peking, or winding and informal, as in Chinese garden design Many of the temple stairs have, in the centre, an inclined plane running the entire height of the rise, richly carved with the symbolic dragon-the so-called spirit stairs by which the beneficent powers are supposed to enter In Japan the tradition is much more informal, but the hilly nature of the country makes stairs an important feature of almost every temple layout. (T. F H)

STAIRCASE, a term for stairs accompanied by walls The carriest staircases seem to have been built with walls on both sides, as in Egyptian pylons Contemporary models of houses, dating back to the Middle Kingdom, show a staircase leading up the side of a court to a roof terrace, with continuous wall below. The origin of such stairs may have been earlier structures in word, or even ladders cut out of logs. Egyptians may have used the self-supporting staircase in which each step is supported at from the three of the such content of the such co

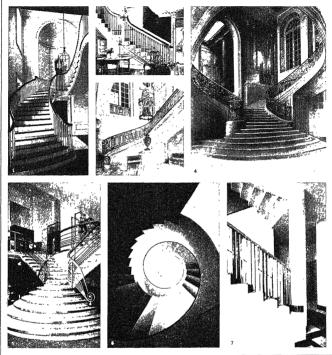


BY COUNTEST OF (2) THE GERMAN BALLROADS INFORMATION OFFICE, (5) THE CANADIAN PROFFIC STEAMSHIPS, (6) THE ARCHITECTURAL FORUM, PHOTOGRAPHS, (1) ANDERSON, (3) PROFIGURES PHOTO SERVICE, (4) GIRALDON, (7, 6) LET AND REUSCHI

## OLD WORLD STAIRCASES

2. The Scale Regis in the Vallian salese, deligned by Bornil used built-between 1625-65 Skillful and eleganted perspective by the promissive intertening of the column makes it one of the most impressive and impressive and impressive and impressive and impressive of all monomental actions. Zero Tenna descriptions are supported in the column of the

early Renalisance 5 The terrace stairs of the temple of Confucius at Paking have the cheracteristic Chinese marine balantrades and in the centre and far rame, leavity carred with foreign estages, to form a spurity way by which benefient spirite could enter. 6 then of the pictureaux and simple of the picture of the picture and famous as the piece where Napolene took leave of last prospe before going to Elias. 8. The staircase, of familyant dolthic, built in the transect of Rouse outside and the picture and the pi



BY COURTEY AN (1) ST. CLAIR & STUDIO, DOTTMOUTH BUILDINGS (1) W. F. MANGELL (ALLERY AND MELIDREN (5 & 7) DANIER

# RENAISSANCE AND MODERN STAIRCASES

- Staircase by John Russell Pope in the Sloane house in New York, a characteristic modern interpretation of late Georgian delicacy and detail
- 2 The starcese of the third quarter of the 18th century, in the Moffatt-Yard-Ladd house in Portsmouth, N H., characterized by the panels, bracketed ends and lavishly turned batusters, so typical of the developed American colonial
- 3. The famous stairs of the Petit Trianon at Versallies, though built by Gabriel in 1766 under Louis XV, show a simple delicacy and a use of straight lines characteristic of the style known as Louis XVI.
- 4. Much more typical of Louis XV work is the lavish and monumental
- stairs of the Hôtel de Ville at Nanoy, France, designed by E Here, with Iron work by Lamour
- 5 Modern freedom in design, the effort to combine many materials and to contrast straight and curved lines, characterize a stair designed by Patou in a Paris shop (La petite Jeannette)
- 6 The circular, concrete staircase in the Martel house in Paris, designed by R Mallet-Stevens, an austere simplification of the more extreme types of modernism
- In his Parls house, the same architect, Mallet-Stevens, combines concrete stairs with a railing of aluminium whose narrow aluminium supports, set at varying angles, catch varying reflections

Greece and Rome.—In classical Greece, interior staricases were common but unimportant, they were placed in out of the way corners, and often built of wood In Rome, a new treatments for staricases became necessary Many of the apartment houses indicated on the marble plan of Rome (c. AD 205), now in the Pakazo dei Conservatori at Rome, seem to have had stair towers built in the centic of a courtyard The Colosseum (ap.) at Rome (completed AD 80) has elaborate and practical entrance and exit stars, by which the crowds could be readily handled. These, in general, are supported by sloping vaults and roofed by others Similar stanicases were common in the heaties.

Byzantine and Romanesque—Merely inclined planes lead up within enormous buttersses at the ends of the nathex of S Sophia (537) at Constantinople, so giving access to the galleries. In S George at Solonca (late 5th century), a spiral starcase surrounds an open well In the early Romanesque there is a growing use of the spiral starcase. To this development the great thickness of Romanesque walls and butteresses was particulally congenial, as it allowed the staircases to be built in solid masonry. Not only was the open circular well used, but the solid newel, in which each step had cut upon it a cylindrical form to act as part of the newel This type of spiral staircase is still in use

Gothic .- The Gothic spiral staircase was cut with the utmost cleverness. We have the radial stone cut in two levels, so that the ascent was twice as fast as by the ordinary method, thus allowing the radius to be remarkably decreased Such circular staircases as lead up in the traceried turrets of the spire of Strasbourg cathedral in Alsace (1435) are miracles of daring design and delicate execution. The late Gothic period also produced a great number of beautiful interior staircases, like the "Stair of the Library" in Rouen cathedral (1477-79), which show that the possibilities of the staircase with straight runs were at last being realized. Of rich interior spiral staircases, the early 16th century staircase leading to the organ in S. Maclou, in Rouen, and the contemporary staircase to the jube (qv), or rood loft, of S Etienne du Mont in Paris (in which a certain amount of Renaissance feeling is piesent) are noteworthy In the larger houses the lack of communicating passages led to many staircases. Thus in the house of Jacques Coeur at Bourges (c 1450), there are eight separate spiral staircases, whose exterior treatment, in rich, tracened towers, furnishes a great deal of the picturesqueness and varied beauty of such a building.

Renaissance.--During the Renaissance, despite such tours de force as Vignola's spiral stair in the palace at Caprarola (c. 1550), the general practice was to have important staircases run up in a straight flight, sometimes varied by landings, and sometimes with changes in direction between walls often crowned with a slanting vault. The most perfect developments of this type were made chiefly during the Baroque period The magnificence of the huge interior flights of the Genoese palaces (e g., the "University," 1623, by Bianco) is famous The Scala Regia is particularly remarkable in the artificial exaggeration of its perspective, through the gradual diminution of width and height as the steps ascend. In France the spiral staircase added by Francis I. to the château at Bloss (1515-24) and the double circular staircase of the château of Chambord (begun 1519) are remarkable. The early Renaissance, however, produced its most remarkable results in the richly ornamented wooden staircases of Tudor and Jacobean houses. The usual arrangement was to have the staircase divided into comparatively short flights, at right angles to each other, around a central open well; the heavy newels at the corners were finished with urn-like finials at the top and carved drops at the bottom, the railing consisted of a large rail supported either by miniature arcades or square balusters, whose mouldings were often sloped to follow the stairs, and the whole was covered with intricate surface ornament of strap work. The staircase at Hatfield house (1611) is typical. The early Renaissance staircases of Spanish palaces are in most cases placed in one corner of the courtyard and run up between walls to a landing with a return flight that opens out onto the upper floor gallery. The walls, and sometimes even the treads and rises, are often cased in brilliant faience tiles. Even in staircases of more Italian type, with balusters, the rich-21-L

ness of wall surface remains, as in the staircase of the hospital of Spanish Renarsance monumental stair design is reached in the "Escalea Dorada" at Burgos cathedral (1519), by D. de Siloe, with its evolusie metal railure.

The developed classicism combined with the Baroque of the later 16th century to give a new trend to staircase design throughout Europe Thus in France a gorgeous series of staircases was produced, of which the "Escalier des Princes" of Versailles is typical. The reaction to the lightness and gasety of the Louis XV period (see Louis Stylks) led to the development of many gracious and inviting house staircases of the type known as self-supporting, full of sweeping curves and with railings frequently of metal In the Louis XVI period the new, popular classicism restrained the exuberance of the earlier staircases but retained their graciousness and lightness, of these, one of the loveliest is that of the Petit Trianon at Versailles (1766), by Gabriel, with a beautiful iron railing Meanwhile, the classic trend had expressed itself in England by the substitution of open string for closed string stairs, that is with the balusters coming down to the top of each tread, rather than being supported on a slanting member, or string, which received the ends of the treads This at once made for a more interesting treatment at the ends of the steps, and led, eventually, to the development of the bracketed step end, in which scrolls and leafage of great richness were carved under the end of each riser. Moreover, the fact that English stairs were largely of wood inspired the design of turned balusters and newels of great variety During the last half of the 18th century, a growing trend toward lightness and delicacy of design led to the substitution of plain. tapered shafts in place of elaborate balusters, and the use of stairs rising in continuing curves instead of straight flights and landings. The same development took place during the 18th century in the colonial work of North America Thus certain of the earliest houses, like the Capen house at Topsfield. Mass (1683). have closed strings and heavy newels of Jacobean type, while the open string staircase, whose steps have papelled and scrolled ends. and whose twisted balusters are as rich as any contemporary work in England. The curved staircase of the Valentine museum at Richmond, Va (1812), is typical of the later delicacy

Modern.—During the middle and the third quarter of the 19th century, starcase design reached its lowest ebb, not only in England and France, but throughout Europe, except in the case of those monumental and official buildings on the Continent the design never fell a victim to the current taste. Closed strings again became the fashion and balusters and newest of garganing proportions and bulbous and meaningless elaboration. Yet one of the most gorgeous and effective staircass in the world deter from this period, that of the Paris Opéra (1861-74), by Charles Garnier.

Two elements have vastly affected modern staircase design, steel and reinforced concrete The use of steel has led to simple plans of straight runs and railings delicate and straightforward in design, with newels usually accented, as in the Jacobean wooden stairs. Reinforced concrete, on the other hand, is a material so facible that the most during curves and fantastic aweeps become structurally sound. Probably the most brilliant example of this modern type of staircase design is in the new portion of the Galeries Lafavyette at Paris (1926), by F. Chanat, a conception of diazying lightness, with modernist iron raillines.

### STRUCTURAL DESIGN

Stone and Marble Staircases.—Modern stone and marble staircases are of two main types. In the first the actual exposed treads and rises form, themselves, the structural elements. In the other type the treads and rises are supported upon a separate structural base which may consist of a masonny vault, a steel framework or a reinforced concrete slab. In the first class, in which the steps themselves are structural, the staircase is usually built into a wall at one side. Each step rests for a small distance upon the step below and is built into the wall for a distance sufficient to make the weight of the wall above prevent it from turning. The undersides of the steps, where exposed, are frequently cut to form an inclined surface, following the slope of the stairs, and may be decorated with panelling or carved or other ornament. This type of stair can be used both for straight and curved runs, and is particularly applicable to monumental entrance halls, where the stair, in a triple run with two landings, or in a continuous, curved sweep, fills a recess opposite the door in such straincases the railing is usually of metal with the uprights securely dowelled into the ends of the steps Stairs somewhat similar can be built with the ends of the steps stairs somewhat similar can be built with the ends of the steps study into the walls on both sides, where a monumental jun rases believen two walls

Wooden Staircases.—These can be divided into two classes, closed and open string stairs. In both the essential support is given by rough timbers called carriages, which follow the slope of the stairs and are cut roughly to the shape of the under side of the steps. In the case of closed string starrcases both sides of the staircase are finished by a sloping, straight-sided plank, approximately an inch and a half thick, on the inner faces of which grooves are cut, whose upper and outer faces exactly fit the top and side of the tread and riser, the under and inner sides are, however, sloped, so that wedges may be driven in to force the tread and riser boards into position and hold them with perfect rigidity. Similar wedges are driven in between the rough carriages and the under sides of treads and risers To give additional strength, the treads and risers are, themselves, rebated together, so that a small, projecting strip of the tread fits into a groove in the bottom of the riser, and a similar strip on the top of the riser fits into a groove on the bottom of the tread. The projecting portion of the tread is moulded and an additional small cover mould placed below to cover the joint

In the open string staircase the strings at the end are cut to the shape of the steps, and the vertical cuts are usually mitred at 45°, so that the ends of the tiered stowers are the string at the ends of the treads dove-tailed sockets are left to receive the dove-tailed ends of the balusters; a moulding, exactly similar to the nosing, as then applied across the end of the step, and covers the bottom of the balusters. At times, bracketed and carved pieces are mitred at the ends of the risers and applied over the face of the string. It is this type of staircase that was the rule during the Georgian period in England and mit the developed American colonial and early republic work. Where an open string stair is built against a wall, it is usually shished at the wall end by a closed or housed string, similar to that described, forming a base-board for the wall.

The structural strength for a wooden staircase is usually furnished by framing a heavy member, called a header, at the top and bottom of every run, to these headers the rough carriages are spiked, and the newels, if they exist, firmly fastened. The newels themselves are designed to receive the finished stair strings, and also the finished string member that is occasionally used at the edges of a floor in the stair-well opening. In staircases similar to those of the early 19th century in England and America, in which newels did not exist, except at the bottom, and in which stair rails and balusters were of the most extreme attenuation, and the whole frequently laid out with complex curves, strength was achieved by the most exquisite workmanship, whereby the careful framing of every part made the finished staircase an independently rigid structure. Frequently the curved plan itself furnished a certain amount of lateral rigidity. In modern staircases of this type additional strength is obtained by inserting iron or steel bands into the hand-rail; occasional balusters may be of steel, well fastened to the string.

Stecl Staircases.—These have become almost universal in modern freproof buildings of all types, except where unusual monumental effect is desired, and the design of steel staircases is largely standardized. They consist of a steel string on each se, which takes the form of a plate or channel of sufficient rigidity to carry the weight.

Iron spiral staircases are usually formed of cast iron members, each of which forms a tread and riser, and has at its inner end, a collar arranged to slip over a vertical pipe or cylindrical bar forming the central newel. Such spiral staircases are rigid independ-

ently of any wall, and are frequently used in open spaces, such as those existing in power houses, gymnasums and the like Renforced concrete, sometimes finished as artificial stone, is used for stairs and permits of infinite variety of form

Moving Staircases .- In many places where continuous transit between floors is necessary, as in large shops, underground railway stations and the like, moving stairs, sometimes known as escalators, are much used These are of two types. In one, an endless belt carries on its surface links or blocks of sufficient roughness to act as treads. This endless band, at top and bottom, rotates around wheels or pulleys, motor-driven At the bend the band disappears through the floor into a slot armed with steel aims, so designed as to occur one in each groove between the raised portions of the treads Another continuous band on each side, geared to the same speed, serves as a hand-rail. The other type has a similar mechanical basis, but the belt, instead of carrying directly upon its upper surface blocks to form the treads, is designed to motivate actual continuous horizontal treads with risers radially shaped, so that at top and bottom the treads slide up on the risers into a continuous moving plane Moving handrails are furnished as in the other type, and in addition, a moving band angularly across the top and bottom, to remove automatically any dropped objects. Moving stairs of the second type are always entered and left at the side, those of the other type directly at top and bottom

Legal Regulation .- As stairs form one of the most necessary methods of exit from a building, their design has formed one of the most important portions of the building legislation of modern municipalities, especially in the case of public, commercial, industrial and educational buildings. Although there is much variation in the detailed requirements of different cities, the methods of regulation are almost the same and state. (1) where fireproof stairs are required, (2) the number of staircases, (3) size, (4) design. Thus, in addition to the universal requirements for structural solidity, the attempt is generally made to furnish at least two stair exits to any large, enclosed, upper floor area; and where fire risk and the danger of panic are unusually great, as in the case of theatres, to demand sufficient stairs to allow the building to be emptied in a very short time, without disorder. Widths of stairs are frequently determined in accordance with the number of people using them In New York, for instance, each staircase must be designed to contain all the people of the floor area it serves, on the basis of one person to each 21 in of width and each one and one half treads. Design is controlled by specifying the relationships of tread and riser, the distance apart and size of landings, whether or not curved stairs are allowed, etc , and often, because of the smoke danger, requiring exit stairs to be enclosed in a fireproof tower, with fireproof, self-closing doors at all entrances BERLIOGARTEW —A. Swan, The British Architect or the Bulder's Treasury of Statrases, Viollet-le-Duc, Dictionname Raisomé de Flarchitecture (1854-76); Letaroully, Edifices de Rome Moderne; F. E. Kadder, Bulding Construction and Superintendence (1911), C. A Martin, Détails of Bulding Construction (1905); Byne and

STALACTITES are pendent masses formed where water containing mineral solutions drops very slowly from an elevation. (Gr. σταλακτός, from σταλάσσειν, to dup ) They are seen, for example, beneath bridges, arches and old buildings where water percolating through the joints of the masonry has dissolved very small quantities of the lime present in the cement and mortar between the stones. On exposure to the air part of the water evaporates and the solution of calcium carbonate becomes supersaturated; a deposit of this substance ensues and as the drop continues to fall from the same spot a small column of white calcite very slowly grows downwards in a vertical direction from the roof In the same way stalactites of ice (icicles) are produced in frosty weather as the water dropping from eaves of buildings, elevations, branches of trees, etc., very gradually, freezes Other minerals often occur in stalactitic growths; thus we find in mines and in the cavities of mineral vems stalactites of limonite, opal, chalcedony and gibbsite. These are never of great size,

Stepley, Spanish Architecture of the 16th Century (1917), Spanish Interiors and Purniture (1921); P. G. Knoblauch, Good Practice of Construction (1923-6)

usually not more than 2 or 3in in length, and probably the method of origin is exactly the same as that of the larger and more common stalactites of ice and calcite.

The conditions essential to the perfect development of stalatics appear to be (1) a very low rickle of water from a fissure, (\*) segular evaporation, (a) absence of disturbance, such as currents of air Hence, ice stalacties form most readily on calm cold nights, and stalactites of ice or calcite are seen in greatest perfection in the interior of caves.

In limestone caves stalactites form in abundance as glimmering white columns covered with a thin film of water The great caves, such as those of Postumia (in Italy), Incolain (Australia), the Mammoth Cave (Kentucky), the Causses district in France, and the grottees of Belgium, are divided into chambers which are richly festooned with stalactites, and fancful mames are given to various groups according to their similarity to different objects, natural or artificial Ice caves of considerable size occur in the Airctic and Antartic regions, and are draped with fice stalactites often wonderfully like those of limestone caves

Where the water drops upon the floor of one of these caves evaporation still goes on and if the air be perfectly still the drop will always land on the same place and a pillar of deposit, called a stalagmite, will rise vertically, till in course of time it meets and joins with the stalactite above. As the stalactites thicken, they assume tapering forms with irregular surfaces. Large stalactites may be 3 or 4ft thick, but in that case they are usually due to coalescence of adjacent ones. Single stalactites 2ft in diameter are not rare. From data obtained by measurement of the rate of growth at the present day it has been estimated that as much as 200,000 years may have elapsed since certain thick stalactites began to grow Caves are of great antiquity but there is, of course, no certainty that the conditions have remained uniform. Sir Archibald Geikie records that stalactites 14in, in diameter had formed beneath a bridge in Edinburgh which was 100 years old, in caves, however, the rate of formation is rarely so great as this Inscriptions on stalactites in the Adelsberg cave after 30 years had been covered with a scarcely perceptible film of new deposit. In one of the Moravian caves a stalactite, about as thick as a goose quill, was broken across in 1880, and in 1891 it had grown 3 or 4cm, from careful observations it has been calculated that one of these stalactites, 7ft. long, may have been formed in 4,000 years The stalagmitic crust on the floor of caves is usually mixed with blocks which have fallen from the roof, sand, mud and gravel carried in by floods, and the bones of animals and men which have inhabited the cave if it had an accessible entrance.

Stalactites also occur in the internor of the lava caves found in Hawain, Samoe, etc Often the upper surface or a lava flow has cooled to form a crust, while the interior is still perfectly fluid, and it sometimes happens that the lupid bask has made its escape, leaving great cavities below the hollow roof of the lava. The interior of these caves is covered with a black shining film of glassy hasalt, and black stalactites of lava hang downwards. Their surface is sometimes changed to brown or red by the action of the acd vapours which filled the cave after the lava retired. These stalactities are tubular, with blumity rounded ends, and probably their mode of growth is somewhat analogous to that of fociets.

STALACTITE WORK, in architecture, one of the most general characteristic of all of the Mohammedna styles, consisting of a series of little niches, bracketed out one above the other, or of projecting prismatic forms in rows and tiers, connected at their upper ends by miniature arches. Its infinite varieties may be classified into three groups, the first consisting of those basically niche-shaped, in which the concave curve is the most important feature; he second group includes those in which the vertical edges between the niches are the most important of the control of the second group includes those in which the vertical edges between the niches are the most important of the control of the second group control of the control of the property of the second group consists of elaborately intersecting, miniature arches. The first two groups occur commonly in Syrian, Moorish and Turkish work and in their simpler forms, in Perisi; the last group is typically Persian and is found also in Mogul work in India.

Stalactites are of comparatively late development in Muslim art, the earliest buildings in Syna, Egypt and north Africa showing no traces of them. They seem to appear suddenly all over the Mushim world toward the beginning of the 12th century. Thus simple forms are found in the mosque at Ani in Armenia, built between 1072-1110, and they are common in Algiers and Sicily during the course of the century, as in the gate at Chella (1118-84), and in the building known as La Ziza at Palermo (1154) In Egypt the stalactite appears in panels flanking the main entrance of the El Akmar mosque at Cairo (1125-50). They reached their highest development in the 14th and 15th centuries, becoming the normal decoration for the heads of door niches and the bracketing under cornices and minaret galleries The richest examples of the prismatic type are to be found in Moorish work in Spain, especially in the intricate wood and plaster ornament of such palaces as the 14th and 15th century Alhambra in Gianada and the 14th century Alcazar at Seville In Turkey, a peculiar type of faceted crystal shape is found and the form became the most common capital decoration.

STALIN, JOSEPH VISSARIONOVICH (Dzzucasar-VILI) (1879–1933), leader of the Communit party of the Soviet Union, prime minister, generalissismo and dictator of the U S S R, was born on Dec 21, 1879, in the town of Gori, Georgia, Transcaucasia His father Vissarion Dzhugashvil, a poor shoemaker, died when Stalin was 11 years old His mother Ekaterina, the daughter of a serf, was an illustrate and deeply religious washerwoman After the death in infancy of three children, Stalin was her only son She brought him up with much tendemess and devotion and chose for him an ecclesiastical career in the Georgian Orthodox Church

The Young Revolutionary.—Georgian folklore, native tribal traditions, fresh memories of serfdom and Georgian patriotic (anti-Russan) sentiment were the strongest influences in Stalin's childhood He attended the parish school at Gori and, in the autumn of 1804, he matriculated at the theological seminary of Thiis (Tbilis) He was a very able pupil, a voracious reader and an ambitious debater. In 1896, while he was still at the seminary, he jonned the ranks of Messame Dassy (the Third Group), a Georgian patriotic and socialist organization; and he came under the influence of Marxism, which was rapidly spreading among the Russian and Georgian intelligential in 1896, when he was about to graduate, he was expelled from the seminary because of his "disloyal" vesses.

He plunged into revolutionary propaganda and agitation. At the turn of the century the revolutionary movement in Russia shed the ideas of agrarian socialism preached by the Narodniks and adopted the Marxist social-democratic program, advocated by G. V. Plekhanov and V I. Lenin in Iskra The young Stalin was a supporter of Iskra. In 1901 he was elected member of the clandestine Social Democratic committee of Tiflis Police persecution forced him to "go underground" Arrested in April 1902, he remained in prison until the end of 1903. But while in prison he was elected member of the Social Democratic committee guiding the movement in the whole of the Caucasus Deported to Siberia, he escaped from there and returned to Tiflis early in 1904, shortly after the Social Democratic party had split into bolsheviks and mensheviks. He joined the bolsheviks, who wielded little influence in Georgia. At this early stage he was already under the overwhelming influence of Lenin's writings, and in local clandestine sheets and periodicals he translated Lemn's ideas from the Russian into the Georgian.

In the revolution of 1905 Stalin played no conspicuous part, but was active in the background as an organizer of bolshevitk fighting squads and partitian groups. He had a hand in organning raids on treasury transports, the so-called "exes" (exprepriations) raids and using them to finance the party's revolutionary activity. Stalin first met Lenin at a party conference at Tampere (Tammersfors), Fin, in 1905. In 1906 and 1907 he participated in party congresses held in Stockholm and London; and in opposition to Lenin he advocated a policy of agrarian revolution identical with that later adopted by the bolshevits in 1917. After the defeat of the 1905 revolution he

STALIN 302

distinguished himself as the bolshevik leader of Baku Many times arrested and deported, he succeeded each time in escaping from the places of exile

In 1912 the bolsheviks finally broke with the mensheviks and constituted themselves into a separate party Lenin then co-opted Stahn as member of the new central committee Stahn (he began to use this pseudonym, the Man of Steel, early in 1913) was the first editor of Pranda, which began to appear on May 5, 1012 At the end of that year he attended important holshevik conferences in Cracow, Pol, and then went to Vienna, Aus, to write Marxism and the National Problem This important study was a theoretical argument in favour of the bolshevik program of "selfdetermination" of oppressed nations The work established his reputation as a foremost expert in this field, but he was looked upon as a man of action and an organizer, not a theoretician On his return to St. Petersburg he was again arrested, and deported to the Turukhan province in the polar circle He iemained in exile un-til the outbreak of the February (March, western calendar) revolution of 1917

Stalin's Role in 1917 .- Stalin's role in the events of 1917 was not prominent. This was the heyday of the brilliant revolutionary orators and agitators, and Stalin was not one of them. He was overshadowed not only by L D Trotsky, who was much more than an orator and agitator, but by G. E. Zinoviev, A. V Lunacharsky, Alexandia Kollontai and other less important bolshevik leaders After his return from Siberia in March, he became editor of Pravda and adopted a vaguely conciliatory attitude toward the provisional government of Prince Lvoy. Soon afterward the bolsheviks, prompted by Lenin, embarked upon a revolutionary course of action; but Stalin remained one of their chief organizers and Pravda's coeditor At the height of the antibolshevik campaign in July he organized Lenin's escape from Petrograd, and in the absence of Lenin, Trotsky, L B Kamenev and Zinoviev, he guided the 6th party congress immediately after the "July days." During the famous controversy which developed in September and October between Lenin, advocating an armed rising, and Zinoviev and Kameney, opposed to insurrectionary tactics. Stalin was among Lenin's adherents, although in Pravda he attempted to bridge the gulf between the two factions
Shevik insurrectionist "centre" which was to join the Military Revolutionary committee headed by Trotsky; but he played no part at all in the insurrection itself.

The People's Commissar .- After the bolshevik victory he was appointed commissar of nationalities, and he held this post for nearly five years. Under Lenin's guidance he set out to put into effect the party's program of "self-determination" for oppressed nationalities One of his first official acts was to proclaim on behalf of the new Russian government the independence of Finland. He participated closely in the working out of the first Soviet constitutions of 1918 and 1923. In 1919 he was, in addition, appointed commissar of the workers' and peasants' inspectorate, an important department whose function it was to supervise alt other branches of the Soviet administration.

His voice carried much weight in the inner bolshevik councils during the civil war (1917-21), although he continued to be overshadowed by Trotsky, the founder and inspirer of the Red army. As member of the council of defense, political commissar and inspector of fronts, Stalin was in charge of the defense of Tsaritsyn (Stalingrad) in the summer and autumn of 1918; he organized the defense of Petrograd against Gen. N. N. Yudenich's offensive m May 1919, and the battle of Orel in October of the same year, when the Red army halted Gen. A. I. Denikin's advance on Moscow and passed to the counteroffensive. He served as political commissar with S. M. Budenny's cavalry corps during the advance on Lwow (Lemberg) in 1920; and he was in charge of the preparations for the final campaign against Gen. P. N. Wrangel's army and of the dramatic battle of the Perekop isthmus, the last battle of the civil was. Some of these episodes, especially his role in the defense of Tsaritsyn and in the march to Poland, were the subjects of much controversy. During the civil war an intense rivalry developed between him and Trotsky, the commissar of war. Not without ground Trotsky charged Stalin with surreptitiously supporting the left-wing Communists who were opposed to the employment of old army officers in the Red army and to the army's centralized structure and discipline established by Trotsky Trotsky's influence remained paramount, but even in 1919 Stalin wielded enough power to bring about the dismissal of J Vatsetis. Trotsky's protégé, from the post of commander in chief and his replacement by S Kameney. After the civil war, in Feb 1021 Stalin initiated the bolshevik invasion of Georgia without the knowledge of Trotsky and the commander in chief

In April 1922, after the 11th party congress, the last congress attended by Lenin, Stalin was appointed secretary general of the party and relinquished his posts in the council of people's commissars This was a turning point in his career as secretary general he soon came to control the whole machinery of the party

and through it the government

The Succession to Lenin.-Lenin's illness in 1023 and his death (Jan 1924), coincided with a crisis of the revolutionary regime. The bolsheviks had from the beginning denied political freedom to the old ruling classes and their parties who opposed arms in hand the "proletarian dictatorship" But the bolsheviks had also pledged themselves to respect and secure "Soviet democracy." that is, freedom of political expression for the working classes and their parties. The proletarian dictatorship had been conceived as a system of representative government, but instead of a parliament, the councils of workers' and peasants' deputies were to form the representative organs. Toward the end of the Lenin era, however. the regime had already developed into a single-party system All nonbolshevik parties had been banned, and only within bolshevik ranks was some freedom of expression preserved. Inevitably the question arose whether the bolsheviks themselves could enjoy the freedom they denied to others The other critical development concerned the party's international orientation. The hope for an imminent spread of revolution abroad, which had inspired the bolsheviks, was decisively undermined in 1023 after the defeat of communism in Germany Bolshevik Russia was at last recognized by most bourgeois governments, but as a Communist state it stood alone. Bolshevism was withdrawing into its national shell and was ill at ease with the revolutionary internationalism of the Lenin era All these issues were brought to a head in the struggle over the succession to Lenin

In 1923 Stalin, Zinoviev and Kamenev formed a triumvirate with the purpose of debarring from power Trotsky, who was generally regarded as Lenin's successor In his last will Lenin advised his followers to "remove Stalin" from the general secretariat of the party on the ground that Stalin was rude and inclined to abuse power. But Stalin, supported by the other triumvirs, retained his office In a constant struggle against his opponents he abolished whatever

power. on the state approaches by the concentrations, relating any other powers and the party into a "monothic" body. In the autumn of 1944 he expounded the theory of "foculation in one country," proclaiming the eight marked a departure from Leiniust internationalism, although Statin and the state of the proclaiming of the state of the proclaiming the self-marked a departure from Leiniust internationalism, although Statin and the state of the present in the present proclaiming the proclaiming the proclaiming the proclaiming the proclaiming the proclaiming the present of the present proclaiming the proclaiming the present in the party's right-wing led by N. I. Budharm, A. I. Rykov and M. P. Tomsky. Zimovev and Kamenev, on the other hand, made common cause with Tokel's alphy with the present of the present present the kulast (well-to-de farmers), and demanded the restoration of "inner party democracy" At this stage Stain, androus to keep in line with the present of the present present the kulast with undertake a frive against the kulask and treated the demanded or rapid industrialization as unreal. But in 1928-20-9, after he had defor rapid industrialization as unreal But in 1928–29, after he had defeated and expelled from the party Trotsky, Zinoviev, Kamenev and their followers, Stalin turned against Bukharin, Rykov and Tomsky He then effected a most drastic change of policy and began to industrialize the U.S S.R. and to collectivize agriculture with a speed and traine in 0.5 s.k. and to conceiving agriculture with a speed and ruthlessness which horrified even the original advocates of these policies In 1929 he expelled Trotsky from the U.S.S.R. and forced all opposition leaders, right and left, to surrender and "recant". He had become undisputed master of the U.S.S.R.

undusputed master of the U.S.A. 
Industrialization and Collectivization.—"We are 50 or 100 
years behind the advanced countries. We must make good this lag 
in 10 years. Either we do it or they crush us." Thus Stalin explained the purpose of industrialization to a conference of industrial managers on Feb. 4, 1931 In the course of the decade the USSR, was indeed transformed from one of the most backward states into a great in-

dustrial power, this was one of the factors which was to assure Soviet victory in World War II Stalin emphatically insisted on the need to develop primarily the heavy industries Industrialization was condevelop primarily the neavy industries industrialization was con-sequently accompanied by an extreme scarcity of consumer goods and by widespread popular discontent. Stalin violently suppressed the discontent. With utmost determination be enforced a policy of in-centive rewards to skilled workers, technicians and administrators. which provoked much indignation among party members brought up in an egalitarian spirit They denounced Stalin as the leader of new

privileged social groups Industrialization on the gigantic scale envisaged in the successive five-year plans encountered many other difficulties which would have haffled and defeated a government less ruthless than Staln's In the 1930s alone about 25,000,000 muzhiks were forcibly shifted from rural areas to the industrial centres and transformed into factory workers by means of intensive training and with the help of an extremely harsh industrial discipline Throughout the Stalin era the USSR's inban population grew by about 45,000,000. In order to free labour for industry and to secure food for the swelling urban population, Stalin dustry and to secule food of the swelling urotan population, Stain collectivized farming. In 1929 there were about 25,000,000 primitive rural smallholdings in the USSR. In 1952 there were 100,000 large and highly mechanized collective farms. The peasantry at first bittelly resisted collectivization. Stallin broke its resistance and ordered the resisted collectivization Stain broke its resistance and ordered the deportation of many "kulaks" into the notorious labour camps Despite mittel failures and famines, the new system of farming achieved a high

mind faitures and famines, the new system of farming achieved a high degree of consolidation in later users for of the noticinal draw, shortly degree of the consolidation in later users of the modificated draw, shortly after be had introduced the quasi-sheral constitution of 1916, Stalm staged the great purper trails in which most of the old boshevies and some military leaders were charged with treason, terrorism and espotentially designed the control of the control character

character Foreign Policy Prior to 1941.—The national crasis which Stalin feated was approaching with World War II. Since Hitler's use to power Stalin grappied with the dilemma between an ant-Hitler condition, but the west and sugreement with Hitler. At first his diplomacy ammed at building up the anti-Hitler coalition, but finding the west reluctant to communities if to an allanace with the USS R, Stalin instel at his radiness to come to terms with Hitler in a speech at the 20th at his readiness to come to terms with Filter in a speech at the 18th party congress in March 1939. In August he struck the bargain with Hitler under which the USSR and Germany divided their spheres of influence in eastern Europe and the USSR avoided immediate

attitude of the Communist International. After a long sense of purges and expulsions Stalin succeeded in transforming the International in a "monolithic" organization, identifying the international into and expulsions Stains succeeded in transforming the Intensational into a "monolathic" organization, identifying the intensit of world Common and Common as the ally. In 1913-29 the Community parties organized the "popular alliles against Hitler. In 1913 pile plet Intensity of the Ribberton-Mojotov pact. German attack on the US S.R., stated on General Issuino—The common attack on the US S.R., stated on Common and Common attack on the US S.R., stated on o

Generalissino.—The German attack on the USSR, statted on June 2; 1945, exquirt Stahu nuaware, as he himself later pubbley admitted In preparation for critical times he had assumed the premieration of May 6; but he still inspet do be also to postpose the man attack he formed the state defense committee consisting of him-self, V M Modelov, G M Malenkov, L P Beria and K. E Voroshlov On July 3, 1944, he made the famous call on the Sowet people to "worth the earth" occupied by the invader "In occupied regions conditions must be made unbearable for the enemy and all his ac-complices. They must be hounded and annihilated a cevery step, and

complices. They must be nounced seria simulations as a very every must their neutron for all their measures frustrated. Throughout World War II Stalin was personally responsible for the major military and diplomatic decisions of his government, although he left considerable freedom of mustive to his generals. After third principle of confusion, his strategy, following the traditional Russianal Properties of the properties sian pattern of 1812, was to withdraw, to conserve strength, to gather new reserves and to force the attacker to spend his impetus and extend his lines—only after that could the USSR pass to the offensive. He his lines—only after that could the USSR, pass to the offensive. He daplayed extraordinary will power tenactivy and coolbeadedness. He stayed on in the Kremlin when Hilder's armies stood at the gates of Moscow and the Sovet government was evacuated to Kubbyshev. From the Kremlin he organized a hasty yet effective evacuation from the threatment areas of industrial plants and of many millions of industrial workers. The shifting of industry from west to east enabled the USSR, to recover from the first blows and to badid up a new and enormous armed power.

and enormous armed power.

Skalin's political conduct of the war was characterized by strong emphasis on Russian patriotism, nationalism and traditionalism. Evokaming the memorase of 1823, be described the struggle as the Great Fatherland War, and he extolled the national heroes of Mother Russia and the millitary traditions of Peter the Great, Suvorov and Kutuzov.

He rehabilitated the Orthodox Church and disbanded the Communist International These moves, dictated primarily by considerations of domestic policy, were calculated to meet the needs of his foreign policy as well. He was anxious to preserve the alliance with the western powers, and his conduct of the war in a nationalist lather than in a revolutionary spirit helped to keep the grand alliance together, despite

inner contradictions and tensions nner contiductions and tensions
Some of the tensions were due to the fact that the western Allies
repeatedly postponed the opening of the "second front" in western
Europe This was the main point in Stain's controverses, with Winston
Churchill in 1942-33. But as the Sovlet army bioké Germany's military power in the "ten offensives" which followed the battle of Staingrad in 1943, this issue lost importance. The course of the war revealed a profound shift in the international balance of power, a shift due gand 1545, this was the superintendent before or the was the control of the property of the pr

writers, musicians, linguists, philosophers and others were made to accept his judgment as final Underlying the bizarre cult were Stalin's accept his judgment as final Underlying the bizarre cuit were Stalin's middibatable achievements. He was the originator of planned economy, he found Russa working with wooden plaws and left it equipped with was marred by the despotsma nod cruelly of his dictationship, and the partrarchal character of his rule, suited perhaps to the mentality of all militarets and backward people, became an anachronism in the industrialized and moderner Russa of his own making.

Stalin's personal role in the conduct of Sowich foreign policy from

Stalins's personal role in the conduct of Struct foreign poley from 1945 to 1943 remained somewhat obscure Communists and anti-Communists alike had seen in him the architect of the revolutions in estern Europe and Chuna In the light of even the senalty documentary information available, this view officers to be illfounded. From the start Europe and the property of the community strategy and tactics in Chuna. On the other hand, he undoubtedly mapped some of the Community revolutions are seatern Europe, and and the community revolution are seatern Europe, and and these which he had obstructed, to adopt the Stalin cult. Dump has sty expra a struggle apparently developed in his entourage between the dis-hards of Stalinsan and those who stood for domestic reform, and also between adherents of a "Gough" foreign policy and advocates and to shape Soviet policy as the resultant of the conflicting trends

trends

He died from cerebral hasmorrhage in the Kremlin on March 5, 1953, at the age of 73—one of the most complex, powerful and controversal fagures in wording to the most complex, powerful and controversal fagures in wording to the first control of the contr

both banks of the lower Volga. Area 52,278 sq mi. Pop. (1939) 2,289,049 (rural 1,396,292; urban 892,757). It is a low-lying area. and the banks of the Volga for some distance on either side of the river are below sea level. The soils on the left bank of the Volga river are salt steppe; on the right, as far as the Don river, they are light brown and gray steppe, with salt efflorescences, while west of the Don is a fertile black-earth re-

The climate is continental and the rainfall scanty and variable from year to year. The region lies in an area subject to terrible recurrent famines due to failure of rainfall, and rapid desiccation has been in progress for some time. In years of sufficient rainfall, the harvest is fairly good. The chief crops are summer wheat and winter rye; millet, sunflower seed, barley, oats and potatoes are grown in less quantity, and vineyards are profitable in the south. Maize cultivation is steadily increasing, Irrigation is the only hope for the district. Experimental stations are working at Stalingrad and at Tingutin.

The most favourable region is the alluvial strip near the Volga and Akhtuba rivers, which is particularly wide near the town of Stalingrad Here the temperature remains above freezing point for nine months in the year and the combination of alluvial soil, warmth and moisture makes grain, fruit and vegetable growing very profitable Poplar trees attain a remarkable growth in ten years, and fruit trees bear for five years in succession. The nearness of the oil wells facilitates the use of internal combustion motors for irrigation purposes, and cheap and convenient routes for export are available. The drawback is the frequent change in direction of the main watercourses and their connecting channels, which may convert a fertile garden into a waste of river mud, or even wash it entirely away Dikes are being built to lessen this danger Sheep, cattle, pigs and horses are bied, and in the years after World War I made rapid progress toward restoration to prewar level. The 1921 famine, particularly disastrous in this region, following on the civil war centring round the town of Stalingrad, had reduced their numbers catastrophically. There is also some camel breeding in the district. Stalingrad is becoming a centre for timber but apart from Stalingrad (qv), there are no ind centre in timele, use part 1 oris Salangian (original properties of the part 1 oris Salangian (original properties of the part 1 oris Salangian (original properties original properties original protection and protection original protection origin barked on a scheme to construct a canal linking the two rivers. This was successfully carried out

was successfully called out in the 5th century by the Finne-Turkle Bulgars, who were in the 15th century driven northward by the Khazars, a closely selated tribe. Later the region formed a part of the empire of the Tatar Golden Horde, one section of which was consent and the selection of the control of the selection 
STALINGRAD (formerly Tsaritsyn), a town of the Russian SF SR, the administrative centre of the region. Its position at the point where the Volga most nearly approaches the Don gave it great importance as a transshipment centre, and after the construction of the railway systems of Moscow and Leningrad, its growth was rapid. The town manufactures metal goods and machinery, has an anpithar-enfining factory, a osawnills, chemical factories, breweries, a confectionery industry and mineral oil works. It is a miportant centre of tractor construction. Pop. (1939) 445,476.

A fort was erected there in 1589, after the fall of Astrakhan, or prevent the randing of settlers by Kalmucks, Kirghiz and Circassans, often joined by Cossacks and runaway serfs. The town took part in the rising in favour of the false Demetrius, and was captured by Stenka Razin in 1670. In 1773-75 it took part in the rebellion of Pugachev. After the revolution of 1597, Stalin held the town against the counterrevolutionary White army, and it was renamed in his honour.

it was renamed in his honour.

Skallagrad was the scene of violent fighting during World War II.

The Germans attacked the city in Aug 7542 and in the next months in the control of the city of the c

STALINO, a town in the Ukrainian S.S.R. Pop. (1930) 463-395. In 1870 a British subject named Hughes received a concession from the Russian government to manufacture iron rails. His company started operations on the site of the present Stalino, formerly known as Hughesovka (Yuzovka). British, French and Belgian capital was freely invested in the development of the industry from 1880 up to 1914. The close conjunction of the

Donetz coal field to non and manganese deposits made the industry very profitable. Following the 1917 revolution the industry was depressed, but from 1924 onward progress was rapid and the population of Stalino doubled between 1923-26.

STALL, literally a place where one may stand, and so applied to a separate division in a stable, shed, etc, in which a single horse, cow or other domestic animal may be kept, to a separate booth, bench or table in a market or other building, or in the street, on which goods are exposed for sale, and in England to the higher-priced seats on the ground floor of a theatre In cathedrals, monastic churches and the larger parish churches the stalls are fixed seats enclosed at the back and separated at the sides by high projecting arms, and placed in one or more rows on the north and south sides of the choir or chancel in a cathedral the canons and prebendaries have each a stall assigned to them. In the chapels of the various knightly orders the stalls are assigned to the members of the order, thus, in St. George's Chapel, Windsor, are the stalls of the Knights of the Gaiter, in Henry VII's chapel in Westminster abbey are those of the Knights of the Bath, adoined with the stall plates emblazoned with the arms of the knight occupying the stall, above which is suspended his banner Architecturally considered, the stalls of a cathedral or church are a marked feature of the interior adornment. They are richly carved, and are frequently surmounted by canopies of tabernacle work. The seats generally can be folded back so as to allow the occupant to stand upright or kneel; beneath the seat, especially in monastic churches, is fixed a small bracket, a miserere (see MISERICORD), which affords a slight rest for the person while standing Among specimens of carved stalls may be mentioned the Early Decorated stalls in Winchester cathedral (1206); the Early Perpendicular ones in Lincoln minster (c 1370); the early 15th-century canopies in Norwich cathedral (15th century), and the towering corner-stalls with their ornate carving filled with figures, in Amiens cathedral (1508-20)

STALLBAUM, JOHANN GOTTFRIED (1793-1861), German classical schoiar, was born at Zasach, near Deltzsch in asxmy on Sept. 25, 1793, and died at Leipag, where he was rector of the Thomasschule, on Jan. 24, 1861. His reputation rests upon his work on Plato, of which he published two complete editions, See C. H. Lipsius in the Osterprogramm of the Thomasschule (1863); R. Hoche in Allgemena deustiche Borgophie, vol. xxv.

STALYBRIDGE, multipla borough in the Stalybridge and Hyde parliamentary division of Chebine, England, 7; mi. E of Manchester Pop. (1951) 19,531 Area, 5 sq. mi. The whole district is densely populated Stalybridge so en of the oldest cotton towns, the first cotton mil having been elected in 176 It was incorporated in 1857 and was a parliamentary borough from 1867 to 1918. Cotton is the principal industry, but there

are also machine works, iron foundries and nail works. STAMBOLISKY, ALEKSANDR (1879-1923), Bulgarian statesman, was born at Slavovitsa, Bulgaria, Sept. 1, 1879. He attended the agricultural college of Halle in Germany. On returning to Bulgaria, aged 18, he took up journalism, and in 1902 became editor of the organ of the newly-formed Agrarian league. Six years later he was elected to the Sobranye, where he led the Agrarian party. He now began to organize the peasant masses, who form 80% of the population of Bulgaria, into agricultural associations. In 1911, when the Grand Sobranye met at Trnovo to amend the constitution, his first conflict with King Ferdinand occurred After the treaty of Bucharest (1913), Stambolisky and the Agrarians were unmerciful in their criticisms of Ferdinand's policy, though deterred from extreme measures by fear of external complications. His opposition to Ferdmand came to a head in 1915 during the negotiations that preceded Bulgaria's entry into World War I. Stambolisky strongly backed the Entente in spite of the king's anger, pressure from the government and the growing influence of the Central Powers. Summoned before the king, Stambolisky threatened him with personal violence if he should fight against the Allies, reminding him that he had a crown to lose. Ferdinand ordered his arrest. He was tried by court martial and condemned to penal servitude for life.

In Sept, 1918, when the resistance of the Bulgarian troops

began to slacken, Ferdinand released Stambolisky, who left for Bulgaria, held elections for the Sobranye, despite the interdict the Macedonian front. He returned at the head of the insurtectionary troops and their arrival at Sofia tesulted in Ferdinand's abdication and flight A partisan of the new ruler. King Bous. Stambolisky became a member of the calinet in Lin 1019 and prime minister in Oct, as head of the government he went to Paris and signed the treaty of Neurlly in the same year In Feb 1920 he dissolved the Sobranye, and the following month was returned to power at the head of a homogeneous Agiarian majority From 1920 to 1923, the Agranans under Stamholisky ruled Bulgaria with a rod of iron They had the Radoslavoy cabinet, which had brought Bulgana into World War I. condemned to death by popular vote. Stambolisky also carried measures based on the interest of the peasants (see Bulmeasures based of carea, carea, and declared "Sofia, that Sodom, that Gomorrah, may disampea! I shall not weep for her" Through his influence postwar Bulgaria loyally carried out the terms of the peace treaty, won the esteem of the Alhes, and secured a reduction of reparations Stambolisky also made persistent efforts to improve Bulgaria's relations with Yugoslavia, with which country he concluded an agreement at Nis (1922) His ultimate ideal was probably some kind of federal south Slav state, embracing Bulgaria

The overthrow of the government by a military faction on Tune o. 1923, was caused partly by dissatisfaction with Stambolisky's domestic policy and partly by the influence of the Macedonian party. The change of regime took place in one night, the Agrarian ministers being arrested in their homes. Stambolisky, pursued by an armed detachment to his native village of Slavovitsa, escaped and fled across the mountains, hoping to reach the frontier After being followed by soldiers for three days, he was eventually surrounded and shot on June 12 A formidable personality, attractive in many ways, and made of finer clay than the average Balkan statesman, Stambolisky has been called a modern Rienzi Tall and broad, his demeanour was fierce and his movements ungainly, his rough-hewn face was crowned by a mass of black hair, he impressed everyone with his strength and the sincerity of his advocacy of a "Green International," to unite the peasants of all countries Stambolisky published Authority. Anarchy and Democracy and What a Politician Ought To Be.

STAMBULOV, STEFAN (1854-1895), Bulgarian statesman, was born on Jan 31, 1854, at Tinovo, the ancient Bulgarian capital, where his father kept a small inn. He entered the seminary of Odessa in order to prepare for the priesthood but was expelled for his association with Nihilists, and, making his way to Rumania, he entered into close relations with the Bulgarian revolutionary committees at Bucharest and Giurgiu. In 1875, though only 20 years of age, he led an insurrectionary movement at Nova Zagora in Bulgaria, and in the following year organized another rising at Orekhovitsa In the autumn of 1876 he took part as a volunteer in the Serbian campaign against Turkey, and subsequently joined the Bulgarian irregular contingent with the Russian army in the war of 1877-78 After the signature of the Berlin treaty in 1878 Stambulov settled at Trnovo as a lawyer, and was soon elected to the Sobianye, of which he became president in 1884 The revolution of Plovdiv, which brought about the union of Bulgaria with eastern Rumelia, took place on Sept. 18, 1885, and it was largely owing to Stambulov's urging that Prince Alexander decided to identify himself with the movement. War with Serbia followed, and Stambulov served as an ordinary soldier in the Bulgarian army

After the abduction of Prince Alexander (Aug. 21, 1886), Stambulov, who was then at Trnovo, established a loyal government there, issued a manifesto to the nation, nominated his brother-inlaw, Gen. Sava Mutkurov, commander in chief of the army, and invited the prince to return to Bulgaria. These measures resulted in the downfall of the provisional government set up by the Russophil party at Sofia. On the abdication of Prince Alexander (Sept. 8) Stambulov became head of a council of regency, with Mutkurov and Petko Karavelov as his colleagues; the latter, however, soon made way for Zhivkov, a friend and fellow townsman of the first regent. Stambulov frustrated the mission of Gen. Nikolay Kaulbars, whom the tsar dispatched as special commissioner to

of Russia, and eventually secured the election of Prince Ferdinand of Cobus to the vacant throne (July 7, 1887) Under the newlyelected ruler he became prime minister and minister of the interior, and continued in office for nearly seven years. The aim of his foreign policy was to obtain the recognition of Prince Ferdinand, and to win the support of the Tuple Alliance and Great Britain against Russian interference in Bulgaria. He gained the confidence of the Sublime Porte, and obtained concessions for the Bulgarian episcopate in Macedonia (see Macedonia) With the assistance of Austria-Hungary and Great Britain he negotiated large foreign loans which enabled him to develop the military strength of Bulgaria

Stambulov's rule was despotic. He ruthlessly stamped out recurrent plots and armed risings engineered by equally ruthless political opponents with close support from influential Panslavist quarters in Russia. There was no clear distinction between party strife and sedition. Stambulov used his police, and sometimes the army, to deal with either Maj Konstantin Panitsa, after a conspiracy, was shot at Sona in 1890, four political opponents were hanged in the following year, and Karavelov was sentenced to five years' imprisonment. Among the deadliest enemies of the regime were the Macedonian committees, whose effective part in the struggle was emphasized by the assassination of Stambulov's colleague Belchev, in 1891, and of the Bulgarian representative in Constantinople, Vlkovich, in 1892

The arrogant way in which Stambulov used his practically unlimited power, and the growing violence of the opposition throughout the country, became intolerable to Prince Ferdinand who, moreover, wanted an accommodation with Russia. He contrived to get his unmanageable premier to resign, and accepted his resignation in May 1894. Stambulov was now exposed to the vengeance of his enemies On July 15, 1805, he was attacked and barbarously mutilated by a band of Macedonian assassins in the streets of Sona. and succumbed to his injuries three days later. His funeral was interrupted by disgraceful riots, and an effort was made to perpetrate an outrage on his remains No attempt was made to arrest his murderers; two persons, however, arraigned for the crime in 1806, were subjected to almost nominal penalties

(JDB; NIM)

STAMFORD, a municipal borough in the parts of Kesteven. Lincolnshire, Eng, on the River Welland, the boundary between Lincolnshire and Northamptonshire. Pop (1951) 10,899 Area 3 sq.mi. It has 11 mi, NW of Peterborough in the Rutland and Stamford pathamentary division. Stamford is a very ancient market town, built of local gray stone and once famous for its cloth Its position on the Great North road and on the borders of the Fens contributed to its importance. Its modern industries include general and agricultural engineering, brick and tilemaking and the manufacture of plastics and toys Of the old churches six remain; St Mary's with a Decorated spire, All Saints with fine brasses, and St. Martin's which contains the Burghley tombs, are the most noteworthy. There are remains of the 7th-century Benedictine priory of St Leonard and a west gate of the Carmelite monastery (1291). Browne's hospital is one of the almshouses known as Calises, from the wool merchants of Calais. There was a Danish fort at Stamford, which later became one of the five Danish boroughs A charter of Edgar dated A.D. 972 mentions a market and a mint. In the reign of Edward the Confessor Stamford was a royal borough governed by 12 lawmen. The Norman castle was built before 1086. Henry III gave the town a charter in 1256 and it was incorporated in 1461-62.

Stamford was known for its wool trade, its churches and its monastic schools, and in 1333 was chosen as the headquarters of the students who seceded from Oxford. An Early Decorated doorway (1300) remains of Brasenose hall The attempt to establish a regular university was prohibited by royal authority. The history of the place centred around the family of Cecil when the great Lord Burghley built Burghley house (1577-85), a fine quadrangular mansion south of the town, now the seat of the marquess of Exeter The house contains notable art collections

STAMFORD, a city of Connecticut, U.S.A., on Long Island

sound and U S highway 1. The city is served by the New York, New Haven and Hartford nalway Pop (1950) 74,293, 1940 federal census 47,938. The city still has the charm of a New England village. It is a residential suburb, with numerous trains daily to and from New York. It is also an important industrial centre. The town of Stamiond (known the first yeab by the Indian name of Rippowam) was settled in 1641 by 29 persons who seceded from the Wethersfield church. In 1662 it submitted to Connecticut. The brough was incorporated in 1830 and in 1949 town and city

governments were consolidated STAMITZ, JOHANN WENZL ANTON (1717-1757). the eldest and most important of a family of Bohemian musicians famous in the 18th century He was born at Deutschbiod on Tune 10, 1717. He was a solo violinist at the coronation of the emperor Charles VII (1742), and in 1745 the elector took him to Mannheim as director of the chamber of music. Stamitz and his successors are known as the Mannheim school. Although Phillip Emanuel Bach in Berhn and the young school in Vienna were arriving at similar results, it seems certain that Stamitz was the real pioneer, who not only demonstrated the dramatic value of the "working-out" section of the first movement of a sonata or symphony, but, by incorporating the minuet, definitely established the four-movement form. In addition he demanded of the orchestra a greater independence from the different instruments, singling out the much neglected viola. He died at Mannheim on March 30, 1757. His works include 27 concertos, sonatas and solos for violin, several sets of symphonies, and harpsichord music, Johann's brother Anton THADDAEUS STAMITZ (1721-1768) was a 'cellist at Mannheim

Much confusion has arisen between Johann and his eldest son CARL STAMIZ (1746-1801), who sometimes used the name Johann, while the father was frequently called Johann Carl or Carl Johann Earl on Experiment of the Johann Carl or Larl Johann Earl or Service of the Johann Carl or Larl Service of the Johann Carl of Larl Service of the Johann Carl of Larl Service of the Johann Carl Order of Larl Service of Larl Servi

BEBLEGGRAPHY—An introduction with details of the family, by Hugo Remain, a included, together with a thematic catalogue of a gyspirrobinstant in Beyern, and other compositions of Johann and Carl are found in series VII, 5. Van ad VVI of the same work. See also Grove, Jottonary of Music and Musician; Remain, Levikon; Eitner, Guellen-Levikon, R. Soudichiener, 'Thormale Enticything der volkgeschiehtig, p. 316 dt steg. (1926).

STAMMERING or STUTTERING, a spasmodic affection of the organs of speech in which the articulation of words is addedily checked and a pause ensues, often followed by a repetition in rapid sequence of the particular sound at which the stopping occurred. There are many grades, from a slight inability to pronounce with ease certain letters or syllables, to a condition mush which the muscles, not only of the tongue and throat and face, but even of those of respiration are involved in sosam.

In normal speech exquisite co-ordination of muscular movement is necessary in larynx, cheeks, tongue, lips, involving also complicated nervous actions. It is when the co-ordination is not effected with sufficient precision that stammering results Stammering rately shows itself before the age of four or five, and may develop in a child with some physical or psychical disorder.

Stammerers, as a rule, find the explosive consonants b, p, d, k and hard  $\xi$  the most difficult to articulate, but many also are unable easily to deal with the more continuous consonants, such as p, f, kb, s, s, kh, m, n, p, and in severe cases even the vowels are cause as certain amount of sparm. Usually the defect is not observed in whispering or singing.

The condition named aphthongia totally prevents speech, and may, at intervals, come on when the person attempts to speak; it is only temporary, and is usually caused by nervous excitement.

Stuttering may, it seems, be overcome in some cases by instrucion in reading and speaking slowly and deliberately, carefully pronouncing each syllable. When feeling the tendency to stammer, the speaker should pause, and then by a strong voluntary effort attempt to pronounce the word. He should also be taught how to

regulate respiration during speech, so that he may not fail from want of breath. In some cases and may be obtained by raising the voice toward the close of the sentence. Sounds or combinations of sounds that present speecial difficulties should be carefully studied, and the defect may be largely overcome by a series of graduated exercises in reading. Intoming is often useful. Some maintain that benefit from such education is often merely temporary. In any case the psychical basis of stammering calls for the most pronounced attention in treatment. In very severe cases, where the seizules affect other muscles than those of articulation, medical treatment is necessary.

STAMMLER, RUDOLPH (1856-1938), German jurnst and legal philosopher, was born on Feb. 19, 1856, in Alsfeld (Hessen) He was professor of law in Marburg (from 1882), Gressen, Halle and Berin (1916-21). He broke the dominance of legal poststivism and historiusm, directed legal philosophy toward nee-Kantian ideas and became the most influential legal philosophe of the early each century, especially in Germany, Spain and Latin America Stammler died April 25, 1938.

STAMP, JOSIAH CHARLES STAMP, 15T BARON, CT

1938 (1880-1941), British economist, was born in London June 21. 1880 Educated at the University of London, he entered the inland revenue department in 1896 and was assistant secretary to the board from 1916 until 1919, when he joined Nobel Industries Ltd, of which he was a director and secretary until he accepted the new post of president of the executive of the London, Midland and Scottish railway in 1925 Stamp sat on the royal commission on income tax (1919); on the finance arbitration committee for Northern Ireland (1923-24); on the committee on taxation and national debt (1924); on the Dawes Committee on German currency and finance (1924); on the court of enquiry into the coal industry (1925); and on the Paris committee of enquity into the reparations question of 1929 He was created K.B E in 1920. GBE. in 1924, and GCB in 1935, and was awarded the OM in 1936. He was the author of many books. He and Lady Stamp were killed in a German air raid on London, April 16, 1041

STAMP ACT, in American history, an act introduced by George Grenville, and passed by the British parlament in 1765, with the object of rusing revenue to pay in part the expenses of the French and Indian Wars (q.v.) It involved an extension of the British system of stamp duties to the American colonies and provided for the appointment of officials to distribute the stamp dupers. The act set stamp duties on every "skin or piece of veillum or parchment, or sheet or piece of paper" used for legal documents, academic degrees, luquor hiences, various commercial instruments, academic degrees, hugor hiences, various commercial instruments, academic hierarchical control of the page of the control of the page of th

The act was passed without debate and with no idea that it would be opposed. Determined opposition, however, was at once shown in all the colonies. It led to the passage of resolutions of protest by many of the colonial assemblies and to the calling of a Stamp Act congress in New York attended by delegates from nine of the colonies. In a resolution of Oct. 19, 1765, the Stamp Act congress declared that the Stamp act and other measures extended "the jurisdiction of the courts of Admiralty beyond its ancient limits . . ." and had "a manifest tendency to subvert the rights and liberties of the colonists." It was further resolved that "it is inseparably essential to the freedom of a people, and the undoubted right of Englishmen, that no taxes be imposed on them but with their own consent, given personally or by their representatives" and that "the people of these colonies are not, and from their local circumstances cannot be, represented in the House of Commons in Great Britain."

So great was the opposition that the proceeds from the duty were less than the expenses of collection. The next year parliament repealed the act as a matter of expediency but passed another act declaring the right of parliament to bind the colonies by its enactments.

The Stamp act was one of the important causes of the American Revolution (see United States: History)

STAMP DUTY, a tax imposed in Great Britain on written

documents which are evidence of legal rights involved. The payment of the tax is denoted by a stamp which is impressed on or affixed to the document

The Stamp act of 1891 remained the principal act governing stamp duties, though new duties and increases were authorized by successive finance acts

The sanction of the act was expressed in very wide terms. It was required that, except in criminal proceedings, an unstamped instrument executed in Great Britam, or relating, wherever executed, to any matter or thing done or to be done in Great Britam, was not to be given in evidence or to be available for any purpose whitsoever, and all judical officers before whom such an instrument was tendered in evidence were required to take notice of the absence or insufficiency of duty.

Further, any person whose duty it was to enrol or record an instrument hable to duty was made hable to a fine if he enrolled or recorded an instrument insufficiently stamped. In some instances, moreover, parties could execuse no discretion to dispesse with written evidence. For example, contracts for matrance (manne, life or general accident) were required to be expressed in the form of a stamped policy, failure to do this not only vitating the contract but rendering the parties liable to fines On the other hand, the stamp does not add to or warrant its

legality, it merely makes it possible for the legality to be examined STAMPINGS, DROP: see Pressed Metal.

STAMPS: see Post and Postal Services and Philately. STANCIOFF, DIMITRI (1864-). Bulgarian diplomatist, was born at Sistov, Bulgaria, in May 1864, and studied at the Theresianum college, Vienna In 1887 he entered the foreign office. Sofia. and was a member of the delegation entiusted with electing Ferdinand, in due course becoming head of the new king's political cabinet Afterward he was successively Bulgarian representative at Bucharest, Vienna and St. Petersburg. He became minister of foreign affairs in 1906 and was for a time prime minister after the murder of Petkoff. In 1908 he resigned and became minister in Paris, where he remained until 1915 when he was sent to Rome. He was made a member of the Bulgarian delegation to the Paris Peace conference, and from 1920 to 1926 was Bulgaria's representative to the court of St James. Stancioff was Bulgaria's chief delegate to the first international peace conference in 1899 and was a permanent member of the International Court of

STANDARD. For the various meanings of this word see Measures and Weights; Physical Units; Dimensional Analysis, Standards, National Bureau of; Electricity; Time, Standard, Standardization.

STANDARD, BATTLE OF THE, a name given to the battle of Aug 22, 1138, near Northallerton, in which the Scottsh army, largely composed of wild and undisciplined Highlanders and Galloway Pricts under King David, was deleated by the English leves of Yorkshire and the north Midlands. The latter formed a single deep line of dismounted men in front of a chariot carrying the consecrated banners of St. Peter of York, St. John of Beverley, St. Wilfred of Ripon and St. Cuthbert of Durham. King David planned to use his nucleus of knights and archers to lead the way and open a gap in the English line, but the face pride of the claamen compelled him to give them precedence. Their headlong onset was repulsed. Left isolated except for his body-guard of knights, King David retried from the field.

See C Oman, Art of War in the Middle Ages, vol. i, pp. 390-396

STANDARDIZATION. Standardization is a continuing process to establish measurable or recognizable degrees of uniformity, accuracy or excellence, or an accepted state in that process. Man's accompishaments, great as they are in this direction, page into insignificance when compared with standards in nature. The constellations, the orbuts of the planets, the changeless normal properties of conductivity, dettidity, lasticity, hardness, permeability, refractivity, strength, or viscosity in the maternals of nature, the orbits of electrons within the atom or the structure of cells, are a few examples of the assounding standardization in nature.

Only through the standardization found in nature is It possible to recognize and classify within the same species the many kinds of plants, fishes, bards or animals. Within these kinds, individuals of plants, fishes, bards or animals. Within these kinds, individuals resemble each other in minutest detail of structure, function and labits peculiar to each. If it were not for such standardization in the human body, physicans would not know whether an individual possessed certain organs, where to look for them or how diagnose or treat disease. In fact, without nature's standards there could be no organized society, no education and no physicians; each depends upon underlying, comparable similarities.

Selectivity.—Nevertheless within all the controlled, structural framework of standards in nature, individuals develop distinguishing characteristics and diversity to stimulate the natural processes of selection and survival. The processes of natural selection, the continuation of types worthy to survive, and the resulting evolution are analogous to the effect of time and experience on the customs, ceremones, rituals, procedures, codes, laws and other standards of a people

When man converts materials to energy, as in the burning of fuel or in the interconversion of mass and energy through fission or fusion, he finds immutable laws even more awesome than the standardization of structure, characteristics and functions noted

Combinations Without Limit.—Yet with this overwhelming evidence of standards none charges natuse with monotony. A though a narrow band of spectral wave lengths forms the foundation, the available vaiations and combinations of colour to delight the eye of the observer are virtually without limit. Similarly, all of the artistry of music comes to the ear through another small group of frequencies. With these examples there is little need to mention other ranges of frequencies no less valuable such as in radio, near, the infra-red, the ultra-violet, X-rays, gamma rays and cosmic rays.

### MANMADE STANDARDIZATION

Manmade standardusation is not confined to language nor to weights, measures, money, onergy, powes, nor to other material commodities or services subject to purchase. One finds standards in folklore, mythology, legend, taboos, in social customs, exercised to the configuration of the common standards and the standards train is important to geography, hotography, chemistry, pharmasy, sately, insurance, education, games, sports, music eligibility to the professions, ethics and religions. There are standards for soils, fertilizers, seeds, fruits, vegetables, grams, meat, poultry, darry products, natural and synthetic fibres and clothing. Standards are available for all kinds of aircraft, airports, highways, bridges, building construction, air conditioning, heating, insulation, plumbing, refrigeration and roofing. There are even standards for lung and standards of success. From prenata care through burial preparation and nices man has set up standards and incorporated many of them into law.

Industrial Production.—Mass production necessitates considerable standardzation of the processes by which the product is manufactured. Success or failure of a business often depends on the ingenuity and wisdom with which standards are employed to cut costs, whether the item is purchased or manufactured. It applies to single plants or groups of plants under the same management, Standardzatton of parts also builds good will by making it possible for the purchaser to obtain replacements quickly and cheaply,

Momenclature—In the last analysis, not only specifications but most other standards, except sizes, are essentially definitions. All buying and selling in which goods do not come under the actual eye of the buyer must necessarily be based upon some sort of standard. Many such standards are unwritten, simple and crude, often being no more than a two-party understanding, such as "like the one I bought from you last time." At the other externe, all of the great commodity markets are dependent upon standards which are in most cases well worked out, are nationally accepted and used, and may even be subject to legal definition. In the absence of such standards, the buyer would himself have to judge the wheat, com, cotton or copper with his own eyes. In each case a standard enables buyer and seller, or the parties to

any other undertaking with which the standard deals, to speak the same language ment, is at least partially independent in the United States competition makes the situation less clear Standards such as those

Purchase Specifications—Buyers of quantities sufficient to warrant a witter contract have traditionally employed purchase specifications to describe characteristics as municiply as practicable and supported by tests on samples of the finished product to reveal hidden characteristics. After about 1046 "performance" specifications began to grow in flavour in order to open up a wide range of materials and competition among sellers. In the United States, by the 1505, more than 200 national organizations had actively developed and published specifications or methods of testing and inspection as a basis for buying on formal contracts. These far outnumbered standards used as a basis for marketing or methods to the contract of the properties of the contract of the

Sellers and Selling Groups .- Because machines operate more effectively with uniform raw materials, and because customers prefer uniform, dependable products, each producer of branded goods develops his own standard of excellence, even if not revealed in full detail to the public. Under the pressure of competition, he endeavours to improve the acceptability of his product, sometimes through both improved quality and lowered price. This naturally led to the development by producer groups or associations of standards for products or services as a basis for selling or marketing Some of these have become so well established that even a large purchaser finds it much easier to buy according to the usual grades, for example, no. 2 common lumber, or 12 k. gold, than to attempt substituting units of his own choice or invention Such standards underly commerce governing producers. distributors, advertisers, consumers, testing laboratories, inspection agencies, and all others concerned, and therefore are of public, not merely private, concern.

Mandatory Labelling—In the United States the Food and Drug administration has complete mandatory authority over the preparation and enforcement of minimum standards for foods, drugs and cosmetics considered fit for human consumption or use. Although it sets minimum standards, seizes foods, drugs, and cosmetics below those minimums, and is ever watchful of false statements or claims on labels, this is not properly grade labelling "Grade" implies difference in quality of a commodity.

The US department of agriculture has mandatory authority through federal statutes to establish grading standards and to inspect selected commodities such as wheat, wool and cotton. Nether the selfer not an independent agency is encouraged or permitted to assume responsibility for such grading. Inspectors must be either employees or licensees of the government. Since the bulk of these selected commodities are sold according to government grade the process might be called mandatory grade identification. During World War II meat was mandatorily grade labelled by the US. department of agriculture with a roller stamp so that each outside cut bore the grade identification. It was claimed that the cost of grading any class of meat did not exceed one-half cent a pound.

Mandatory grade labelling requires additional governmental machinery for the istablishment and promulgation of standards, for the inspection of goods, application and wording of labels, seizure and action through the courts to punish violators, all of which places a burden on all who sell, handle or buy the goods In agriculture, for example, where the number of producers runs from thousands to tens of thousands, enforcement by government may seem logical. In industrial areas involving a smaller number of repostable producers, or consumer goods moving through channels having access to testing laboratories, voluntary grade labelling or declarations of quality binding upon the seller as a part of the sales contract generally result in fewer court cases and a much smaller over-all cost burden.

In the free countries of the world, standards are generally formulated under governmental supervision after consultation with those directly engaged in the production, inspection, testing, or purchase of the goods or services concerned. The Britistiution, although supported largely by the govern-

ment, is at least partially independent. In the United States competition makes the situation less clear. Standards such as those for avaition, drugs, farm products, food, highways, precious metals and transportation, whether mandatory or voluntary, are formulated under the auspices of the federal government. In engineering and technical fields there are such private organizations as the American Standards association and the American Stociety for Testing Materials. Several hundred other national technical societies and trade associations carry on standardization activities

Voiuntary Grade Labelling —For many goods technical methods of measuring and testing to determine conformity to grade did not advance sufficiently to make grade labelling practicable Where the cost of inspection or grading is high it is not feasible. For many commodities, however, suitable methods of measuring and scoring were developed to the point where the cost became relatively minor. Meat, poultry, eggs and milk are good examples among foods of voluntary grade labelling.

To foster fair competition, facilitate trade and build good will, many industries embarked on a system of voluntary grade labelling or declarations of quality that are intentionally enforceable via civil law and therefore self-policing for commodutes such as cement lumber, plywood, shingles, steels, fuel oil, ol burners, plumbing fixtures, rating of diesel engines, power shovels and cement mixers.

National Standardizing Bodies—Except for the British Standards institution (1907), industrial standards and eveloped largely after World Wat I By the 1950 there were at least 32 mational industrial standardizing bodies in the following countries Argentina, Australa, Austra, Belgum, Brazil, Canada, Chie, China, Czechoslovakia, Demark, Finland, France, Germany, Great Britán, Greece, Hungary, Inda, Israel, Italy, Japan, Madagascar, Mexoc, the Netherlands, New Zealand, Norway, Polan, Portugal, Rumania, South Africa, Spam, Sweden, Switzerland, Urugusy, United States, and the U S S R.

International Standardization—International uniformity was attained in basic scientific nomenclature in acoustics, sero-dynamics, astronomy, biology, chemistry, electronics, geodesy, geophysics, metrology, microscopy, medicine, music, kindick, kinematics, statics and other branches of science. Parts of this work have been carried out through international congresses and others through specialized international organizations such as the International Electroctechnical commission, the International Civil Aviation organization, the International Commission on Illiumination, the International Radio Consultative committee, the Five-Power Telecommunications conference, the International Scientific Radio union, etc.

In 1926, at Basle, Switz, the International Standardization association (1.8 A.), later superseded, was established. Following World War II, national standardization [S.O.) with headquarters at Geneva (Dec. 1947) The activities of I.S.O. with headquarters at Geneva (Dec. 1947) The activities of I.S.O. with the adquarters at Geneva (Dec. 1947) The activities of I.S.O. cover a broad field in such diverse area as a photographic and acoustical standards; documentation standards for libraries including microfilm technique; and innit systems for machine parts to provide for interchangeable fits. World-wide interchangeablity was obtained in some cases; e.g., metric hall bearings and i. of min. moving pictures

International trade and cultural interchange were greatly facilitated by uniformity in fundamental scientific standards and by progress in industrial standards.

Special Fields—The assembly line in the modern automobile factory became a classical illustration of great reduction in the cost of manufacture through the use of standards and mass production methods. The standardized parts of the completed car, or radio set, or refrigerator, are not made from stock and stored in a supply bin as in earlier factory practice, but flow continuously by means of automatic conveyors from the point of finished fabrication directly to the assembly line. This involves the manufacture, either within the plant or elsewhere, of thousands of parts which must be sure to fit, conveying these parts to the exact point in the plant or schedule; fastening them together accurately at a precise rate.

Similarly, the completed cars or other units do not normally go into a warehouse, but directly to dealers. Many large automobile manufacturers do not maintain covered storage space for even a single day's production of cars

Thorough-going standardization and incentives for producing higher grades greatly enlarged the market for citius and other fruits, vegetables and farm products With the aid of the U.S. department of agriculture growers and packers market their products by standard sizes and quality grades.

Specifications for iron, steel, nonferrous metals, oils, textiles, ceramics, and many other raw and semifinished materials entering into international trade were developed in all industrial countries and came into extensive use for quality identification to promote confidence and expedite sales.

BINLIOGRAPHY — Joseph Zimmerman, ed., Standard Metal Directory, vit. (1988–196). Jesse V Coles, Standards and Labels for Consumer's Goods (1949). Maria Leach, ed., Standard Dictionary of Folklore, Mythology and Legend, vol. 1 (1949), vol. n (1950)

STANDARD OF LIVING. The precise meaning of this phrase must usually be judged from its context. In popular literature it is likely to imply the relative kind and quantity of consumer goods used. Social scientists use the phrase in a different sense and have supplementary concepts. The standard of living to them relates to conditions considered essential by a person or group The standard of consumption relates solely to consumer goods, whereas the standard of living includes many other thingslessure time, working conditions, freedom to choose consumer goods and a job. In professional literature the range of things included by the phrase is not always spelled out. At times it seems to be restricted to consumer goods. The statement that people of the U S have a high standard of hving may imply that the mass of the population has come to consider certain consumer goods as essential which are accepted in other countries as the right of a select few The concepts, level of living and of consumption, relate to existing conditions-what is experienced in contrast with what is considered essential Many so-called standard of living studies might more accurately be described as studies of consumption levels They do, of course, give indirect information about standards since use tends to determine essentiality

A few people undoubtedly have, at least for short periods of time, an excess of some of the things which they desire, in which case their level of living is higher than their standard. The standard of others may be higher than their level Vague fleeting wants for things not available may occur. These do not constitute a part of the standard It relates only to those wants which generate a strong drive for their fulfilment. Their achievement brings a marked sense of gratification and their continued lack leads to unrest and a sense of frustration.

Man has biological, social and aesthetic needs. The specific ways in which these are met are culturally determined. Inherited customs and traditions ensure continuity in a society. Nevertheless cultural change is universal, although its nature and extent differ among societies and from time to time. In the United States the experience of migration to a new environment and the mingling of people from many countries tended to increase the willingness to accept new goods. Scientific and other developments that reveal better ways of meeting recognized needs lead to qualitatively higher standards. If productivity increases at a faster rate than population, quantitatively higher standards are made possible Important changes within societies may occur. The dominance of the democratic ideal and the decreasing cost per unit of output which characterizes mass production tends to reduce class differences. The mediaeval ideal was a stable class society, stable with respect to both occupation and consumption. In it demarcations in standards of living among groups were so important that sumptuary laws existed which prohibited spending beyond one's station in life. Freedom to compete for jobs and in consumption does not entirely wipe out class lines. In a study of the class structure of U.S. communities by W. Lloyd Warner and his associates, six social classes were identified in a typical U.S. city. Differences in pattern of consumption were found that were independent of income, especially for education, housing and the automobile. These differences led to the conclusion that the standard of living of the groups differed qualitatively as well as quantitatively. The study century, the decline in the rate of population growth in industrial-

did not seveal, however, which groups were influencing most the direction of change.

Some attempts have been made to measure the extent and urgency of both met and unmet needs Attitude studies, in which people have been asked about their needs and desires, were still in an experimental stage at mid-20th century In addition, analyses have been made of change in purchases with change in income and price These led to the classification of goods as necessities and luxuries-a classification which is, however, very crude Studies over a period of time show that luxuries of one period are necessities in another; and furthermore the so-called luxuries in a given society may be looked upon as necessities by some of its

Standards of consumption affect population growth and long-run labout supply through their effect on the age of marriage and the birth rate They also affect the total labour supply in the short run in that people weigh the relative ments of more income against more lessure or more direct production for the family, they affect the labour supply in a given occupation insofar as more income and the additional consumer goods thus made possible may compensate for less pleasant work. The existence of the desire for more consumer goods is also important in inducing families to migrate Standards of living also have a bearing on the business cycle Forecasters would like to know when income falls to what extent will families cut consumption? To what extent will they decrease sayings and draw on assets in order to maintain customary consumption? And furthermore if production rises, will it find a ready market because of desires previously unmet? Or will the additional income go wholly or largely to savings? (See Consump-TION.) In the administration of a war economy or other emergency when customary levels of consumption cannot be maintained it is helpful to know where cuts will be least resented, and how best to carry on an informational program in order to make clear the need for the shortages and thus minimize unrest and frustration.

In the United States it is not uncommon for the claim to be made that the wages of husbands are madequate to provide the American standard of living, if they seek work beyond their regular job, if wives (especially those with young children) seek work outside the home or carry on industrial work in the home, or if children are taken out of school to help support the family the basis of such indices the incomes of many husbands are inadequate. Census reports show that the lower the income of husbands the higher the percentage of wives seeking gainful work

The drop in the percentage of wives working with higher incomes was more pronounced in families with children under ten years of age than in others, suggesting that a greater sacrifice is made by them in family production or in leisure in order to earn

Occupation is an important part of the standard of living Some types of work are so much preferred over others that a lower income will be accepted in lieu of a lower ranking job. Changes in income differentials during World War II in the United States brought considerable mobility of workers from more preferred to less preferred types of work. Ideas prevail based largely on customary income as to what the standard of hvmg of a given occupational group should be. Jessica Peixotto, in Getting and Spending at the Professional Standard of Living (1927), emphasized the special consumption needs of professional people, and pointed out that the desire for high consumption would attract people away from academic professions unless earnings were made more nearly comparable to those of alternative jobs. Except in industries where wages are unusually low, the need to attract workers and ability of industry to pay rather than a minimum standard of hving are the major factors of wage negotiations in the United States.

The standard of living has long been a matter of major interest to population analysts. Thomas Malthus, in his Essay on Population (1798), argued that population growth is determined by means of subsistence. He believed that it was held in check chiefly by starvation, pestilence and war, all of which were direct results of population pressure on means of subsistence. This view assumed a static standard of living By the beginning of the 20th ized countries after decades of rising productivity shifted attention to the effect of a rising standard of living. Then two tears came to be expressed (1) that tamilies in general would come to place such a high value on material goods for themselves and their children that the birth rate would fall to a point where total population would decline, and (2) that the effect of a high standard of living on the birth rate was especially marked among families with high income, thus, the quality of the population was likely to be adversely affected. An upturn of the birth rate in some western countries after the middle 1930s, however, allayed the first fear. For example, the 1950 census of the United States reported a 55% increase since 1940 in children under 5 years of age, while the total population increased by only 14%.

An increase in real income or a change in relative values or both may have played a part Joseph S Davis considered that this change may have been due to "a change in standards of living . of such a nature that mairiage and children are given a relatively higher priority in what is urgently desired, instead of continuing to lose ground to ever higher per capita consumption, comfort, and lessure" (J. S Davis, The Population Upsurge in the United States, Food Research Institute War-Peace Pamphlets No 12, Stanford University, Stanford, Calif, Dec 1949, p 57). Population analysts by 1950 also had evidence that the inverse relation of birth rate to income was tending to disappear, and that within social classes buth rate and level of income tended to be directly related. The highest birth rate was still found at the lowest income level The factors responsible for this awaited investigation, there might be a relative lack of interest in consumer goods available in the market in contrast with desire for children, or an acceptance of a low level of education for children so the cost of rearing them is low, or children might be desired as a means of security in old age, or there might be lack of knowledge of birth control methods; or an assumption might exist that society would care "adequately" for the children

Policies and programs of the United Nations brought to the torefront once more a consideration of the validity of the Malthusian doctrine. Among the nations of the world high birth lates occur where the level of consumption is low, and where death rates are high. The value system of these societies tends to stimulate high birth rates Only thus can the population be maintained in the face of high death rates. Experience indicates that industrialization brings a reduction in mortality before a decline in fertility To what extent is a decline in fertility dependent on a rising standard of hving? What is the process of bringing this about? are no clear cut answers, in spite of the experience in western countries with falling birth rates which resulted, in part, from a rising standard of hymg.

Standards of hving of individuals are a dominant driving force in a society There are, in addition, social standards of living which are the basis of many types of policies. The levels of consumption provided those in prison or on relief are, for example, an expression of a society's minimum standard for its members. Social standards are implicit in minimum wages, unemployment benefits, public old age pension systems, family allowances and the provision of various goods from public funds. In addition to individual and social standards there are normative standards provided by scientists and other specialists which are used as yardsticks in evaluating consumption

There are, for example, the recommended dietary allowances of the National Research council (1945), the major yardstick used in appraising the nutritional quality of U.S. diets. The American Public Health association, through its committee on the hygiene of housing, provided a yardstick for measuring adequacy of housing. Such standards as these are commonly utilized in formulating quantity budgets to measure the cost of a given level of consumption. The quantity of goods included in such budgets may exceed those consumed by families at the general level of the budget at the time it was prepared. Since normative standards incorporate the scientific development at a relatively early stage of its impact on consumer demand they tend to point the way in which consumption is developing. (See also Consumption; Cost of Liv-ING.

Bibliography — Joseph S Davis, "Standards and Content of Liv-g," American Economic Review (March 1945), American Public Hallh Association. Committee on the Hygiene of Housing, Basic Hadth Association, Committee on the Hygene of Housing, Basic Principles of Healthyll Housing (1939), John Dollard, Gaite and Class in a Southern Town (1949), Graham Hutton, Melweit at Noon (1946), Clyde V Kiese and F K Whelpton, "Social Research of the Housing of the Housing and Ho Health Association, Committee on the Hygiene Spending on The Vellen, The Theory of the Lessure Class (1926), W. Lioya walling and Paul Lint, The Social Life of a Modern Community, "Yankee Carnet Series," vol. 1 (1941), Carle Zimmelman, Consumption and Standards of Living (1936), F. Zweig, Labour, Life and Poverty (1948) (M. R.)

STANDARD OIL COMPANIES. These individual U S petroleum corporations were formerly a single group operating throughout the world under the stock ownership of Standard Oil Company of New Jersey, but later became separate competing enterprises. In 1911 the United States supreme court ordered the dissolution of the New Jersey company, and shares of 33 subsidianes were distributed to stockholders of that company

Thereafter there was a gradually decreasing community of interest among the different units, and ownership of the shares became widely diversified Active competition arose between certain large former Standard Oil companies in every branch of the petroleum activity, in domestic marketing territory and in foreign

As was the case with other large independent companies never associated with the Standard Oil group, tremendous growth of certain former Standard Oil companies was notable after the petroleum industry became predominantly a gasoline industry Most of the companies formerly in the Standard Oil group tended toward integration of their operations in the four major fields of production, transportation, refining and marketing. Moreover, certain companies formerly in the Standard Oil group-notably Standard Oil company (N J ), Socony-Vacuum, and the Standard Oil Company of California-became active in foreign production. transportation, refining and marketing The Socony-Vacuum Oil company resulted from a merger in 1931 of two former Standard Oil corporations, the Vacuum Oil company and the Standard Oil company of New York, a merger officially approved on the grounds that it was not a lessening of competition because the operations of the two companies were primarily in separate, complementary fields

In 1911 Standard Oil companies purchased the bulk of their domestic crude oil requirements from independent producers, and themselves were little engaged in production. But this was quickly changed as large independent crude oil producing companies built their own transportation systems and refineries and enlarged their markets. It was estimated that, by the 1950s, former Standard Oil companies were producing about 22% of U.S. crude oil production. The Standard Oil company (New Jersey) remained the largest U.S. oil company and one of the greatest U.S. industrial corporations.

Principal companies of the 1950s formerly in the Standard Oil group were: Standard Oil company (N.J.); Standard Oil company (Indiana); Socony-Vacuum Oil Co, Inc.; Standard Oil Company of California; Atlantic Refining company, Standard Oil company (Ohio); the Ohio Oil company; Standard Oil company (Kentucky); and South Penn Oil company.

STANDARD PRICE: see Price Maintenance.

STANDARDS, NATIONAL BUREAU OF. Established March 3, 1901, by an act of the congress of the U.S.A, the national bureau of standards is the principal agency of the federal government for basic and applied research in physics, mathematics, chemistry and engineering. Supplementing the enabling legislation, congress further prescribed the functions of the bureau in public law 619, July 22, 1950 Six major functions are listed. (1) maintenance and development of national standards of measurement and their application, (2) determination of physical constants and properties of materials, (3) development of methods of testing materials, structures, and mechanisms and the testing of materials, supplies and equipment, (a) scientific and technical co-operation with government and private agencies, (5) advisory services for federal agencies, and (6) invention and development of devices to serve special needs of the government. In addition to these general functions other types of activities are specifically justicized, melding research in nuclear physics, radio propagation, and mathematics as well as the classic divisions of the physical sciences.

The bureau is organized into sections, grouped according to subject matter into 15 major divisions: electricity, optics and metrology, heat and power, atomic and radiation physics, chemistry, mechanics, organic and fibrous materials, metallurgy, nuneral poducts, building technology, mathematics, electronics, ordanic missiles and radio propagation. The principal laboratories are in Washington, D. C. Field stations were maintained in 15 states in the 1956s, while 5 stations were outside the continental limits of the United States.

The basic research of the bureau is related to scientific standards and measurements. Continued research is conducted even in fields often assumed statuc (e.g., length and time standards) in response to new or anticipated developments in other fields of science. Thus, the bureau developed atomic standards of length and time in order to provide more precise measurements needed in atomic and nuclear physics and high frequency communications. The bureau's first atomic clock, based on the utilization of the constant frequency of wheration of the atoms in ammonia, provided a time constancy of one part in 1,000,000,000,000 appears feasible. Two new clocks—one using ammonia, the other using acessum—were later developed. New measurements of the magnetic moment of the proton promise to yield an atomic standard of mass in the future.

Major projects unvolving pute and applied research and development are undertaken in accordance with needs of the federal government. Extensive work was under way, in the 1950s, in stonic and nuclear physics. The atomic bomb project was initiated by the bureau, upon presidential request, in 1950, and work in this area was expanded to mclude nonunitary aspects, particularly in the field of ladinactive isotopes. Contributions to the national defense also included projects in ordinance and missale devices. The only successfully used guided missile of World War II—the BAT —was developed by the bureau, which was also responsible for the basic proximity fuze for nonrotating projectiles. The development of special optical glasses, synthetic mica, radio beacons, and the instrument landing system (ILS) for blund landing of aircraft were other typical projects of a specific nature

The manifold expansion of the nuto-frequency spectrum after World War II created many problems concerning the behavour and properties of high-frequency radio waves. Extensive studies of the ionesphere, of ionospheric propagation, ground effects, and climatological factors have been conducted. These studies had direct applicability to commercial radio and television One phase of this work included continuous monitoring of the ionosphere at various locations around the world, providing the bass for predictions of the best frequencies to use at any time and place. These predictions are issued for a one-month period, there months

In mathematics considerable progress was achieved in numerical analysis—e.g., the general problem of finding eigenvalues of matrices and systems of differential equations and methods of solution for the partial differential equations of physics—in the compliation of specialized mathematical tables, in the application of modern statistical inference to complex engineering and sampling problems, and in the study of theory of samples consisting of small numbers of specimens. The increasing importance of mathematics in nuclear physics and aerodynamics, for analytical reasons as well as economy, led the bureau into the field of electronic comouters.

SÉAC—the National Bureau of Standards Eastern Automatic Computer—was completed in 1950 and continued in operation, day and night, on problems in the physical sciences, management, and machine experimentation. SEAC was the fastest generalpurpose, automatically sequenced electionic computer in operation up to that date A second machine—SWAC—was constructed later, and the bureau has also sponsored computer development projects by industry.

The work of the hureau of duect interest to the general public has to do with standards of measurement. The ordinary standards of weights and measures used by the public and industry, and which affect every commercial transaction, are dependent upon the basic work of the bureau Every instrument-ranging from the electric meters in households to altitude indicators on supersonic aircraftdepends on the bureau's standards, measurements, and calibrations for its precision and accuracy Safety codes and safety measures concerned with housing, plumbing, electricity, fire, X-ray, radioactive isotopes, elevators, 14dio, etc., are developed by the bureau Extensive studies of building materials and structures have been pursued Studies of dental materials, hospital equipment, surgical tools, the structure of the human skeleton, cutting of tissue for microscopic examination, and synthetic blood plasma are typical of the work conducted by the bureau in those areas of the biological sciences which have problems essentially physical in nature (See STANDARDIZATION )

The results of the bureau's work are available through a monthly periodicals (Journal of Research, Technical News Bulletin, and Busic Radio Propagation Predictions) and a series of nonperiodical publications. An indexed list of publications (Publications of the National Bureau of Standards, circular 460, 375 pp) is available from the superintendent of documents, U.S. government printing office, Washington 25, D.C. (Hit., O)

STANDERTON, a town in South Africa at the Vaal river bridges, pop. (1946) 9,277 (4,303 whites), 114 mt SE of Johannesburg, altitude 5,022 ft It is chief town of a district of the same name and the centre of an agricultural and coal-mining region.

STANDISH, MYLES or MILES (c 1584-1656), American colonist, was born, according to Nathanael Morton, in Lancashire, England, but became a soldier in the Netherlands, where he met the Pilgrim Fathers He sailed with them in the "Mayflower" in 1620, and became the captain or military defender of New Plymouth As soldier and linguist he was invaluable in dealing with the natives He rescued Weymouth colony from the Indians in 1623, returned to England on behalf of Plymouth colony in 1625-26, and later helped to buy out the Merchant Adventurers. He was treasurer of the colony 1644-49, and for a time assistant governor; but was never elected governor, perhaps because not a member of the Pilgrim Church He removed to Duxbury, 1642, where he died, 1656, and a monument was erected to him in 1872. Longfellow's well known poem, Courtship of Mylcs Standish, is based on a late tradition, published in Alden's work on Epitaphs in 1812-14

The story that Chorley Church register was defaced to defeat his title to local lands is proved to be unfounded. Myles Standish was one of the Ormskirk branch of the Standish family

See the histories of Plymouth colony by William Bradford and by Nathanael Morton Also Porteus Captain Myles Standash (1920) and History of Standash (1927) (T. C. P.)

STANDPIPE is a vertical pipe coupled to a ground hydrant, to lead off water suitably for filling buckets, street-watering pace, fire bose, watering carts, etc. The pipe is either permanent or detachable, and the top may be of fixed or swivel type, with one or more outlets. A tall hent pipe is sometimes attached for filling watering carts or small locomotives. A standpost is often combined with a drinking fountain or with a lamp column. In the United States a standpipe is a vertical pipe or high tank to which water is forced in order to obtain a better head pressure than is afforded by the mains. (See Hyddaws).

STANFIELD, WILLIAM CLARKSON (1704-1867). English marme painter, was born of Irish parentage at Sunderdad in 1794. As a youth he went to sea, but he practised sketching to such good effect that, on being incapacitated by an accident, he was able to paint scenery at the "Old Royalty," a sailors' theatre in Wellcloss Square, London, the Coburg theatre, Lambeth and at Drary Lane. His first easel exhibit was "Wreckers off Fort Rouge" at the British institution in 1827, and in 1832 he was

art was influenced by his early scene painting and tends to be spectacular and dry and hard in colour, on the other hand the treatment is broad and effective

Hs prancipal works are "Mount St Michael", "The Opening of London Bridge" and "Portsmouth Habour" (1822), "The Battle of Trafajaga" (1836) for the United Service Club, "Siola Bella" (1841), "The Victory' bearing the Body of Nelson towed into Gibraltar" (1853) and "The Abandoned" (1850). Stanfeld's Coast Scenery contains 40 of his works engraved in line

STANFORD, SIR CHARLES VILLIERS (1852-1924), Irish composer, was born in Dublin on Sept. 30, 1852. After studying in London under Ernst Pauer he won (1870) a scholarship at Queen's College, Cambridge, whence he migrated to Trin-ity College m 1873, and succeeded J. L. Hopkins as college organist, a post he held till 1892 His appointment as conductor of the Cambridge University Musical Society gave him great opportunities. In 1874 to 1877 he visited Germany each year, studying under Reinecke and Kiel His first important composition was incidental music to Tennyson's Oueen Mary (Lyceum, 1876). In 1881 his opera, The Veiled Prophet, was given at Hanover; followed by Savonarola (Hamburg and Covent Garden, 1884), and The Canterbury Pilgrims (Drury Lane, 1884). A long interval separates these from his later operas, Shamus O'Brien, the least pretending but most successful of his dramatic works (Opéra Comique, 1896) and Much Ado About Nothing (Covent Garden, 1901). Meanwhile he had been appointed professor of composition at the Royal College of Music, 1883; conductor of the Bach choir, 1885, professor of music in the university of Cambridge, succeeding Sir G. A. Macfarren, 1887; conductor of the Leeds Philharmonic Society, 1897, and of the Leeds Festival from 1901 on. He was knighted in 1902 and died in London March 29, 1924. His instrumental works include six symphonies, many chamber compositions, among them two string quartets; besides many songs, part-songs, madrigals, etc., and incidental music to the Eumenides and Oedipus Rex (as performed at Cambridge), and Tennyson's Becket. His last operatic work was The Travelling Companion, posthumously produced in 1926. His church music and editions of Irish and other songs are well known. See his Studies and Memories (1908), and Pages from an Unwritten Diary (1914).

STANFORD UNIVERSITY: see LELAND STANFORD JR.

UNIVERSITY.

STANHOPE, CHARLES STANHOPE, 3RD EARL (1753-1816), English statesman and scientist, was born on Aug 3, 1753, and educated at Eton and Geneva, where he studied mathematics. In politics he was democratic; he represented High Wycombe from 1780 until his accession to the peerage in 1786, giving his support (1783-84) to the administration of Pitt, whose sister, Lady Hester Pitt, he married in 1774; but when Pitt forsook his Liberal principles, Stanhope severed their political connection. He was the chairman of the "Revolution Society," which expressed its sympathy, in 1790, with the aims of the French Republicans, and in 1795 he introduced into the Lords a motion deprecating any interference with the internal affairs of France, on which point he was in a "minority of one." He thereupon retired from politics for five years. He spent much money on experiments in science and philosophy. His inventions include the printing press and the lens which bear his name, a monochord for tuning musical instruments, and two calculating machines. He projected a canal through Devonshire, and took the levels himself. His writings include Principles of Electricity (1779); a reply to Burke's Reflections on the French Revolution (1790); and an Essay on the rights of juries (1792). The lean and awkward figure of Lord Stanhope figured in a host of caricatures. His first wife died in 1780, and in 1781 he married Louisa, daughter and heiress of the Hon. Henry Grenville, who survived him, and died in 1829. Lady Hester Stanhope (q.v.) and Lady Lucy Rachael Stanhope, who eloped with the family apothecary and was never reconciled with her father, were daughters by his first wife. Lord Stanhope died at Chevening, Kent, on Dec. 15, 1816. See G. P Gooch, Life of Charles, 3rd Earl Stanhope (1914).

STANHOPE, LADY HESTER LUCY (1776-1839), the eldest child of the 3rd Earl Stanhope by his first wife, Lady

made A.R.A and in 1835 R.A. He died on May 18, 1867. His Hester Pitt, was born on March 12, 1776, and hved at her father's seat of Chevening in Kent until early in 1800, when his excitable and wayward disposition drove her to her grandmother's house at Burton Pynsent. In 1803 she became the chief of the household of her uncle, William Pitt Although her wit and beauty cheered his declining days, her satire created enemies. Lady Hester Stanhope possessed great business talents, and when Pitt was out of office she acted as his private secretary. On his death she was granted a pension of £1,200 a year, dating from Jan. 30, 1806 On Pitt's death she lived in Montagu Square, London, but in 1810, she left England for ever After many wanderings she settled among the Druses on Mt. Lebanon, and from the lonely villa of Djoun, 8 m. from Sidon, she wielded an almost absolute authority over the surrounding districts, maintained by her commanding character and by the belief that she possessed the gift of divination Ibrahim Pasha, when about to invade Syria in 1832, solicited her neutrality She died on June 23, 1839 Her disappointments and her dictatorship intensified a temper naturally imperious. In appearance as in voice she resembled her grandfather, the first Lord Chatham

Some years after her death there appeared three volumes of Memors of the Lady Haster Stanhope as related by herself in Conversations with her Physicana (Dr Meryon, 1843), and these were followed in the succeeding year by three volumes of Travels of Lady Hester Stanhope, formus the Completion of her Memors narrated by her Physical Physical Physical Rev. 1841. alope, forming the compension of new aemourn nutration by new rays are compension. They presented a lively picture of this strange woman's line of the compension of the compe

STANHOPE, JAMES STANHOPE, 1ST EARL (c 1673-1721), English statesman and soldier, the eldest son of Alexander Stanhope (d 1707), a son of Philip Stanhope, 1st earl of Chesterfield, was educated at Eton and Trimty college, Oxford. He served in Italy and Flanders as a volunteer against France, and in 1605 obtained a commission in the British aimy. Entering the House of Commons in 1701 he still continued his career as a soldier. In 1706 he was appointed British minister in Spain, and in 1708 commander-in-chief there. He captured Port Mahon, assisted at the battles of Almenara and Saragossa in 1710, but was forced to capitulate to the French at Bribuega on Dec o. 1710. and was imprisoned in Spain for a year.

Returning to England in 1712 he became one of the leaders of the Whig opposition in the House of Commons, and, in 1714, he became secretary of State for the southern department, sharing with Walpole the leadership of the House In 1716, as George I's foreign minister he only just failed to conclude a treaty with France He was made first lord of the Treasury in 1717, but in 1718 returned to his former office of secretary of State In 1717 he was created Viscount Stanhope of Mahon, and in 1718 Earl Stanhope. He helped to conclude the quadruple alliance between England, France, Austria and Holland (1718) He died in London on Feb. 5, 1721, just after the collapse of the South Sea scheme, for which he was partly responsible, though he did not

STANHOPE, PHILIP HENRY STANHOPE, EARL (1805-1875), English historian, better known as Lord Mahon, son of the 4th earl, was born on Jan 30, 1805, was educated at Christ Church college, Oxford, and entered parliament in 1830. His chief interest was in literature. He was a trustee of the British Museum, and in 1856 proposed the foundation of the National Portrait Gallery, whose subsequent creation was due to his executors. He also assisted in the establishment of the Historical Manuscripts Commission, and was president of the Society of Antiquaries from 1846 onwards. In 1855 he founded the Stanhope Essay prize at Oxford. His works include Life of Belisarius (1829); History of the War of Succession in Spain (1832); History of England from the Peace of Utrecht to the Peace of Versailles (1836-53); Life of William Pitt (1861-62); and History of England, comprising the reign of Queen Anne until the Peace of Utrecht (1870, new ed. 1908), the last two of which remain standard works. Stanhope had unique access to ms, authorities, a clear style, and a general impartiality in criticism He died on Dec. 24, 1875, and was succeeded by his son, Arthur Philip (1838-1905).

STANIMAKA, a town of south Bulgaria, at the foot of the Rhodope mountains. Pop. (1934), 17,817. It is a very old Greek colony, its inhabitants speak a dialect containing otherwise obsolete classical terms. On the hill above the town is "Tsar Asen's tower" This was a very strong fortress, and here Remer of Trit, the Latin Count of Philippopolis, was besieged for nine months, until relieved by Villehardouin (q v). A few miles un the valley of the Cepelare is the monastery of Backovo, the

second in Bulgaria, with a famous library.

STANISLAUS I. [Leszczynski] (1677-1766), king of Poland, born at Lemberg in 1677, was the son of Rafael Leszczynski. palatine of Posen, and Anne Catherine Jablonowska. He married Catherine Opalinska by whom he had one daughter. In 1607, as cunbearer of Poland, he signed the confirmation of the articles of election of Augustus II. In 1703 he joined the Lithuanian Confederacy against Augustus, and in the following year Charles XII. selected him to supersede Augustus, and by bribery and intimidation secured his election (July 2, 1704). A few months later Stanislaus was forced by a sudden inroad of Augustus to seek refuge in the Swedish camp, but finally on Sept. 24, 1705, was crowned king with great splendour. Stanislaus at once concluded an alliance with Charles, and rendered him some small assistance against the tsar; but he depended entirely on the success of his ally's arms, and after Poltava (1709) the vast majority of the Poles hastened to repudiate him and make their peace with Augustus, and Leszczynski, henceforth a mere pensioner of Charles XII . retreated to Swedish Pomerania. On the restoration of Augustus, Stanislaus resigned the Polish Crown (though he retained the royal title) in exchange for the little principality of Zweibrucken. residing at Weissembourg in Lorraine.

In 1725 Louis XV. of France married Stanislaus' daughter Mary, and supported his claims to the Polish throne after the death of Augustus II. in 1733, which led to the war of the Polish Succession. On Sept 9 1733 Stanislaus himself arrived at Warsaw. having travelled through central Europe disguised as a coachman, and on the 10th was once more elected king of Poland. Russia, however, protested, proclaimed the Saxon candidate king as Augustus III. (June 30, 1734), and in October besieged Stanislaus with his partisans in Danzig. The expected French help did not arrive until May 20, 1735, when a fleet disembarked a small force, which, however, could do little. On June 30 Danzig capitulated unconditionally after a stubborn resistance of 135 days. Stanislaus, disguised as a peasant, had contrived to escape two days before. He attempted to rally his partisans from Konigsberg, and to secure fresh help from France and from Count Potocki in the Ukraine, but without avail,

In 1736 Stanislaus again abdicated the throne, but received by way of compensation the dukedom of Lorraine and Bar, which was to revert to France on his death. He settled at Lunéville. founded there the Academia Stanislai, and devoted himself for the rest of his life to science and philanthropy He died in 1766 at the age of 80. Among his works may be mentioned: Ocuvres du philosophe bienfaisant (Paris, 1763; 1866).

See Robert Nishet Bain, Charles XII. (1895); Louis Lacroix, Les Opucules inédites de S. L. (Nancy, 1866); Lettres inédites de S. L., ed P. Boyé (1901); Marchioness Des Reaulx, Le Roi Stanislas et Marie Lesscynishi (1895).

STANISLAUS II. AUGUSTUS [PONIATOWSKI] (1732-1798), king of Poland, the son of Stamslaw Poniatowski, palatine of Cracow, the friend of Charles XII. of Sweden. Through the influence of his uncles the powerful Czartoryski, he was sent to St. Petersburg in the suite of the English ambassador Hanbury Williams. Subsequently, through the influence of the Russian chancellor, Bestuzhev-Ryumin, he was accredited to the Russian court as the ambassador of Saxony. Through Williams he was introduced to the grand duchess Catherine, who was irresistibly attracted to the brilliant young nobleman, for whom she abandoned her other lovers. Poniatowski was concerned in the conspiracy to set aside the succession of the grand duke Peter and his son Paul in favour of Catherine, a conspiracy frustrated by the Russian princes, which became extinct in 1340 when Casimir the

unexpected recovery of the empress Elizabeth and the consequent arrest of the conspirators.

Stanislaus returned to Warsaw much discredited, but nevertheless was (Sept. 7, 1764) elected king of Poland through the overwhelming influence of Catherine, and crowned on November 25 to the impotent disgust of his uncles. He was hated by the nobility, yet he tried to do his best. He maugurated some economical reforms. After the first partition he sought to restore the power of their country, while his eloquent oration before the Diet on taking the oath on May 3, 1791, moved the deputies to tears. But when the confederation of Targowica was formed against the constitution, he was one of the first to accede to it, in this way completely paralysing the action of the army which, under his nephew Prince Joseph and Thaddeus Kosciuszko, was performing prodigies. On the outbreak of the insurrection of 1794 he was obliged to sue for his very life to Kosciuszko, and saw his effigy expunged from the coinage a year before he was obliged to abdicate his throne. The last years of his life were employed in his sumptuous prison at St. Petersburg (where he died in 1798) in writing his memoirs. He contracted a secret marriage with the countess Grabowska. He was capable of the most romantic friendships, as witness his correspondence with Mme, Geoffrin,

slupe, as witness his correspondence with Mine. Geoffrin.
See Lars won Engelvino, Mineme och Antechniquer, vol. 1. (Stockholm, 1876). Correspondence heddle des Stanulus Fondelcowik over
holm, 1876). Correspondence heddle des Stanulus Fondelcowik over
trame of Stanulus Augustus (Fol. Cracow, 1889). Minemiers secrets
et médits de Stanulus Augustus (Cleiptz, 1862). Stanulus om Prace
t single from the Stanulus Augustus (Cleiptz, 1862). Stanulus om Prace
t single from the Stanulus Augustus (Cleiptz, 1862). Stanulus Correspondence, in
Stanulus's dates and letters, which were for many years in the
Stanulus's dates, and letters, which were for many years in the
Stanulus's dates, and letters, which were for many years in the
Stanulus's dates, and the Stanulus's group of
to January 1965. See also R. N. Bamb The Last King of Folord
STANISTA AUSWY Stanulus name of Constantine Screenwich

STANISTA AUSWY Stanulus name of Constantine Screenwich

STANISLAVSKY, stage name of Constantine Sergeevich Alexeev (1863-1938), Russian theatrical producer, was born in Moscow. His father was a rich mill owner and his grandmother a French actress; he studied at the imperial school of dramatic art and in 1888 began work as an actor and producer in the Society of Art and Literature and after ten years of training founded in 1898 together with the playwight V. Nemirovitch-Dantchenko (18587-1943) the Moscow Art Theatre. His productions were varied, ranging from the historical Czar Fedor to the extreme naturalism of Chekhov's plays He was also an actor of great force and subtlety, taking the leading parts in Chekhov's and Gorky's plays. Stanislavsky revolutionized the art of producing and was the father of the modern Russian theatre.

See Stanislavsky, My Life in Art (Eng. trans., 1924). STANISLAWÓW, a province of Poland. Area 7,090 sq.mi. Pop. (1931) 1,477,000. In 1931 68 9% were Ruthemans, 22 4% Poles; the rest mostly Jews. The Ruthemans speak a different dialect from that of the Ukramans and the Polesian groups, those in the Carpathian area maintaining their Highland customs, especially the interesting tribes of Hucules, who seem to be of Rumanian admixture. They are members of the Greek Catholic or Uniat Church. The province consists of a fertile belt drained by the tributaries of the Dniester, which forms its northeast boundary, of the Carpathian slopes and the mountains themselves, which rise in height to the east and form the lofty Czarna Hora, with dense forests of beech, fir, etc. The province produces large quantities of timber, Stanislawów is famous for its horses and dairy cattle. The salt of Kolomyja has been worked since the earliest times, forming part of the salt belt which extends all along the mountains to Cracow. Potash is found at Kalusz and Turka. The Stanislawów district also has oilfields. Other districts, such as Kolomyja, produce oil and there is mineral gas at

The mountain scenery of the province is very beautiful, particularly in the valley of the Stryj. There are a number of health resorts, such as Kosów, in Pokucie. The chief towns are Stanislawów (pop. 1931, 60,000), Stryj (30,682), Kolomyja (33,385), Kalusz and Sniatyn. Halicz (Russian Galich), the ancient capital of the three provinces of Stanislawów, Tarnopol and Lwow, is a small town near the Dniester. It was the capital of a line of

Great occupied the principality The province was occupied by soviet troops in 1939 and was conquered by axis troops in 1941.

STANLEY (FAMILY), derived its name from Stanley in Leek (in the Staffordshire "moorlands") Its first known ancestor is Adam de Stanley, brother of Liulf de Audley, who lived in the time of King Stephen His descendant, Wilham de Stanley, acquired the forestership of Wirral, with an heiress, in 1284, and was ancestor of two brothers, Sir William and Sii John Stanley. The former married the heiress of Hooton in Wirral and was ancestor of the Stanleys of Hooton, whose baronetcy, created in 1661, became extinct in 1893. The younger brother, heutenant of Ireland under Richard II and Henry IV, obtained from the latter the Isle of Man in fee. His grandson Thomas was father of the first carl of Derby and of Sir William Stanley of Holt, whose great wealth led to his execution for treason in 1495, and also of Sir John Stanley, ancestor of the Stanleys of Alderley, who obtained a baronetcy in 1660 and a barony in 1839 The earls of Derby are noticed under DERBY

The barony of STANLEY OF ALDERLEY was created in 1839 for Sir John Thomas Stanley, Bart (1766-1850), of Alderley Park. EDWARD JOHN STANLEY, 2ND BARON (1802-1869), entered the House of Commons in 1831 and became under-secretary to the home department in 1841, patronage secretary to the treasury from 1835 to 1841, paymaster-general in 1841, and under-secre-tary for foreign affairs from 1846 to 1852 In 1848, two years before he succeeded to the barony of Stanley, he was created Baron Eddisbury of Winnington He was president of the board of trade from 1855 to 1858, and postmaster-general from 1860 to 1866. His wife, Henrietta Maria (1807-1805). a daughter of Henry Augustus Dillon-Lee, 13th Viscount Dillon, was a remarkable woman Before her marriage in 1826 she had hved in Florence, and had attended the receptions of the countess of Albany, the widow of Charles Edward, the Young Pretender; and in London she had great influence in social and political circles. When he was patronage secretary her husband was described by Lord Palmerston as "joint-whip with Mrs Stanley" Later in life Lady Stanley of Alderley helped to found the Women's Liberal Unionist Association, and she was a strenuous worker for the higher education of women, helping to establish Girton College, Cambridge, the Girls' Public Day School Company, and the Medical College for Women. She died in 1895.

STANLEY, ARTHUR PENRHYN (1815-1881), English divine, dean of Westminster, was born on Dec. 13, 1815, at Alderley, Cheshire, the son of Edward Stanley (1779-1849), afterwards bishop of Norwich. He was educated at Rugby under Arnold, and at Balliol college, Oxford In 1839 he was elected fellow of University college, also taking orders In 1840 he travelled in Greece and Italy, and for ten years he was tutor of his college. In 1845 he was select preacher, and published in 1847 Sermons and Essays on the Apostolic Age He was a strong advocate of toleration and used his influence to protect from formal condemnation the "Tractarian" party. In 1847 he resisted the movement set on foot at Oxford against R. D. Hampden's appointment to the bishopric of Hereford Finally, in 1850, in an article in the Edinburgh Review, in defense of the "Gorham judgment" he asserted two principles which he maintained to the end of his life-first, "that the so-called supremacy of the Crown in religious matters was in reality nothing else than the supremacy of law," and, secondly, "that the Church of England by the very condition of its being, was not High or Low, but Broad, and had always included and been meant to include, opposite and contradictory opinions."

He was greatly interested in university reform and acted as secretary to the royal commission reporting in 18-29. Stanley was also appointed to a canony at Canterbury. During his residence there he published his Memoir of his father (1851), and completed his Commentary on the Epistics to the Commissions (1855). In the winter of 1859-35 he made a tour in Egypt and the Holy Land, the result of which was his well-known volume on Simila and Plestine (1856). In 1857 he travelled in Russia, and collected much material for this Lectures on the Eastern Church (1867).

At the close of 1856 Stanley was appointed regius professor of Bennett. He went to Crete and Specclesiastical history at Oxford, a post which, with the attached Paris by Mr. Gordon Bennett, Jr.

canomy at Christ Church, he held till 1865. He published the first two volumes of ha History of the Jewsh Church in 1865 and 1865. In the storm which followed the publication of Essays and 1865. In the storm which followed the publication of Essays and Revuess Stanley opposed the High Church Party. In 1836 he published a Letter to the Bishop of London, advocating a relaxation of the terms of clerical subscription to the Thrity-nne Articles and the Prayer Book. An act amending the Act, of Uniformity, and carrying out in some degree Stanley's proposals, was passed in the year 1865. In 1862, Stanley accompanied the prince of Wales in Egypt and Palestine

In 1863 he was appointed dean of Westminster In December he married Lady Augusta Bruce, sister of Lord Elgin, then governor-general of India He wrote a third volume of his History of the Jewish Church, a volume on the Church of Scotland, another of Addresses and Sermons preached in America, and another on Christian Institutions (1881) He was constantly fighting for the interests of the poor He gave offence by defending Bishop Colenso, although he disapproved of Colenso's views, and, still more, by his invitation to the Holy Communion of all the revisers of the translation of the Bible, including a Unitarian among other Nonconformists He desired that the Athanasian Creed be optional instead of imperative in the Church of England In 1874 Stanley, who was much esteemed by Queen Victoria, conducted the Anglican ceremony at the marriage of the duke of Edinburgh and the grand duchess Marie He died on July 18, 1881, and was buried in Henry VII 's chapel

Stanley's other works include: Life of Dr. Arnold (1844), Essays on Chinch and State (1870); Memorials of Westmunster Abbey (1865). See G. G. Bradley Recollections of A. P. Stanley (1883); R. E. Prothero and G. G. Bradley, Life and Correspondence of Dean Stanley (2 vols., 1893).

STANLEY, SIR HENRY MORTON (1841-1904), Brit-ish explorer of Africa, discoverer of the course of the Congo, was born at Denbigh, Wales, on June 10, 1841, of a family named Rowlands or Rollant John Rowlands, by which name Stanley was baptized, was brought up first by his maternal grandfather. and after his death was boarded out by his mother's brothers at half a crown a week. In 1847 he was taken to the St Asaph Union workhouse, where the schoolmaster, James Francis (who eventually died in a madhouse), was a tyrant of the Squeers type, and in May 1856, Rowlands, after giving Francis a thrashing. ran away from school. His paternal grandfather having refused to help him, he became a pupil teacher at Brynford, where his cousin was master But within a year he was sent to Liverpool, where he lived in poverty with an uncle, and after working at various trades, he sailed as a cabin boy to New Orleans, where he landed in 1859. There he obtained a situation through the good offices of Henry Morton Stanley, who subsequently adopted the lad as his son, but died without making provision for him

When the Civil War broke out in 1867 Stanley enlisted in the Confederate army; he was captured at the battle of Shioh (April 1862), and after two months' impuisonment at Camp Dougha, Chicago, he obtained release by enrolling in the Federal artilery. In less than a month he was discharged as unfit. In Nowmber 1866 he returned to Liverpool "every poor, in bad hattle and in shabby clothes," and made his way to Denbigh, but was turned away from his mether's door. For a livelihood he took to the sea—was wecked off Barcelona—and in August 1864 enlisted in the United States anay. After the war he crossed the plans to Salt Lake City, Denver, and other parts, and became a vivid descriptive writer.

Thus began a series of adventures in search of "copy," which led him through Asia Minor, Tiffis and Tibet In 1866 Stanley revisited Denbigh and St. Asaph, returning thence to America, where he joined General Hancock's expection against the Red Indians, acting as correspondent for the Missouri Democrat and other papers His reports induced the New Pork Herald to send him to accompany the British expection of 1867-68 against the emperor Theodore of Abyssinā. Succeeding in sending through the first news of the fall of Magdala, Stanley received a roving commission from the proprietor of the Herald, James Gordon Bemett. He went to Crete and Spain, but in 1869 was recalled to. Paris by Mr. Gordon Bemett.

Convinced that David Livingstone was alive Bennett commissioned Stanley to go in search of him But he cumbered Stanlev with a large number of commissions in Egypt, Syria and Persia before the quest for Livingstone could be begun. Eventually he sailed from Bombay for Africa, reaching Zanzibar on Jan 6, 1871

The journey to the interior was begun on March 21, on Nov. to, having overcome innumerable difficulties. Stanley arrived at Uill, where he found Livingstone With Livingstone Stanley navigated the northern shores of Tanganyika, settled the question as to whether the Rusizi was an effluent or an affluent-a point then much debated in connection with the hydrography of the Nile basin, and regained Zanzibar on May 7, 1872 His story, made public in a picturesque narrative, How I Found Livingstone (1872), was received in London with some incredulity; but the journals of Livingstone, which he brought home, silenced the critics, and from Queen Victoria Stanley received a gold snuff-box set with brilliants and her thanks for his services

A series of public lectures in England and America followed In 1873, as war correspondent of the Herald, he accompanied Wolseley's expedition to Ashanti, which he described, together with his Abyssinian experiences, in a volume entitled Coomassie and Magdala · Two British Campaigns (London, 1874) On reaching the island of St Vincent from Ashanti in 1874 he first heard

that Livingstone was dead

Second African Journey .- Stanley now desired to return to Africa to determine geographical problems left unsolved by the deaths of Livingstone and Speke, and the discovery by Sir Samuel Baker of Albert Nyanza, a lake then reputed to extend illimitably in a southerly direction. A fund was raised by Lord Burnham, Gordon Bennett and others for an Anglo-American expedition under Stanley's command This expedition lasted from October 1874 to August 1877 and accomplished more than any other single exploring expedition in Africa. Politically the journey led to the foundation of the Congo State and to the partition of the hitherto unappropriated regions of Africa between the states of western Europe Stanley started from the east coast and reached the ocean again at the mouth of the Congo, having demonstrated the identity of that river with Livingstone's Lualaba by navigating its course from Nyangwe-the point at which both Livingstone and Lovett Cameron had turned aside

Of the three white men who accompanied him all died during the journey; Stanley himself was prematurely aged The discovery of the course of the Congo, though the greatest, was but one of many geographical problems solved during this memorable expedition The part played by the Kagera in the Nile system, the unity and approximate area of Victoria Nyanza, the true length and area of Tanganyika and the whereabouts of its outlet. and the discovery of a new lake, Dweru, which at the time Stanley believed to be a branch of Albert Nyanza, are some of the other discoveries made by Stanley at this time. The story of the expedition was given at length in Through the Dark Continent (London, 1878). Stanley's letters from Uganda and his call for missionaries to go to the court of Mtesa met with an immediate response and proved the first step in bringing the region of the Nile sources under the protection of Great Britain. Commercially the discovery of a navigable waterway penetrating the heart of Africa, was of paramount importance, a fact which was grasped by Leopold II, king of the Belgians, who sent commissioners to intercept Stanley at Marseilles, when he was on his way back to England, with proposals to return to the Congo, proposals which Stanley, much needing rest, put aside for the time. In November, 1878, Stanley went to Brussels and entered into the schemes of the Belgian king.

Congo Free State.-A Comité d'études du Haut Congo was formed and Stanley was entrusted with the leadership of the new expedition. Stanley reached the Congo in August 1879, and the work he accomplished there in the ensuing five years enabled the comité, which had meantime changed its name to that of Association internationale du Congo, to obtain the recognition of America and Europe to its transformation into an independent

Leopold. Stanley described his labours in The Congo and the Founding of its Free State (London, 1885). For the political aspects of the question see Africa. Partition Among European Powers: Congo Free State He was restricted by the enterprise of the French traveller de Brazza, who, reaching Stanley Pool by a more northern route, placed the neighbouring districts on the north bank of the Congo under French protection (1880). Stanley returned to Europe in the middle of 1884 and attended the Berlin Conference of 1884-1885, which dealt with African affairs, acting as technical adviser of the American plenipotentiaries.

Third African Journey .- Stanley now became interested in the schemes of Mr (afterwards Sir) William Mackinnon for establishing a British protectorate in East Equatorial Africa, and it was believed that this object could be furthered at the same time that rehef was afforded to Emin Pasha (qv), governor of the Equatorial Province of Egypt, who had been isolated by the Mahdist rising of 1881-1885 Stanley agreed to conduct an expedition, nominally in the service of the khedive of Egypt, for the relief of Emin. He decided to go by way of Zanzibar and the Congo State. He left Europe in January 1887 and at Zanzibar entered into an agreement with Tippoo Tib, the chief of the Congo Arabs, appointing him governor of Stanley Falls station on behalf of the Congo State, and making another arrangement with him to supply carriers for the expedition On June 15, Yambuya, on the lower Aruwimi, was reached, and here Stanley left his rearguard under command of Major E. M. Barttelot and Mr. J. S. Jameson On the 28th Stanley and the advance-guard started for Albert Nyanza, "and until Dec 5, for 160 days, we marched through the forest, bush and jungle, without ever having seen a bit of greensward of the size of a cottage chamber floor. Nothing but miles and miles, endless miles of forest." Starvation; fever. the hostility of the tribes, were daily incidents of this terrible march, during which Stanley lost nearly 50% of his men. On Dec 13, Albert Nyanza was reached, and after some delay communication was opened with Emin, who came up the lake from the Nile in a steamer. Disquieted by the non-arrival of his rearguard, Stanley retraced his steps, and on Aug. 17, 1888, a short distance above Yambuya, found that Tippoo Tib had broken faith, that Barttelot had been murdered, that Jameson (who soon afterwards died of fever) was absent at Stanley Falls, and that only one European, William Bonny, was left in the camp

Collecting those who survived of the rearguard Stanley for the third time traversed the primeval forest, and in January 1889 all that was left of the expedition was assembled at Albert Nyanza Of 646 men with whom he entered the Congo, but 246 remained In April the return journey to Zanzıbar by way of Uganda was begun. Emin reluctantly accompanying Stanley On this homeward journey Stanley discovered Ruwenzori (the Mountains of the Moon), traced the course of the Semliki River, discovered Albert Edward Nyanza and the great south-western gulf of Victoria Nyanza. During his stay in the Congo forests he had also obtained much information concerning the pygmy tribes As to the political results of the expedition. Stanley's proposals to Emin to hold the Equatorial Province for the Congo State or to move nearer Victoria Nyanza and enter the service of Mackinnon's British East Africa Company had not been accepted, but he concluded agreements with various chiefs in the lake regions in favour of Great Britain, agreements which were handed over to the East Africa Company Zanzibar was reached on Dec. 6, 1889, and the expedition was at an end. In Darkest Africa, was published (in six languages) in 1890.

Returning to England, Stanley was received with much honour, and received many distinctions. There was, nevertheless, bitter controversy over the fate of the rearguard of the expedition. On July 12, 1890, he married Miss Dorothy Tennant, second daughter of Mr Charles Tennant, sometime M P. for St. Albans. Later in the year he visited the United States, and in 1891-1892 went to Australia and New Zealand on lecturing tours. On his return he was renaturalized as a British subject, and after an unsuccessful attempt in 1892, he was elected member of parliament in 1895 He did not seek re-election in 1900 In 1895 Stanley pubstate ("The Congo Free State") under the sovereignty of King lished My Early Travels and Adventures in America and Asia, in which he retold the story of his experiences with the Red Indians and of he eastern pourney of 1860-1870. In 1897 Stanley paid his last visit to Africa. He went to the Cape as the guest of the British South Africa Company, spoke at the opening of the rail-way from the Cape to Bulawayo, vasted the Victora Falls of the Zambeza and had an interview with President Kruger, of whom he gives a characteristic pen-picture. One result of this journey was Through South Africa (1898), the last of his published works. In 1899 in recognition of his services in Africa he was made a KC B. The last, few years of his hie were spent mainly in retirement on a small evate he had purchased, Fuzehmond Terrace, Whitchall, on May 10, 1904, and was buried at Pibright. The monoith over his grave bears the inscription "Henry Morton Stanley 1841—1904" with his African name "Bula Mataru" and the one word "Africa".

In geographical discoveries Stanley accomplished more than any other explorer of Artica. Notwithstanding his frequent conflicts with Arabs and negroes, he possessed in extraordinary degree the power of managing native races, he was absolutely fearless and ever leady to startine either himself or others to achieve his object. His books differ widely from the ordinary books of travel. Stanley had a gift of dramatic narrative, and his power of portraiture was remarkable. Curnously, the least successful of his works was the only one which he cast in the form of fiction, My Kalniu, Prince, King and Slave. My Dark Companions and their Strange Stories (1893) is a valuable contribution to folklore.

Stronge Stories (1893) is a valuable contribution to loutoure.

The Authorisemph of Sir Henry Morton Stanley, ed by his wife,
Duochy Stanley, appeared in 1909 Henry M. Stenley, the Story of the
Life. . . (London, in d. 1871), by C. Rowlands, centains, not-the
standing many maccuraces, valuable information concerning his family
and early career The following books may also be consulted Mis
J. S. Jameson, Story of the Rear Column of the Emin Pache Relief
Expedition (1890), W. G. Barttleot, The Life of Edmind Mugrave
Battleot . . (1890), H. Brode, Tippoo Tib, the Story of its Cereer
in Central Africa (1997).

STANLEY, THOMAS (1625-1678), English poet and philosopher, son of Sir Thomas Stanley of Cumberlow, in Herts, was born in 1625 His mother, Mary Hammond, was the cousin of Richard Lovelace, and Stanley was educated in company with the son of Edward Fairfax, the translator of Tasso He studied both at Cambridge and Oxford, and travelled widely in Europe. Stanley was the friend and companion, and at need the helper, of many poets, and was himself both a writer and a translator of verse. His Poems appeared in 1647; his Europa, Cupid Crucified, Venus Vigils, in 1649; his Aurora and the Prince, from the Spanish of J Perez de Montalvan, in 1647; Oronta, the Cyprian Virgin, from the Italian of G. Preti (1650); and Anacreon; Bion; Moschus; Kisses by Secundus . . . a volume of translations, in 1651. Stanley's most serious work in life, however, was his History of Philosophy (3 vols., 1655-61). A fourth volume (1662), bearing the title of History of Chaldaick Philosophy, was translated into Latin by J. Le Clerc (Amsterdam, 1690). The three earlier volumes were published in an enlarged Latin version by Godfrey Olearius (Leipzig, 1711). In 1664 Stanley published in folio a monumental edition of the text of Aeschylus He died at his lodgings in Suffolk Street, Strand, London, on April 12, 1678.

The English metaphysical school closes with Stanley, who went on weaving his faintastic conceits in elaborately artificial measures far into the days of Dryden and Butler. His History of Philosophy was long the principal authority on the progress of thought in

Stanley's original poems were imperfectly reprinted in Sir S. Egerton Brydges's edition of 150 copies in 1814. His "Anacreon" was issued, with the Greek text, by Mr. Bullen in 1892.

STANLEY, WENDELL MEREDITH (1904—), U.S. biochemist and Nobel prize winner, was brom on Aug., 16, 1904. In Ridgeville, Ind. After receiving his Ph.D. degree from the University of Illinois, Urbana, in 1290, he became a research associate and instructor in chemistry there. In 1931 he entered the Rockefeller Instituté for Medical Research, and in 1794 became a member of the institute. In 1938 he became director of the laboratory for vivus research at the University of California. In

research on the virus which caused the "mosaic disease" in tobaccoplants, Stanley found that while it appeared to act like an inammate chemical it presented evidence of being a living and growing organism. For "their preparation of enzymes and virus proteins in a pure form," Stanley and John H. Northrop divided equally one-half of the Nobel prize in chemistry in 1946, the other half being awarded to James B. Sumner for his discovery "that enzymes can be crystallized"

STANNARIES, un mines (late Lat. stannum, Cornish, stéan, tin) Stannary courts exercised a jurisdiction peculiar to Comwall and Devon. By ancient charters, the tinners of Cornwall were evempt from all other jurisdiction than that of the stannary courts, except in cases affecting land, the and limb. Tin mining in Cornwall, from the very earliest times was always prosecuted in accordance with a particular code of customs, the earliest charter which embodies them is that of Edmund, earl of Conwall, but it is minossible to say how far these customs co hack

Twenty-four stannators were returned for the whole of Cornwall. Their meeting was termed a parliament, and when they assembled they chose a speaker. In earlier times the combined tinners of Devon and Cornwall assembled on Hingston down, a tract of highland on the Cornish side of the Tamar After the charter of Earl Edmund, the Cornish stannators met (apparently) at Truro, those of Devon at Crockern Tor on Dartmoor An officer was appointed by the duke of Cornwall or the crown, who was lord warden of the stannaries. The last Cornish stannary parliament was held at Truro in 1752. A committee was appointed to report on the subject, and an act of parhament was passed (1836), suppressing the law courts of the stewards of the different stannaries and giving to the vice-warden their jurisdiction. By the Stannaries act, 1855, the respective parliaments or stannaries courts of Cornwall and Devon were consolidated By the Stannaries Courts Abolition act, 1806, the jurisdiction was transferred to the county courts. The most important customs were (a) "free tinners" had the right to work upon rendering the "toll-tin, usually one-fifteenth of the produce, to the owner or lord of the soil; (b) the right of "tin-bounding," that is, the right of bounding waste lands, subject to tin-toll

See G R Lewis, The Stannaries (1908); W. S. Lewis, West of England Tin Mining, with bibliography (Exeter, 1923); A. K. Hamilton Jenkin, The Cornish Miner (1927).

STANTHORPE, a town in the S.E. of Queensland, Australia, 198 mn. SW of Brisbane by rail Alltitude 2,650 ft; average annual temperature is 80° ft. 035° ft. 103° sverage annual rainfall is 305 in. It so no the main interstate line Brisbane-Sydney), and is a summer resort. It hes at the north end of one of the largest masses of granite in eastern Australia, and gold and comperary when fuerthy. Pon (1042) 2,380

and gold and copper are mined nearby. Pop (1947) 2,380. STANTON, EDWIN McMASTERS (1814-1869), American statesman, was born at Steubenville, O, on Dec 19, 1814. He attended Kenyon college at Gambier, O, and was admitted to the bar in 1836 In 1847 he removed to Pittsburgh, Pa As counsel for the State, he invoked successfully the aid of the Federal Government in preventing the construction of a bridge over the Ohio river at Wheeling, Va., (now West Virginia)-on the ground that the structure would interfere with the navigation of that stream by citizens of Pennsylvania He removed to Washington in 1856 In 1858 he was sent to California by the United States attorney general as special Federal agent for the settlement of land claims. Before the Civil War, Stanton was a Democrat, opposed to slavery, but a firm defender of the constitutional rights of the slaveholders, and was a bitter opponent of Lincoln, whose party he then hated and distrusted. In the reorganization of President Buchanan's cabinet in 1860 Stanton became attorney general, and he did what he could to strengthen the weak policy of the President Although he had often violently denounced President Lincoln, the latter thought he saw in Stanton a good war minister, and in January, 1862, invited him into his cabinet. Stanton was often harsh, and his peremptory manner was the cause of friction with the generals, an instance being his controversy with Gen. Sherman over the terms of surrender granted to J. E. Johnston's army. But he removed a horde of fraudulent contractors, kept the armies in the field well equipped hexameters and infused energy into procrastinating generals. Not the least of his achievements was the peaceable disbandment of 800,000 soldiers at the end of the war

Remaining in the cabinet of President Andrew Johnson, Stanton exerted all his energies toward thwarting the policies of that executive, especially those related to the reconstruction of the Southern States He expressed disapproval of the Tenure of Office Act, making the consent of the Senate necessary for the removal of civil officers, and diafted the supplementary act on reconstruction, passed over the President's veto on July 19, 1867. Stanton was finally asked to resign, and on his refusal to do so the President suspended him (Aug 12) from office and appointed Gen. Grant (who had disapproved of the secretary's removal) secretary ad interim When the Senate, however, under the terms of the Tenure of Office Act, refused (Jan 13, 1868) to concur in the suspension. Grant left the office and Stanton returned to his duties On Feb. 21, 1868, Johnson appointed Gen Lorenzo Thomas secretary of war ad interim, and ordered Stanton to vacate, but on the same day the Senate upheld Stanton, and by way of reply the secretary made oath to a complaint against Thomas for violating the Tenure of Office Act, and invoked military protection from Gen Grant, while Congress came to Stanton's rescue by impeaching the President, the principal article of impeachment being that based on the removal of Stanton (see JOHNSON, ANDREW). When the impeachment proceedings failed (May 26) Stanton resigned and returned to the practice of law. Stanton had a violent temper and a sharp tongue, but he was courageous, energetic, thoroughly honest and a genuine patriot He died in Washington on Dec 24, 1869

See George C Gorham, Life and Public Services of Edwin M. Stanton (Boston, 1899) and Frank A Flower, Edwin McMasters Stanton The Autocrat of Rebellion, Emancipation, and Reconstruc-

STANTON, ELIZABETH CADY (1815-1902), American leader in the woman's rights movement, was born in Johnstown, NY, on Nov. 12, 1815, the daughter of Judge Daniel Cady. In her father's law office she learned of the discriminating laws under which women lived, and many tragic cases observed there determined her in the ambition to equalize the rights of her sex. She did much by the circulation of petitions to secure the passage in New York in 1848 of a law giving a married woman property rights In the same year, on June 19 and 20, in Seneca Falls, was held, chiefly under the leadership of Mrs Stanton and Mrs. Lucretia Mott, the first woman's rights convention in the United States. For this convention Mrs. Stanton had drawn up her famous woman's bill of rights setting forth the inferior and unjust position of women in State, church, law and society, and resolutions demanding redress, which were adopted. All of these demands have since been extensively granted One of them, introduced without Mrs Mott's approval, was a resolution in favour of equal suffrage for women, which, when approved, became the first organized demand in the United States by women for the ballot, In 1850 she became associated with Susan B. Anthony and for 40 years the two worked together, each admirably supplementing the other, Mrs Stanton writing, Miss Anthony managing affairs. In 1867-70 they co-operated in editing The Revolution, a women's rights newspaper She was president of the National Woman Suffrage Association from 1865 to 1893. With Miss Anthony and Mathilda Gage she wrote The History of Woman Sufrage (4 vol. 1887-1002) She died in New York city on Oct. 2, 1902. See T. Stanton and H S Blatch, ed., Elizabeth Cady Stanton as Revealed in Her Letters, Diary and Reminiscences (1922).

STANYHURST, RICHARD (1547-1618), English translator of Virgil, was born in Dublin in 1547. At University College, Oxford, he met Edmund Campion. After studying law, he went to Spain, ostensibly as a physician, but really to keep Philip II. in touch with the Catholic interest in England. In 1602 he took holy orders, and died at Brussels in 1618. He translated The Pirst Foure Bookes of Virgil his Aeneis (Leiden, 1582), to prove Gabriel Harvey's theory that classical prosody could be applied to English poetry. The translation is a jargon arranged in so-called

A reprint in 1583 by Henry Bynneman forms the basis of J Maid-ment's edition (Edinburgh, 1836), and of Professor E Arber's reprint (1880), which contains an excellent introduction Stanyhurst's Latin voiks include De rebus in Hibernia gestis (Antweip, 1584) and a life of St Patrick (1587).

STAPLE, originally a prop or support, in current usage a Ushaped piece of metal, generally galvanized or wrought iron, in wire form with sharpened points, and used as a fastener by driving into wood, also the chief or ordinary bulk articles of trade In England the term was applied to towns which were appointed by the king to be the merchants of the staple. These merchants had a monopoly in the staple commodities, viz, wool, wool fells, leather tin and lead, and were the our of all English trading companies. (See also Natl Manufacture )

See C. Gross, Gild Merchanis, W Cunningham, Growth of English Industry and Commerce

STAR, the general term for the luminous bodies seen in the sky, but more especially applied to the "fixed stars," which maintain practically the same relative positions in the sky and form constant patterns or constellations. The planets or "wandering stars" are accordingly excluded (see Astronomy)

Unlike the planets which shine by reflected light from the sun, the stars are self-luminous. They are bodies of the same nature as the sun; and the only reason why the sun appears so much more brilliant is that it is comparatively close to us. The following figures speak for themselves . Distance of sun-93,000,000 miles; distance of nearest star-25,500,000,000,000 miles. Each star is a fiery globe and most stars are enormously larger than the earth. though a small proportion are comparable in size with the major planets. Some stars may have planets, but it is not possible to detect these by direct observation; if sufficiently massive, they might be detected by the disturbance of the motion of the parent star caused by their gravitational attraction. In this way a few of the nearer stars have been proved to have companions which, though considerably more massive than Jupiter, are much less massive than any known star. It can be inferred that these companions are not self-lummous, and they are therefore to be regarded as planets.

Although we have been able to learn indirectly the actual dimensions of many of the stars, their size is not revealed by telescopic observation. In the largest telescope a star remains a point of light, and there is no possibility of observing surface markings such as we see on the sun. One unexpected feature, however, is seen directly a telescope is used, a considerable number of the stars which appear single to the naked eye, are seen in the telescope to consist of two stars. The occurrence of close pairs of stars is far too frequent to be due to chance; and, indeed, in some cases the two components have been observed to be revolving round one another. We have to recognize that although single stars like the sun are in the majority, evolution has very frequently taken another course and furnished pairs of luminous globes.

It can be recognized with the naked eye that the stars differ in colour. The colour is not very vivid; but, for example, if the reader is familiar with the constellation Orion, he will easily see that the brighter of the two shoulder stars (Betelgeuse) has a reddish tinge in contrast to all the other bright stars in the constellation, which are white. The quality of the light (crudely indicated by the colour, and in a more detailed way by examination with a spectroscope) is a clue to the surface temperature of the star. As we should expect, the "white-hot" stars are the hottest, and the "red-hot" stars the coolest. Another fact which can be verified with the naked eye, though it requires patient and systematic watching, is that some of the stars give an inconstant light There are several different kinds of variable stars described below: in one class the variation is a genuine physical change, the star swelling and contracting with regular pulsations.

The Stellar Universe .- Thus the statement that the stars are "suns," while giving a correct general idea of their nature, must be amplified to cover a wide variety of objects with many individual characters. They differ greatly in physical condition. Betelgeuse (above-mentioned) is an example of one extreme; it is a gigantic globe so large that the whole orbit of the earth could be put inside it, but so tenuous that its density is less than 1000 that of air-many a so-called vacuum is not more exhausted ian this. An example of the other extreme is the companion of Sirius (see Sirius), which is compressed to a density far exceeding anything known on earth, and is in size not so large as the planet Uranus. Besides the study of the stars as individual units we have to consider their organization as a system. The principal indication of this organization is found in their motions. Although we often call them fixed stars, they are moving rapidly with speeds of the order 10 to 100 mi a second. Notwithstanding their great distance, the resulting changes of position in the sky can be determined by refined measurement, it is the exception for a bright star to have a motion too small to be detected in, say, 20 years. Further evidence of organization is afforded by the distribution of the stars in the sky. They are crowded toward one special plane, viz, that marked out by the Milky Way, or Galaxy, a hand of diffuse light stretching all round the sky which, under telescopic examination, is resolved into millions of faint stars. In general, in speaking of the stars we refer to this galactic system or universe, but it is known that the spiral nebulae, of which there are a great number, are island universes coequal with our galactic system. In some of these other galaxies individual stars can be detected by aid of the largest telescopes.

We find ourselves then in a galaxy which is just one amid many millions This galaxy has two dwarfish satellites-the Star Clouds of Magellan, which are at a distance of about 80,000 light-years Beyond these, the nearest of the other systems is so remote that light takes 750,000 years to traverse the void which separates us from it The number of stars in our own galaxy is of the order of 100,000 millions. To one of the less distinguished stars of this host is attached the earth, which is our home. The evolutionary process which has swept across this system, condensing stars out of the numitive mist, has occurred a time which must be reckoned in thousands of millions of years. From this orgy of inconceivable numbers we may, perhaps, glean an impression of man's place in the material universe. The space and the time which belong to him are as nothing in the far extent and the untold ages of inorganic nature. Is terrestrial man the one and final purpose of it all? Nothing in astronomy has appealed more to the imagination than the conception that each of the myriad points of light in the sky may be giving warmth and light to planets like our earth. It would seem a presumption to deny to them inhabitants of the same order of creation as ourselves. Nevertheless, we must not forget the prodigality of nature. If indeed she has no grander aim than to bring forth her favoured child, man, it would be just like her methods to scatter a million stars whereof but two or three might haply achieve her purpose. Strong reasons have been given by J. H. Jeans for regarding our solar system as a very unusual development. Although probably not unique, the formation of a system of planets is not the normal course of evolution of a star. It only happens when, at a critical stage of development, disruption is caused by the accidental approach of another star-a fortune which, perhaps, not one star in a hundred millions would be likely to undergo. This theory is subject to much uncertainty; but it is at least a useful corrective to the view, often too facilely accepted, which assumes an almost infinite plurality of hving worlds.

History of the Study of Stars.—In the older books on astronomy most of the space is devoted to the bodies of the solar system (sun, moon, planets, comets); the little that was known of the stars could be compressed into two or three chapters at the end. It is natural that our first acquired knowledge should relate chiefly to the bodies that are nearest to us. Much labour was devoted to observing the stars, but that was largely because they had to serve as graduation marks in the sky against which the movements of the planets and comets could be recorded. Of late the centrifugal march of astronomical knowledge has been very remarkable, and the study of the stars is now the largest field of astronomical research. The following may be selected as the chief fandmarks in this progress:

 The first new star or nova was discovered by Tycho Brahe in 1572. 2 The first variable star (Mita Cett) was discovered by Fabricius in 1596.

3. The first double star (Mizar) was discovered by Jean Baptiste Riccioli in 1650

4 Edmund Halley first detected the proper motions of stars (Arcturus, Aldebaran, Sirius) in 1718

5 Sit William Herschel may be tegarded as the pioneer of studies of the sidered system He discovered the solar motion (motion of the sun through the system of the stars) in 1783. By his famous counts of stars (start-gauges) he established the fialtened form of the stellar universe. In 1803 he was able to announce, from his measures of double stars made drung the previous 25 years, the confirmation of the theory (urged by Christian Mayer in 1720) that the components revolve round one another

6 In 1839 distances of the three stats 61 Cygni, α Centauri and Vega were found by measurement of parallax by F W Bessel, T Henderson and F G. W. Struve respectively. This gave the

first definite idea of the scale of the stellar system

7 In 1862 William Huggins applied the spectroscope to the stars and identified many familiar terrestrial elements as present in their atmospheres. The classification of stars according to their spectra was instituted by Angelo Secchi shortly afterwards.

8 Photography of the stars was developed between 1882 and 1887, the international photographic chart of the heavens and catalogue (not yet completed) being planned in the latter year

9 Measurement of the velocities of stars in the line of sight by means of the spectroscope was developed very slowly in the latter part of the 19th century. The early measurements were entirely untrustworthy, and it is difficult to say when this powerful and to stellar research properly started. Good results were obtained by H C Vogel and J Schemer in 1838–91. A great development of this branch of work was brought about by W W Campbell from 1897 onward. The first spectroscopic binary star (Mizar) was tough by E C Pickening in 1880.

10. J C Kapteyn discovered, in 1904, that, at least in our local system, the stars are moving in two main streams. This gave great stimulation to statistical studies of the sidereal universe.

11. The distinction between giant and dwarf stars made manifest by the researches of E. Hertzsprung and H. N. Russell began to be generally accepted about 1913

12. The study of the internal constitution of the stars, on the basis of the theory of radiative equilibrium, was begun by A S Eddington in 1916.

13 The first direct determination of the angular diameter of a star, ic, the apparent size of its disk, was made by F G Pease and J A. Anderson in 1920, using an interferometer designed by A. A. Michelson.

14. The physical theory of ionization was applied by M N Saha to the interpretation of spectral features of the stars in 1920 This led to a branch of research which has had most extensive developments.

The Twinkling of Stars .- Before entering on a fuller account of this progress we must refer to a question which is often put Why do the stars twinkle? If we trace the beam of light, roughly 10 in. in diameter, which fills the eye-pupil back toward the star, it has passed through some miles of terrestrial atmosphere. Differences of density due to slight inequalities of temperature will cause continual changes of retraction at one point or another on the path, giving rise to a general unsteadiness. More important still is the "interference of light." The irregularity of density may be such that the light at opposite edges of the narrow beam has traversed different effective thicknesses of air, so that the corresponding waves are delayed by different amounts. If the delay amounts to half a wave length the waves will arrive creston-trough, and, instead of summing up to give a bright starimage, they will cancel one another. Thus the image pops in and out as the changes of atmospheric density succeed one another The condition for cancelling is different for light of different colours (corresponding to different wave lengths), consequently the star sparkles with different colours. To understand why this does not happen to the light of the planets we must recall that the disk of the planet, unlike the star-disk, subtends a considerable angle at the eye. The diameter of Saturn, for example, is normally about 20 seconds of arc, which means that at the height of a mile the rays which reach the eye fill an area 6 m. in diameter. This gives plenty of scope for the variations of the individual beams ('A'm in diameter) to average out, and consequently they combine to give a fairly steady brightness. Interference or canceling of waves occurs between waves teaching different parts of the pupil, but not between waves starting from different parts of the disk of the planet or star, thus trivialing depends on the ratio between the angular sizes of the celestial object and of the eyepula as viewed from an average height in the earth's atmosphere

## NUMBER AND MAGNITUDE OF THE STARS

On a clear dark night the stars seem to be innumerable in multitude, but in reality the number in the whole sky visible to the unaided eye is about 6,000 A small telescope greatly multiplies the number, and the largest instruments (aided by long photographic exposures) would reveal some hundreds of millions. The brightness is expressed by "magnitudes," the progressively fainter stars being of progressively greater magnitude. A star is defined to be one magnitude higher than another if its light is fainter in the ratio 2 512; this ratio is adopted so that a difference of five magnitudes may correspond to a light-ratio of 1 100. The faintest stars visible to the naked eye on clear nights are about the 6th magnitude The brightest star, Sirius, has magnitude -1.6 se, 76 magnitudes brighter, or just over 1,000 times more luminous, than the faintest naked-eve stars. Classified on the same scale, the sun's magnitude is -26 7. It is possible with the largest instruments to reach stars of about the 21st magnitude. It gives some idea of the light-grasp which has been attained if we notice that the interval from the sun to Sirius (25 magnitudes) is comparable with the interval from Sirius to the faintest stars observed (23 magnitudes).

If the stars were distributed uniformly through infinite space and their light suffered no absorption, each magnitude would comprise 3.98 times as many stars as the preceding magnitude (the number 3.98 times as many stars as the preceding magnitude (the number 3.98 is the 3-power of the light-ratio 2.512). This theoretical star-ratio is not realized in the actual distribution. It may be taken as a rough rule that an increase of one magnitude multiplies the number of stars about threefold for the highest stars. This is an indication that the density of distribution of the stars in space falls of at great distances—that we are in the middle of a limited cluster or star-cloud. The following table gives the results of F H Seares and P, J, van Rhyin (1925) for the number of stars in the sky brighter than the midicated visual magnitude

Magm-	Number	Magni-	Number	Magni-	Number
tude	of stars	tude	of stars	tude	of stars
40. 5.0 6.0 70 8.0	530 1,620 4,850 14,300 41,000	90 100 11.0 . 120 130	117,000 324,000 870,000 2,270,000 5,700,000	14.0 15.0 16.0 17.0 18.0	13,800,000 32,000,000 71,000,000 150,000,000 296,000,000 560,000,000

Up to a certain point each magnitude contributes more star hight than the precoding, the mcressed number of stars in the magnitude-interval more than counterbalancing their individual faintness. The maximum is reached between the 11th and 12th magnitudes, the 1,500,000 stars in this interval giving a combined light equivalent to 8, stars of magnitude 10. Beyond this the contribution falls off. All the stars together give as much light as 1,100 stars of magnitude 1.0—a result which has been checked closely by direct measurement of the general light of the sky By extrapolating to fainter magnitudes, Seares and van Rhijn estimated the total number of stars to be about 30,000,000,000. In 1925 the dimining of distant stars by the diffuse matter in interstellar space was not realized. This dimming must result in counts of stars gwing an underestimate of the total number of the stars.

The above figures relate to the whole sky. Interesting results

are tound when we compare the density of distribution of the stars in different parts of the sky, particularly when we compare regions in the plane of the Milky Way with those near its poles. The galactic concentration (ratio of the number of stars in equal areas in the galactic plane and at the galactic pole) increases from 34:1 for mag 4 to 4 3.1 for mag. to, and to 2 1.1 for mag 18. These results refer to photographic magnitude, no sufficiently extensive counts for visual magnitude being available. The great access of stars in the galactic regions is not wholly or even mainly due to the star-clouds of the Milky Way itself; the star-density increases steadily from the poles to the galactic plane, and the conreached. This phenomenon was discovered by William Herschel and the modern results are in good agreement with the starcounts made by him and by his on, John Berschel.

The density of the stars in the vicinity of the sun (the "local system") was found by Jacobus Kapteyn to diminish in all directions outward from the sun They were therefore believed to form one of many star-clouds lying in the galactic plane, the whole being coiled into a spiral nebula. But the effect of dimming by obscuring matter has to be taken into account. The average effect is an obscuration of about 08 magnitudes in a distance of a kiloparsec The obscuring matter is not uniformly distributed and the amount of the obscuration is different in different directions and does not increase uniformly with distance. It is at present doubtful whether there is an increase or decrease of star-density outward from the sun and the existence of a local system remains uncertain From other considerations it is known that we are very far (about 8,000 parsecs or 26,000 light-years) from the centre of the galaxy, which is found to be in the direction of the constellation Sagittarius. The sun cannot be said to occupy a privileged position among the stars it is an outlier in the galaxy, which in turn is only one among many millions of its kind

Nomenclature of the Stars.—The brighter stars are designated by a Greek letter followed by the name of the constignation, according to a system introduced by J. Bayer in his star maps in 1605. The letters are assigned roughly in order of brightness, but for stars of nearly equal brightness the order is that of position in the constellation usually beginning at the head of the object figured. Alternatively, a system of numbers (followed by the constellation name) introduced by John Flamsteed can be employed; this covers many stars which have no Bayer letter. Flamsteed's numbers were assigned in order of right ascension. For example, 27 Germonium — 6 Geminorum, 32 Leonis « Leo-

nis = Regulus A number of ancient names of conspicuous stars reference to a theory of the progress of stellar evolution which survive, many of these are of Arabic origin. The list on page 319 gives those which are familiar to the modern astronomer, together with their Bayer equivalents and their visual magnitudes

The Arabic names of many additional stars are in common use in sea and air navigation, where a proper name is preferred to a Greek letter followed by the name of the constellation, the Arabic names of these additional stars are rarely used by astronomers Only 20 stars are ranked as brighter than mag 1 5 Of these 17 (including the variable Betelgeuse) are named in the above list. The other three are the southern stars, & Centauri (mag oo6),

β Centauri (0 86), β Crucis (1 50). Stars not bright enough to have a constellation letter or number are designated by their reference number in some catalogue Thus we have names like Bradley 1,940, Groombridge 2,230, Boss 3,932, the last reference (Lewis Boss, Preliminary General Catalogue), being especially preferred The most comprehensive source of reference is the Bonn Durchmusterung made by Argelander. This work, completed in 1862, lists the places of 324,000 stars between the north pole and 2° S. An extension to 23° S by Schonfeld adds 133,000 stars Star charts to be used with the catalogue are published, and there is no difficulty in identifying in the sky a star referred to, for example, as B D.+13°, 2,966. The Cordoba Durchmusterung (CDM) and Cape Photographic Durchmusterung (CPD,) fulfil a similar function for the rest of the southern sky. For stars fainter than the limits of these surveys an author must describe the identity as best he can.

Double stars are generally designated by the name of the discoverer, with the ordinal number of his discovery, or the number in Burnham's General Catalogue may be given. Variable stars are assigned (in order of discovery in the constellation) Roman capital letters from R to Z, or a pair of these letters, eg., X

Cygni, RT Aurigae Colour of Stars.—In stellar observation the photographic plate is used quite as commonly as the eye Alongside the visual scale of magnitudes measuring the brightness of the stars as judged by the eye, we have a photographic scale of magnitudes giving the brightness as judged by the effect on ordinary photographic plates It is well known that blue light has proportionately greater actinic power than red light; consequently a comparison of the magnitudes of a star on the two scales gives a measure of its colour The difference, photographic minus visual magnitude, is called the colour-index. (See Photography, Celestial) The visual estimation of magnitudes for stars differing in colour is complicated by the Purking effect, the relative sensitivity of the eve to differing colours varying with the intensity of the light Photovisual magnitudes, determined photographically with isochromatic plates and a suitable colour filter, agree closely with the visual scale and are free from the Purkinie effect, and have accordingly in large measure superseded the visual magnitudes.

A classification which runs nearly parallel with classification by colour is afforded by examination of the spectrum of the light In the Draper classification, now universally adopted, a continuous sequence of types is recognized denoted by the letters O, B, A, F, G, K, M. Intermediate types are indicated by decimal division, e.g., A2 is a type two-tenths of the way between Ao and Fo. A cursory examination of the spectrum is sufficient to determine the type, and 225,000 stars have been classified in this way by Miss A. J. Cannon (Harvard Annals, vols. 91-99). The sequence O to M corresponds to progression in colour from blue to red, and progression in temperature from the hottest to the coolest stars. The sun is of type Go. The percentages of stars catalogued in these classes are: B, 2; A, 29; F, 9; G, 21; K, 33; M, 6. Type O is rare, not more than 20 stars brighter than mag. 6.25 being known. The letters R, N, S denote other rare types whose relation to the recognized sequence is still uncertain. The properties of the stars (distribution, mass, luminosity, motion, variability, etc.) are all closely correlated to the spectral type; so that in nearly all investigations it is necessary to study the different types separately. The terms "early type" and "late type" are still commonly used in accordance with the order in this series, ie., for the bluer and redder stars respectively. The terms originally had is now entirely discarded

Some progress has been made with the direct measurement of the heat received from the stars, and the corresponding bolomet-11c magnitudes (related to heat intensity in the same way that visual magnitudes are related to light intensity) have been determined The star-image is focussed on a small disk in which a thermoelectric junction is embedded, and many hundreds of stars are found to give sufficient heat to be measured in this way. The main trouble in these investigations is that the radiant heat over a certain band of wave lengths is largely absorbed by the watervapour in our atmosphere, and rather large corrections must be applied on this account. The bolometric magnitude may also be applied of this account inferred from the visual magnitude by applying a correction depending on the spectral type of the star This correction, called the heat-index, is analogous to the colour-index, and varies in correspondence with it. Naturally, the red stars are "brighter" bolometrically than visually, because their radiation is of low luminous efficiency The greatest luminous efficiency is for stars of types F and G, perhaps because the human eye has been developed so as to make the most of sunlight. In still hotter stars there is a falling off of luminous efficiency, the radiation being too far in the violet and ultra-violet to suit the eye

Absolute Magnitude.-We turn now to consider the real brightness of the stars How would they compare with the sun in splendour if we could see them at the same distance? To infer the true brightness from the apparent brightness we must first know the distance (for the methods of measuring the distance see Parallax). An idea of the variety of brightness may be given by considering the seven most conspicuous stars. Sirius gives 28 times the sun's light, but it has a companion only 3 40 as bright as the sun. Canopus is so remote that its distance cannot be found accurately, but it can scarcely be less than 10,000 times as luminous as the sun. a Centauri consists of two stars, one almost a replica of the sun and the other considerably fainter. Then follow Vega and Arcturus with luminosities 50 and 100 in terms of the sun. Capella consists of two stars, with luminosities 110 and 70, having a faint distant companion of luminosity about oor. Rigel is remote, but its distance is more certain than that of

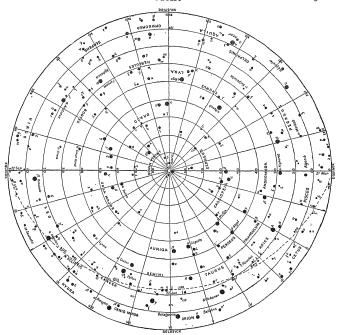
Canopus, its luminosity is greater than 10,000.

This shows that there are stars tar surpassing the sun in brilliancy; but, naturally, if we pay attention only to the most conspicuous stars we shall form an exaggerated idea of the general order of brilliance. There would be the same difficulty if we extended our survey to all the naked-eye stars; these would include the most luminous stars contained in a very wide region and the feebler stars in a much smaller region. It is only by rather elaborate investigations that we can get together a fair sample of the stellar population, in which the luminous stars are not over-represented by forcing themselves on our attention. According to the latest discussions the following table gives the relative proportions of stars of different degrees of intrinsic brightness in any volume of space:

Light power	Number	Light power	Number
10,000 × sun 1,000 " . 100 "	3,300 42,000	1 Xsun . 0.1 " 0.01 "	200,000 350,000 500,000 600,000

Stars fainter than the sun far outnumber those which are brighter. At present the faintest known star is one to which attention was drawn by G. van Biesbroeck. It is a distant companion to the star BD+4°4048 and has an absolute photovisual magnitude of 18.1 and an absolute photographic magnitude of 19.5 It has only 1/200,000 of the brightness of the sun, but it is still seven magnitudes brighter than Jupiter at full phase. It is intrinsically fainter by about three magnitudes than the next faintest known star, Wolf 359. The faintest known stars are all cool red stars.

At the other end of the scale it is difficult to assign an upper limit to the brightness because the objects suspected of great brilliancy are generally too remote for parallax measurement. In

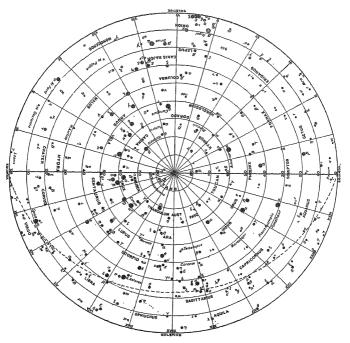


# MAGNITUDE: 1 2. 3. 4.

ST COURTEST OF J. C. CLANCEY, I.S.O., F R A S., FROM "SIMPLIFIED STELLIN MAPS" PUBLISHED BY THE SUPERINTENDENT, GOVERNMENT PRINTING AND STATIONERY, RANGOON

### STAR CHART OF NORTH POLAR HEMISPHERE

used their shight to the make see and onth of the calcular expector are shown in this chart. The North Starposite, is shown clustify fa the right of the north colerate pole. This star is not except two earth. At the sectom of the chart is the first magnitude star Betsjones in the constitution of Orion. This was the first of the large stars to have its dimensior measured. At the first of the contribution of Orion. This was the first of the large star to have its dimensior measured. At the first of the contribution is the "Greet Bear" with its pointer time solar system is moving at the rate of about 12 miles per second. Owing to the rotation of the earth on its axis, all stars thorn in this chart speace to rotate around the north coleration pick in a counter clockwise direction. 320B STAR



# MAGNITUDE: 10 20 3.4.

BY COUNTEST OF J. C. CLANCEY, I S. O., F H. A. S., FROM "SIMPLIFIED STELLAR MAPS" PUBLISHED BY THE SUFFEMENTENDERY, GOVERNMENT PRINTING AND STATIONERY, PANGOON

### STAR CHART OF THE SOUTH POLAR HEMISPHERE

Showing all of the principal ster wishts to the maked eye found onth of the solicital sensior. To the left of the seath scattalin food. In the chart is the Southern Gross, (from), Salve the south scattalin point est slightly to the left is Secretic which contains the gleat red star Antara, which has the greatest dismater of any star that has been measured us to the present time. It is visible from practically waver point in the inhabited word. To the right it consistent of the principal scatter of the principal scatter of the scatter of the chart. All star shows in chart space for receive around he south octubilization in chart space for receive around he south octubilization is chart space for scattering the scattering that scattering the scattering the scattering that scattering the scattering the scattering the scattering that scattering the scattering the scattering that scattering the scattering that scattering the scattering the scattering that 
the star clusters, however, we see a group of stars all at practically the same distance, and can therefore measure at once the relative hightness of different classes of objects. The variable star S Doradas in the Greater Magellaine Cloud has a mean absolute magnitude -9-4(500,000/\$um), and other stars in the same cloud are not far short of this. The tange in real brightness of the stars is at least 24 magnitudes—very much the same as the range in apparent brightness of are as it is possible to observe it.

Size of Stars.—The radius of a star may be calculated from the absolute luminosity (which requires a knowledge of the star's distance) and the observed surface-temperature. Other things being equal, the luminosity is proportional to the area of the surface, ie, to R2, but allowance must be made for the different radiating power of surfaces of different temperatures, this allowance can be calculated from the laws of radiation (Planck's law) In this way it is found that the stars differ greatly in size Some have diameters some hundreds of times greater than that of the sun; others have diameters less than one-hundredth that of the sun If the sun were placed at the centre of Antares. the entire orbit of Mars would be well within the star. Van Maanen's star, on the other hand, is smaller than the planet Neptune. For a few stars, the sizes deduced from the star's luminosity and surface temperature have been confined by direct measurement of the apparent angular diameter of the disk with Michelson's interferometer

Interferometer Measurements.-The measurement of the angular diameters of a few favourable stars has been made by means of Michelson's interferometer (q.v). As adapted to astronomical work this consisted of a 20 ft. beam carrying two inclined mirrors which could slide along it, and carried on the 100 in telescope at Mt. Wilson observatory; the light from the movable mirrors fell on two fixed mirrors, and was directed by them on to the great telescope mirror Virtually the observer was looking simultaneously through two apertures whose separation could be varied up to 20 ft, very much as in a gigantic range finder. (See BINOCULAR INSTRUMENT Stereoscope) The effect of using two apertures is that the spurious (diffraction) disk of the stellar image is crossed by fine diffraction lines, and the lines become closer as the separation of the apertures is increased. If the object looked at is not a mere point of light, its finite size blurs the diffraction pattern, and the object of using widely separated apertures is to obtain a diffraction pattern so fine that even the invisible disk of a star is sufficient to blur it out and make it disappear. Seven stars have been found to have angular diameters exceeding o."02 which is about the limit attainable with this instrument, a 50 ft interferometer has been constructed at Mt. Wilson, with which some further measures have been made, but the great majority must remain beyond the scope of this method. In some ways this application of the interferometer is to be regarded rather as a tour de force than an important advance of knowledge, serving merely to confirm the angular diameters inferred from the diameters, computed as described above, and measured distances Of special interest, however, are the observations of the variable stars, Mira Ceti and Betelgeuse; here the interferometer measurements indicate variations in the diameter, rare. and seem to confirm the theory, put forward on other grounds, that this type of variability is due to pulsation.

Another application of the interferometer is to measure the separation of double stars in which the components are so close that ordinary visual measurements are impossible. In particular Capella, which is, known to be a double by spectroscopic observation, cannot be resolved by any telescope. Nevertheless, by interferometer measurement the ordinary by the second of the second

## DOUBLE STARS

About the year 1650 Jean Baptiste Riccioli made the first discovery of a double star, viz., Mizar or § Ursae Majoris, the middle star in the tail of the Great Bear. Looking at Mizar with the naked eye, we see a fainter star, Alor, very close to it; it is a

fair test of eyesight to separate them. Their separation is however, 11', and although there is no doubt that Mizar and Alcor have a physical association, since they are found to be moving at just the same rate across the sky, the term double star is only applied in case of much closer proximity Riccioli's discovery was that Mizar itself consists of two stars separated by 15" or about 10 of the distance between Mizar and Alcor This would now be regarded as a wide pair, and many of the most interesting double stars have a separation under 1". The actual distance between the two components of Mizar is not less than II times the distance of Neptune from the sun. The two stars must be attracting one another, but the gravitational control across such a distance is so teeble that they will take more than 3,000 years to complete their orbital revolution. It is, therefore, not surprising that the measures made during the last 150 years fail to indicate definitely any orbital motion; and the only evidence of genuine connection (apart from the improbability of two independent bright stars lying so closely in the same line of sight) is aftorded by their common motion across the sky, and common radial velocity.

Similar discoveries followed rapidly  $\theta$  Orionis (in the mids of the great nebula) was resolved by Huyghens in 166.9. A misst by Hooke in 1664. In the southern hemisphere the duplicity of  $\alpha$  Crucis and  $\alpha$  Centauri was discovered by Jesut missionaries in 1685-89. The foundation of systematic measurement and study of double stars is due principally to William Herschel and Whilehm Struve The latter, working at Dorpat between 1813 and 1835, formed a catalogue of 3,110 pairs as the result of surveying about 120,000 stars.

The number of recognized visual double stars is now about co,000, but the number is necessarily somewhat arbitrary since, if too wide limits of separation are admitted, stars which are only in accidental poximity may be included. Among the naked-eye stars, one in nine is a telescopic double. It is certain that the true proportion of binary systems is much greater than this, many being too close to be resolved with the telescope. Thus, taking the nearest known stars (which give the best chance of observing duplicity), eight out of 20 are double.

Catalogues of double stars no doubt contain a number of spurious pairs, i.e., stars which are not actually near one another in space and merely happen to lie in the same line of sight, but considerations of ptobability show that there will not be many of these. The physical connection is generally shown, as in the case of Mizar, by common proper motion II spectroscopic determinations of radial velocity have been made these will provide an additional check. The connection implied is evidently the connection of a common origin. The two stars were born from the same abould, they originally shared in common the velocity of the parent hebula, and they have given the same influence to get their bear in most of them the gravitational tie is too weak to resust any differential disturbance, e.g., another star passing between the pair. The fact that so many of these wide doubles survive teaches us that chance approaches of stars to one another must be very rare.

Of greater interest are those double stars close enough together to show the effects of their mutual gravitation. There are about 170 double stars for which it has been possible to work out definite orbits. In about 2,000 more there is a rough indication of orbital motion, but the arc described since observation commenced is too short to determine the orbit satisfactorily. The shortest periods are 5.7 years (8 Equulei) and 6 9 years (13 Cet1); about 60 pairs have periods of under 100 years It is natural to enquire whether the planes of the orbits tend to he m any particular direction-parallel to the galactic plane, for example. A curious difficulty arises in this investigation. If the reader has watched the revolution of a cup-anemometer (or of a garden sprinkler) he will probably recall that the direction of revolution appears obvious and unmistakable, but after blinking the eyes the revolution seems just as unmistakably in the opposite direction and in a different plane. For the same reason we always find two planes of rotation of the double star, either of which may be the true one We can only adopt both planes, and investigate as best we can the resulting mass of data, half of which is correct and half spurious. So far as can be ascertained the planes of double star orbits are quite at random.

The two dog-stars, Sirius and Procyon, are double stars of exceptional historic interest. Being conspicuous stars they were well observed a hundred years ago and used as fundamental reference stars for determining time, etc. It was found that they were moving irregularly-not with uniform proper motion like other stars It was evident that each was being disturbed by the gravitation of a massive body in its neighbourhood, although the comand orbits were computed from the observations, the periods of revolution being 50 and 39 years respectively The disturbing stars, whose existence was thus convincingly demonstrated, have since been seen. The companion of Sirius was observed by Alvan Clarke in 1862, and 1s a comparatively easy object for modern telescopes; the companion of Procyon, which is more difficult, was observed by Schaeherle in 1806. They are faint stais, respectively 10 and 13 magnitudes fainter than their primaries Nevertheless, they must be massive bodies to exert so large a pull on their brilliant neighbours

Another star of special interest is the double star, 6: Cygn: In 1942 Stand found that one of the visual components was perturbed by an unseen faint companion, which proved to have a mass of only  $\frac{1}{2}$  that of the sun. This is considerably more massive than Jupiter, but much less massive than any star of known mass. It is inferred that this faint companion cannot be self-luminous and it must therefore be regarded as a massive planet and not as a star.

Masses of Stars.—The orbital motion of double stars conforms to the law of gravitation. It gives evidence that gravitation is universal in the stellar system. The study of binary systems performs a unique service in the general advance of our knowledge of the stars since it is through it that we arrive at knowledge of the stars. By the law of gravitation the extent to which a body disturbs the motion of other bodies is proportional to its mass. It is when we find bodies in dose proximity that we obtain a chance to observe the disturbance, and so obtain a measure of the mass. It is good fortune for the astronomer that the course of evolution has been such as to provide pairs of stars close enough together; otherwise we should probably still be in total ignorance as to the masses of stars, except in so far as the sun's known mass might be assumed to be twrated.

If  $M_1$ ,  $M_2$  are the masses of the two components, a the mean distance between them (strictly the semiaxis major of their relative orbit), and P the period of revolution, Kepler's laws give

$$k(M_1+M_2)=a^3/P^2$$

where k is a universal constant. Let us measure the mass in terms of the smis mass a unt, the perfol in years, and an astronomical units, sc, in terms of the earth's distance from the sun Applying the equation to the earth's motion round the sun (the earth's mass  $M_t$  being negligible) we see that for these units k=1. Now apply the equation to Sritus. The mean distance of the two components is 7.55 seconds of arc. To convert this into linear measure we must know the parallar of Sirus, 9.37 second. This ments that one astronomical unit seen at the distance of Sirius would appear to catend 0.37 second; hence 7.55 seconds corresponds to 9.4 astronomical units, determining a. The period P is 4.9 years. Hence

$$a^3/P^2 = (20.4)^3/(40)^2 = 3.5 = M_1 + M_2$$

We learn, therefore, that the combined mass of the two components is three and one-half times that of the sun If it is preferred to express the mass in tons, this can be done since the sun's mass is 1,980,000,000,000,000,000,000 tons.

To find the masses of the two stars separately we must determine their absolute orbits about their common centre of gravity instead of the relative orbit considered above. This means measuring the motions of the components with respect to surrounding stars instead of with respect to one another, It is found that

the bright star has the greater share of the mass, nearly in the ratio 3 I

From the visual double stars, together with the spectroscopic binaries (described below), an idea of the masses of stars in general has been obtained. Comparatively few determinations reach high accuracy, because a rather accurate parallax is reoured which is not generally forthcoming. The first thing that strikes us is the wonderful uniformity of mass. By fai the majority of the determinations give between one-third and three times the sun's mass, which seems a very small range when compared with the great differences of luminosity. Another result brought out is the close relation of mass to luminosity, the brighter stars being the more massive. It is probable that (excluding a peculiar class of stars known as white dwarfs) the luminosity depends almost entirely on the mass; it makes little difference whether the star is in a dense or in a diffuse state. The theory of this relation will be explained later Having checked it by the masses determined for double stars, we can use it to find the masses of other stars whose absolute brightness is known

We naturally select the most conspicuous stars for special investigation, and as a result we tend to pick out exceptionally inwestigation, and as a result we tend to pick out exceptionally inmasses. Among the spectroscopic binaries some very high masses have been found, which, however, are believed to be exceptional. For one binary of Type O discovered by J. S Plaskett the components have masses greater than 87 and 73 in terms of the coulding the properties of the control of the control of the conponents have masses greater than 87 and 73 in terms of the summasses 36 and 34. The eclipsing variable V Puppis has twoponents each of mass 19 2. There is at present no evidence of any stellar masses below one-sixth of the sun's mass.

From the close uniformity of stellar masses it follows that the stars of gigantic volume like Betelgeuse must be of extremely low density. Assuming that the mass of Betelgeuse is something less than 100 times the sun's mass, in order to fill a volume 50,000,000 times greater than the sun, the density must be less than  $\frac{1}{100}$  that of air. The small compact stars, like the companions of Siruis and Procyon, which are of planetary dimensions, must be of extremely high density, many thousands of times that of water. The large, diffuse, highly luminous stars are called gunt stars; the stars of low luminosity, which are smaller and of higher density, are called durn't star.

Spectroscopic Binaries.—When a source of light is approaching us, the lines in its spectrum appear displaced towards the violet end: when receding, the displacement is toward the red end. By means of this "Doppler effect" (see Light) the velocity of a star in the line of sight can be measured. In examining the stars with a spectroscope we sometimes turn the instrument on to what is telescopically a single point of light, but is actually a double star with components too close to be separated. Since the two components have different velocities toward or away from us their spectra will not be exactly superposed and every spectral line will appear double. The first example of this was found by E. C. Pickering in 1889. This was the star Mizar already mentioned as the first visual double star to be discovered. The two components seen in the telescope take at least 3,000 years to perform their revolution; but the doubling of the spectral lines of the brighter component shows that it is itself a double star with a revolution period of 104 days. If a star showing a doubled spectrum is watched for some time it is seen that the doubled lines close up and then cross one another This is in accordance with the theory of orbital motion, for the two components must approach us and recede from us alternately in the course of a revolution.

It is only when the two components are of nearly equal brightness that this doubling of the spectral lines can be observed A difference of about two magnitudes is sufficient to render the finiter spectrum invisible. In the majority of spectroscopic binaries only the brighter spectrum is observed, and the binary character is inferred from the periodic approach and recession of the source emitting it. The argument is that the changing displacement of the spectral lines shows that the source of light is describing an orbit; there must be some mass for it to revolve around; and therefore a fainter component must exist although invasibe About 1,500 spectroscopic binaries have been discovered, and definite orbits have been computed for about 400 of these The spectroscope can only measure velocity in the line of sight, and many binaries must escape detection through having their orbits nearly perpendicular to the line of sight.

Spectroscopic binaties, afford valuable additional information as to the masses of statis, but of a statistical rather than of an individual kind. When one component only is observed, all that can be deduced is a rather complicated function of the masses and the unknown inclination of the orbit; but when both spectra are observed, a minimum mass of each component can be found. This minimum mass has to be multiplied by cosec? a (s-inclination of orbit plane to the sky plane) which is unknown unless the star can also be observed visually or is an eclipsing variable, but in researches on the average mass of any class of stars a

suitable mean value of this factor may be used

and an electronic to a state of may be observed as a visual and a spectrostopic burn's but in general only the close pairs with person of the close pairs with person of the close pairs with person of the person o

Multiple systems containing more than two components are not uncommon We have already noticed the system of Mizar. The star Castor is an easy visual double, both components of which are spectroscopic binaries These systems all appear to be built by successive subdivisions of one mass into two, and it is clear that after such a fission a long period of evolution and condensation must elapse before either of the resulting masses is ready to divide again. An important question is whether the widely-separated pairs were originally formed with their present separation or whether the distance has increased in the course of time. It is difficult to resist the impression that the components gradually recede from one another, especially as the statistics show markedly that the stars supposed to be oldest in evolution form the widest pairs. Two causes are acting which will tend to increase the initial separation to some extent, viz., the mutual tidal forces and the loss of mass of the stars by radiation; but neither can produce a large effect. The cumulative effect of perturbations by casual approaches of other stars would in the long run, drive the components further apart; this process, however, is too slow to produce much effect, even in the long periods of stellar evolution The general problem of the formation of double stars is discussed in the article Cosmogony.

# VARIABLE STARS

There are three main classes of variable stars: (1) eclipsing variables, (2) Cephied variables, (3) long period variables. In a sense the sun is a variable star, since the changes of its surface condition which follow the suspect cycle of 1rly years must anvolve some small variation in the rate of emission of light and heat (see Suv.) but this is not analogous to any of the recognised forms of stellar variability. Nowae or "new stars" might also be counted technically as variables; it is, however, no longer be-lieved that they have anything in common with the ordinary types of variables, and we shall not include them here. (See Nov.).

Retipsing Variables—In this type of variation there is no physical change in the star. It emits light steadily all the time, but it is occulted at times by another body passing in front of it. The present explanation dates from 1798, when John Goodricke, having discovered the regular-period of fluctuation (2<sup>4</sup> 20<sup>4</sup> 49<sup>89</sup>) of the variable star Algol, suggested that the periodic dimming was caused by a dark body revolving round it and ethissing it once a revolution. Knowing, as we now do, that there

are multitudes of close binary systems, it is only to be expected that we should sometimes observe an eclipse of one component by the other. Each system will provide regularly recurring eclipses for observers stuated sufficiently near the plane of the orbit, the eclipsing variables are therefore ordinary binaries whose orbits we happen to be viewing nearly edge on. For Algol and many other variables of this class it has been venified that the object is a binary system, and that the decline of light occurs when the principal star is in the part of its orbit most remote from us, which is the time when the second component would intervene

It is not necessary to assume that the intervening object is a dark body Even if the system consisted of two equal stars a total eclipse of one by the other would halve the light received in most systems that have been studied, one component is considerably brighter than the other, but the light of the second component is quite recognisable. Half a period after the main eclipse, when the faint star occults the brighter, a secondary eclipse is observed owing to the bright star occuling the fainter There is, of course, a considerable period when no eclipse is occurring and the system shines steadily with its maximum light (By this feature eclipsing variables are easily distinguished from all other types). The steadiness in these intervals is, however, only approximate, and is complicated by two phenomena of singular interest.

(1) Reflection Effect—Systems in which the two stars are very click together have the best chance of showing echipses, since the orbit does not then need to be so accurately orientated with respect to our terrestinal post of observation. The closeness of some of the best-known echipsing variables is remarkable, the components being separated by no more than their own diameter. Each is therefore strongly illuminated by the other, and the hemisphere turned toward the companion becomes heated and shines more brightly than the other hemisphere For the fainter star in particular, the disparity in brightness of the two hemispheres is considerable, and as it moves round its orbit it exhibits variations of brightness analogous to the phases of the moon Owing to this reflection effect, the end of the principal celipse is followed by a gradual brightening, which continues until the dup representing the secondary echipse begins

(2) Ellipsoidal Effect.—Owing to their close proximity the two stars are distorted, being clongated toward one another. Thus, in addition to the variation due to eclipses and reflection, there will be a variation depending on the aspect of these clongated objects. Their apparent sections will be smallest when we see them end-on near the time of the eclipses; halfway between eclipses we see the prolate spheroids broadside-on and correspondingly brighter.

We may hope ultimately to learn much as to the physical state of the stars from these two effects; but, microtrusately, they are only just within our range of detection, and it is difficult to obtain accurate measurements of their amount. Meanwhile, an examination of the light-curve during the echipes teaches us much about the dimensions of the system. The method of analysing the light-curves was developed by H. N. Russell and H. Shapley, for an example of the results obtainable see Alcoia. As a rule the fainter component is found to have the larger diameter although it has the smaller mass; i.e., the companion is one of the giant diffuse stars of fairly low density and surface temperature. The colipses are usually partial, but are in a few stars total or annular. The number of ecloping variables known at present is about 200.

Cepheid Variables—Like the preceding class the Cepheid variables have short periods seldom exceeding 20 days, but the cause of the variation as entirely different. A very agantican fact is that the colour of the light (or the spectrum) is different at maximum and minimum light, showing that the star undergoes an actual physical change The surface temperature is much higher at maximum than at minimum, and, in fact, the changes of brightness may be ascribed to the changes of temperature. It is probable that the Cepheid variable is a pulsating star—a globe which swells and contracts with a regular period. Leaving aside the question as to how the star comes to let this-oscillating state, the pulsation theory agrees with the main phenomena The alternate compression and rarefaction naturally produces the

324 changes of temperature; moreover, the approach and recession, as the part of the surface presented toward us heaves up and down, is observed and measured spectroscopically. The most striking confirmation is the agreement of the theoretical period of such a pulsation with the observed period. The natural free period of a pulsation of a spherical mass of gas should vary approximately as the inverse square root of the density, and the observations show that the Cepheids closely follow this law; moreover, the absolute value of the period can be calculated (with a small margin of uncertainty due to our ignorance of the chemical constitution of the star's interior) and the observed period is found to agree On the other hand, no satisfactory theoretical explanation has yet been given of the phase-relation between the velocitycurve and light-curve. The mathematical theory of a pulsating star seems to show that maximum brightness must occur at the

moment of greatest compression, whereas in all the more typical

Cepheids it is found to occur a quarter-period later.

The study of Cepheid variables is likely to lead to results of the greatest importance, since they give the opportunity of observing stellar matter in motion, thereby extending the information obtainable from the ordinary static stars. They are important also for another reason. In 1012 it was noted by Miss Leavitt that, when the periods and apparent magnitudes of the variables in the Lesser Magellanic Cloud were plotted as abscissae and ordinates, the points lay on a smooth curve. Since the stars in the Cloud must all be at approximately the same distance from us. this indicates that the absolute brightness is a definite function of the period. H. Shapley subsequently found the same uniformity in a number of globular clusters. The same period-magnitude curve is repeated in each cluster, except that the curve is dis-placed as a whole towards fainter or brighter (apparent) magnitude, according as the cluster is remote or near It follows that Cepheids of the same period have the same absolute luminosity, and presumably are alike in all respects. The absolute brightness being identical, the apparent brightness indicates the distance: e.g., if the apparent magnitude of the Cepheids of 5-day period in a particular globular cluster is 13 we know at once that the cluster is 100 times as distant as a Cepheid of apparent magnitude 3; if the 5-day Cepheids observed in a spiral nebula have apparent magnitude 18, the nebula is ten times more remote than the cluster Thus the general structure of the universe can be plotted out to scale. The scale is made absolute by a study of the brighter and nearer Cepheids which are not beyond the range of ordinary methods of distance determination. The Cepheids are stars of high intrinsic luminosity, which are visible at great distances; practically all our knowledge of the distances of the more remote objects of the sidereal universes has grown up from the study of these stars. The only caution required in using these variables as standard lights for gauging distance is that we must have evidence whether their light has been dimmed by passing through absorbing matter. It is known that the interstellar spaces contain extremely diffuse matter in the form of atoms, molecules and particles of dust, which causes both a dimming and a reddening of the light from distant objects. This matter is concentrated near the plane of the Milky Way, but is not uniformly distributed. Allowance can be made for the average effect of the dimming produced by it, but there is necessarily some uncertainty in the individual distances derived for remote objects in the Milky Way regions,

and the therefore it is also dispersion to minky way regular. No theoretical basis for the period-magnitude relation has yet been send of the best of the same than the period of the period described of the period of the best of the period of the

The typical Cepheid variable which has given its name to the class is  $\delta$  Cephe I its period is  $\varsigma$  366 days. It is seven magnitudes brighter than the sun, and is believed to have about mise the sun's mass. It is a giant diffuse star having a radius of zo million kilometres, which changes by  $\pm 1.2$  million kilometres in the course of the pulsation. The light-trange is  $\sigma$  6 mag, visual and 1.0 mag photographic, the difference being due to the fact that the light becomes much bluer at maximum brightness. The "cluster variables" are a subclass of the Cepheids; they have very short periods usually about 12 hours. The shortest period known is 3 22 hours.

Long Period Variables.—There are very few variable stars with periods between 30 and roo days, but beyond roo days and especially near 300 days they become numerous again. The numbers within given limits of period are:

Days	100-200	200-300	300-400	400-500	500
Stars	64	194	182	54	12

The leading characteristics of these long-period variables are (i) their light-range is very great averaging 5; magnitudes, and in a few stars exceeding 8 magnitudes; (2) the variations do not repeat themselves with the clocklike precision of the other classes of variables, and both the amplitude and period influctual erregularly; (3) they are red stars, chiefly of type M, but sometimes of the rarer spectral types R. N, S; during the great outbust of light at maximum, bright emission lines of hydrogen appear in the spectrum.

The enormous variation of light is rather misleading to us, because there is no such large variation in the output of heat. The surface-temperature is varying through a range which happens to be especially critical for the sensitiveness of the human eye. The following results relate to Mira Ceti which is the most famous star of this type (discovered by Fabricius about 1506). To the eye at minimum it appears as a faint star of magnitude 9, difficult to distinguish from the numerous other minth magnitude stars in the field; but the more impartial bolometer, which measures the total radiant energy or heat received, singles it out as a very conspicuous object of bolometric magnitude 1.5. At maximum the surface temperature has risen a little, causing a moderate increase of radiation and bringing it up to bolometric magnitude o 2, at the same time the character of the radiation becomes more suited to the sensitiveness of the eye, so that an enormous increase of visual brightness occurs. At maximum Mira is generally between mag. 3 and 4 (visual), and occasionally it reaches mag. 2. Accordingly the variation of heat output is not much more than one magnitude, and is much the same as in the Cepheid variables. It is now generally believed that the long-period variables are pulsating stars not essentially different from the Cepheids. They are very diffuse stars of great bulk, and this extreme physical condition is probably responsible for the differences of behaviour between them and the typical Cepheids. Pease has measured the angular diameter of Mira, obtaining the result o".056. It is probable that the star has a radius of at least 1.5 astronomical units or 300 times the radius of the sun.

A number of minor classes of variables are recognized, which differ in material respects from the three chief classes here described. The whole subject of variable stars is now one of the most active branches of stellar research.

### STELLAR MOTIONS

We learn about the motion of a star in two ways. Firstly, the change of position in the sky can be observed directly by making from time to time accurate measurements of the position with respect to surrounding stars. The motion thus detected is called proper motion. It is measured in seconds of are per year; if the distance of the star has also been measured, the result can be converted into miles per second. Secondly, by measurements of the positions of lines in the star's spectrum, the speed of approach or of recession can be found; this radial velocity is given immediately in miles per second, whether the distance of the star is known or not. The two methods supplement one another, the

first giving the motion transverse to the line of sight, and the second the motion in the line of sight; combining them we obtain the direction and speed of the whole motion

Proper Motions .- The stars differ greatly in proper motion. For a naked-eye star a motion of about 3" per century may be taken as typical The corresponding change of position would be measurable without difficulty in an interval of ten years. For some stars the displacement is less, either because their actual speeds are small, or because their motion is mainly in our line of sight, or because they are very distant. Other things being equal, the stars which are especially near to us will have large proper motions. Just as great apparent brightness may be due to nearness or to high intrinsic luminosity, so great proper motion may be due to nearness or to high actual speed; but, in general, great proper motion is a much more dependable indication of nearness than great apparent brightness, and it is used as a criterion to pick out stars likely to have measurable parallaxes from the great majority which are too far away to be measured Proper motions have been measured in tens of thousands; and, moreover, there are methods of quickly detecting stars of large proper motion on a pair of plates of the same region taken at a suitable interval of time (see Blink Microscope).

The star of greatest proper motion known up to the present is a ninth magnitude star discovered by Barnard, which travels 10½" per year (more than 300 times the typical speed mentioned above). Even at this speed it would take about 900 years to go from end to end of Onon's belt. The following table gives particulars of the stars of largest proper motion

Star		Ann	Dist	Spe	Lum.	
Star	Mag P.M.		(LY)	Trans	Rad	Lum.
Barnard star	97	10" 25 8 76	60	90	-117	0004
Kapteyn star Groombridge 1830	9 2 6 5	7 05	10 3 32 0	330	+242 - 97	23
Lacaille 9352 Cord 32416	7.4 8.3	6 90	11 2	112	+ 12 + 26	000
61 Cygni .	56	5 20	10.9	82	- 64	.058

The distance in light-years is given in the fourth column; the transverse and radial speeds are given in m. per sec. in the fifth and sixth columns, the last column gives the intrinsic lummosity, the sum's lummosity being the unit. If will be noticed that these are all inconspicuous stars, fant both apparently and actually. Well-known stars which come further down the list are \( \alpha \) Cartain and Arcturus, with annual proper motions 3"66 and \( a^2 \), a respectively. The motions cannot have caused any noticeable change in the appearance of the sky with mistoric times; but the change in, say, 25,000 years would be considerable, and it is doubtful if any of the familiar constellations except Orion would be recognizable. When the parallar is known, proper motion is convected into linear measure by the formula:

The Solar Motion .- If we examine the proper motions in any small region of the sky, it is at once evident that they are not directed at random; an average motion in a certain direction is plainly shown. Comparing different regions of the sky and allowing for the different aspects of projection, it is found that the stars in the mean are moving in a direction toward the southern constellation Columba, not far from the south part of Canis Major. The same average motion is also shown by the spectroscopic radial velocities; i.e., the stars in the Columba region have an average motion away from us, whilst those in the opposite part of the sky have an average motion towards us The effect is so pronounced that a dozen stars taken at random will be sufficient to show the prevailing direction roughly (the first determination by Sir William Herschel was made from seven stars only); but in attempts to fix this important direction as accurately as possible many thousands of stars have been used.

In measuring proper motion, or radial velocity, our standard of reference is the sun; and the foregoing result shows that the stars

in the mean are travelling past the sun in the direction toward Columba. This, however, is rather an egocentric way of expressing the facts It is more natural to say that the sun is travelling relatively to the mean of the stars in the opposite directiontoward a point in Hercules or Lyra not far from the bright star Vega This point is called the solar apex, and the relative velocity that is found is the solar motion. Attempts to determine an accurate position of the solar apex are not very closely accordant. In particular, radial velocity determinations seem to give systematically a lower declination than the proper motions, and bright stars give a lower declination than the faint stars. It is now generally agreed that systematic errors in the proper motions are mainly responsible for these differences We could scarcely expect the apex to be definite, because the "mean of the stars" is an indefinite conception. The stellar background appears to consist of interpenetrating clusters with different motions, and the relative solar motion will depend on what part of this background is sampled by our observational data. In round figures the general result is Solar apex, R.A 270°, dec +30°, speed 20 km per sec In measuring the parallaxes of stars we use the diameter of

the earth's orbit as base line-a length of two astronomical units. The solar motion of 20 km per sec. transports the observer through 4.2 astronomical units per year, so that observations taken now and 50 years ago give us a base line of 210 astronomical units With the longer base line it is possible to survey the stellar system to a distance far exceeding that attainable by parallax measurement. The method cannot be applied to individual stars because the parallactic displacement cannot be discriminated from the star's own motion, but when we are dealing with a class of stars (eg., stars of 9th magnitude, bright stars of type K, long-period variables, etc.) which are not likely to have any important common tendency of motion as compared with the general mean of the stars, the method will give the average parallax of the class. Fortunately, results obtained in this way can be checked by an independent determination based on similar principles. The cross proper motion, or component at right angles to the line towards the solar apex, is a component of the individual motion of the star, the radial velocity (after correcting for the known solar motion) is also a component of individual velocity. Hence, for a class of stars we can find the average value of a component of individual velocity both in arc and in linear measure; comparing the two results we deduce the mean distance These methods have proved extremely useful in supplementing the meagre knowledge of the distances and absolute luminosities of the stars furnished by direct parallax determinations. For still greater distances the method described under Cepheid Variables and analogous methods are employed.

Moving Clusters.-A number of groups of stars have been recognized which share a common proper motion, and evidently form a connected system. We must assume that they have a common origin, i.e., are evolved from the same nebulous con-densation. Apparently, having started to move together, they continue to move together simply because encounters which might deflect them are extremely rare. One of the arguments against the existence of great numbers of dark stars in space, is that their passage between the stars of the moving cluster would break it up too rapidly There is a typical moving cluster in Taurus, studied by L. Boss, which includes many of the stars in the Hyades. The true motions of these stars must be very nearly equal and parallel, otherwise the cluster would rapidly disperse, but as projected on the sky they appear to converge toward one point. As the cluster covers a reasonably large area the convergent point can be found with considerable accuracy. By geometrical construction it becomes possible (without parallax measurement) to determine the distance of each star of the group and to find the precise arrangement of the stars in three dimensions. Another cluster consists of five stars of the Plough together with Sirius and some other bright stars; the sun is in the middle of this moving cluster, so that its members appear in different parts of the sky. The stars of type B seem to have a special tendency to form associations of this kind: one of the best marked groups consists of about 16 stars in Perseus and neighbouring constellations. Perhaps the most important conclusion to be drawn from these clusters is that the stars are not born individually and independently, e.g., by accidental collisions of extinct stars, but that the evolutionary process of star formation is capable of generating a number of stars simultaneously

The Two Star Streams .- Eliminating the recognized moving clusters, we are left with the general body of the stars whose motions have no obvious association with one another. It is found on examination, however, that their motions are not at random. In 1904 J C. Kapteyn showed that the proper motions show a decided preference for two favoured directions, apparently implying that the stars around us do not constitute a single system but a dual one The observed motion of the stars in the mean towards the solar antapex is due to the intermingling of two systems moving in very different directions. These two streams are found to prevail in every part of the sky examined; they are shown both in the proper motions and in the radial velocities. It is not likely that the same stream motion extends throughout the galactic system, but up to the present no limit has been found. Originally discovered in the motions of the bright stars, the phenomenon is found to be essentially the same in stars as faint as mag. 11 5, and there is evidence of its occurrence in much fainter stars. The following determinations of the apices and relative speeds of the two streams refer respectively to the bright stars of Boss's catalogue (Eddington) and the Cambridge photographic proper motions of faint stars (Smart). The speed is expressed in terms of a theoretical unit which is probably about 22 km, per second.

	Bright stars			Faint stars		
	RA.	Dec.	Speed	RA	Dec	Speed
Apex of stream I "" II Vertex Solar apex	91° 288° 94° 267°	-14° -64° +12° +36°	1 52 0 86 1 87 0.91	88° 289° 92° 273°	-12° -73° +20° +44°	

The first two lines give the motions of the streams relative to the sun, but greater cosmical importance must be attached to the motion of one stream relative to the other, which is given in the third line of the table. The principal difference between bright stars and faint stars lies in their distribution between the two streams. For the bright stars the numbers belonging to stream I and stream II are as 3:2; for the faint stars the numbers in the two streams are practically equal. It is partly for this reason that the declination of the solar appear increases progressively with the faintness of the stars; considered; stream II is receiving more and more weight in the "mean of the stars,"

If two interpenentating streams of stars exist, moving relatively to one another in space, all that can be learned about their motions is the direction and magnitude of their relative motion. Schwarzschild pointed out that the observed phonomena can be explained by supposing that the stars have a greater freedom of movement in a certain direction than in other directions or, in other words, that there is a preferential direction of motion of the stars, instead of the motions being at random. The direction of preferential motion lies in the plane of the galaxy and neaty, but not exactly, in the directions toward and away from the galactic centre.

Stars of type B are aloof from the two star-streams. Their motions (relative to the mean of the stars) are smaller than those of other types, and show little systematic tendency of any stars of other types are associated with them and form a third stream, known as stream O. In most parts of the sky it is difficult to disentangle stream O from stream I, but he regions where the circumstances of projection are favourable the little stream slavays appears clearly.

Rotation of the Galaxy—If the galactic system is analo-

MOTATION of the Galaxy—If the galactic system is analosous to a spint abelial its presumably rotating in its own plane; in any case its flattened form would lead us to suspect rotation. If the rotation were like that of a rigid body the radial velocities, as viewed from any point, would be unaffected, but it is more reasonable to suppose that the angular velocity diminishes out-

wards from the centre of the system, as with the planets in the solar system Then, if we take a group of stars surrounding the sun, those between us and the centre will be gaining on us and those outside us will be lagging behind. This shearing motion distorts a square into a parallelogram, that is to say one diagonal is lengthening and the other diagonal is shortening, so if we observe stars in two opposite regions of the sky, corresponding to the direction of one diagonal, these should be receding from us. and along the other diagonal, 90° away, the stars should be approaching us, on the average J H. Oort has found that this effect is quite prominently shown in the observed radial velocities. and that the direction of the galactic centre deduced from it accords well with the direction generally accepted (deduced from the distribution of globular clusters and other classes of distant objects) Moreover, taking different classes of stars, the positions found for the centre are very accordant, and the effect increases, as it should do, proportionately to the mean distance of the class. Oort's results have been fully confirmed by J S. Plaskett, from the analysis of his measures of the radial velocities of stars of types O and B, which are particularly suitable for the purpose, because of their high intrinsic luminosities. The rotation of the galaxy has also been investigated by using the proper motions of the stars, though this method suffers from the drawback that the greater the distance of the star, the smaller is its proper-motion

The analysis of the radial velocities of stars at different disances gives the change of velocity throughout the region covered by the survey, but does not give the actual velocity at any point. The velocity in the neighbourhood of the sun can be found from the radial velocities of the globular clusters, which extend well beyond the centre of the galaxy. The velocity is found to be about 300 km. per sec., but is subject to a somewhat large probable error. The distance to the centre of the galaxy and the mass of the system whose gravitational attraction controls the orbital motion can be determined when reasonable assumptions about the distribution of the mass in the system are made. The distance to the centre is some 30,000 high-years, the period of rotation at this distance is about 200,000,000 years and the total mass of the system is about to 6 thousand million times the mass of the system is about to 6 thousand million times the mass of the system is about to 6 thousand million times the mass of the

It was suggested by H. H. Turner that the preferential direction of star-streaming was toward the centre of the galaxy: he pointed out that the comets of the solar system, because of the elongated shape of their orbits, have a preponderatingly radial direction of motion. Situated, as the sun is, at some distance from the centre, the directions to and from the centre appear as the favoured direction of southout. The direction of preferential motion deviates by about x2° from the direction to the galactic entre; it is doubtful to what extent this deviation is significant. B. Lindblad has suggested that a satisfactory agreement can be obtained by taking into account not merely the general gravitational effect of the system as a whole but also the local gravitational fields due to star clouds and local aggregations of stars.

Individual Motions.-After eliminating all systematic motion there remains the individual motion of the star itself. An interesting field of study arises from the correlation between individual speed and other characteristics, such as mass, spectral type, brightness. The earliest result of this kind was found by W. W. Campbell and J C. Kapteyn in 1910; viz., a progressive change of mean speed with spectral type Campbell's results for bright stars were. Type B, 6.5 km. per sec.; A, 11, F and G, 15; M, 17 km. per second. The figures refer to the radial component only, and must be doubled to give the mean speed in three dimensions. At the time it was thought that this sequence of types represented the order of evolution, so that the progression implied that the speed of the stars increases with their age; with the recognition of giant and dwarf stars this interpretation has become inadmissible. Actually type M consists of two distinct classes, viz., very diffuse stars supposed to be in an early stage of condensation from a nebula, and very dense stars supposed to be at a later stage of the evolutionary sequence; both classes have high speeds, the latter being particularly large. Generally speaking, faint stars have greater speeds than bright stars; owing to the

mass-lumnosity relation this means that stars of small mass have greater speeds than massive stars. It has been suggested that there is a law of equipartion of energy so that the average value of \( \frac{1}{2}\) mu^3 is the same for all classes of stars, this might have a dynamical explanation, since the speeds of the molecules of a ga distribute themselves according to the same law. Up to a certain point observations agree with the equipartion law, but there are noteworthy exceptions, the massive B stars have low average speed as the law requires, but the most massive stars of all, type O, have rather large speeds. The present position is that our knowledge of the factors determining the mean speed of different kinds of stars is made up of fragmentary correlations, and has not yet led to any exemptly commerchancy theory.

One complicating factor is the asymmetry of high velocity stars, which was discovered by J H Oort and G Stromberg Stars with speed greater than about 80 km per sec. are moving almost exclusively toward one hemisphere of the sky. The group as a whole is moving nearly in the galactic plane and at right angles to the direction to the centre of the system, so that it lags behind the average of the stars at the same distance from the centre by about 80 km. per sec. No stars with velocities in excess of the average by a similar amount are observed. Any such stars originally present in our local star-cloud have been lost to it because their velocities have exceeded the "velocity of escape" Stars with velocity below the velocity of escape are permanent members of the system, and describe orbits within it under its gravitational attraction; on the average, therefore, they move as much in one direction as in the opposite. Stars with velocity above that of escape cannot be permanent members, they pass once through the system and do not return, accordingly they may well show an asymmetry of motion, dropping into our local star-cloud from a cluster or clusters on one side of it, passing through it, and not returning The value of the velocity of escape is more or less what we should expect from our general knowledge of the extent of the star-cloud and the number of stars per unit volume

About 25 stars are known within a sphere of 4 parsecs radius surrounding the sun, s.e., having parallaxes greater than o"25; there may be a few additional faint stars yet to be detected. Many of these near neighbours are red dwarfs with masses onequarter or one-fifth that of the sun; on the other hand a considerable proportion are double stars (here counted as one) The total mass within the 4 parsecs sphere may be estimated at about 17 times the sun's mass In addition to the mass of the lucid stars there may be other masses in the sphere, e.g., dark stars, in addition to scattered nebulous matter of great tenuity. There is direct observational evidence, referred to at the end of this article, for the existence of a cloud of diffuse matter in interstellar space. It is extremely rarefied; one atom per cubic centimetre is the most we can possibly allow consistently with the dynamics of stellar motions Even so, the total mass of this rarefied matter in the galactic system is comparable to the total mass of the lucid stars.

#### CONSTITUTION OF THE STARS

Density.-When the mass and radius of a star are known. the mean density of the material can be calculated immediately. Direct determinations of the mass are only available for double stars; but for other stars the mass may with some confidence be inferred from the absolute magnitude by means of the massluminosity relation described later in this section. In any case the range of stellar masses is so restricted that errors are not likely to affect the general order of magnitude of the densities deduced. The radius R may be calculated from the absolute luminosity and the observed surface-temperature. In this way we find that some of the red giant stars, such as Betelgeuse, Antares, Mira, have densities less than  $\frac{1}{160}$  that of air; Capella has a mean density nearly equal to air; the sun, we already know, has a density 1.4× water, the faint red dwarfs have density about 10× water For the class of stars called white dwarfs, which includes the companion of Sirius (see SIRIUS), the method gave an enormous density 60,000 times that of water; this result was at first regarded as incredible, but it is now clear that it is to be accepted literally.

For the more diffuse stars it is evidently legitimate to treat the stellar material as perfect gas. The study of stellar equilibrium thus reduces to the study of the equilibrium of a globe of perfect gas held together by its own gravitational attraction It was thought that the simple theory must break down for stars of higher density (such as the sun) owing to the deviations from the laws of a perfect gas, but in 1924 it was found by Arthur S. Eddington that the dense stars agreed observationally with laws which had been deduced theoretically for gaseous stars. The fact is, that at the temperatures of the order of 10,000 000 degrees occurring in the stellar interior, the atoms are stripped of all their outer electrons and reduced to ions of very small dimensions; consequently the samming of atoms against one another, which causes the breakdown of the gas laws, does not occur in the stars until far higher densities are reached. The high density found for the white dwarfs confirms this conclusion, close packing is possible because the atoms have lost their balloonlike envelopes. In all stars other than white dwarfs the material may be treated as perfect gas, except that in the stars of least mass (red dwarfs) there is a small correction arising from the electrostatic forces between the ions which makes the gas superperfect, i e, makes it deviate in the opposite direction to the deviations of imperfect terrestrial gases

Internal Temperature and Pressure.-The distribution of temperature and density in a sphere of gas in equilibrium under its own gravitational attraction is a classical problem studied by Lane, Ritter, Emden and others. The mathematical analysis developed in these earlier researches is used in the modern theory, but three new features have been introduced (1) It used to be supposed that the heat radiated from the star's surface into space was brought up from the interior by convection currents, but it has now become evident that it is transferred by radiation Accordingly the stars are now assumed to be in radiative equilibrium instead of in convective equilibrium. The condition of radiative equilibrium is that each region must have settled down to a temperature at which it ladiates an amount of heat equal to that which it absorbs from the radiation passing through it. One simplification resulting from this change is that we no longer need to know the ratio of specific heats of stellar material-a physical constant difficult to estimate, (2) Radiation-pressure is sufficiently great to play an important part in the equilibrium, especially of the massive stars, and it is now taken into account. (3) Formerly the average molecular weight of the stellar gas was taken to be the weight of the atoms likely to preponderate, e g, iron (at. wt. 56). It is now recognized that the atoms in the interior will be highly ionized; most of the electrons which circulate round the nucleus will have broken loose, and must be counted as independent "molecules." Taking this into account the molecular weight will be slightly over two, a result nearly independent of the chemical constitution of the star provided only that there is not an excessive proportion of hydrogen. Owing to this decrease in the adopted molecular weight, the internal temperatures are considerably lower than those calculated on the older theories

Since it is believed that a star's heat is maintained by liberation of substonic energy, another unknown condition enters into the problem, viz, the distribution of substomic sources in the interior. This, however, has no very important effect on the main results of the investigation, and, by considering the extreme case of a source wholly connectrated at the centre and a source evenly distributed through the mass, we can set limits to the uncertainty.

For the sun the central temperature is found to be of the order 20,000,000 °C. The mean temperature (averaged for equal mass) is about 12,000,000 °, and is less subject to uncertainty arising from ignorance of the distribution of the source of energy and other data Moreover, all stars of the Main Series (see STRILAR CONSTITUTION AND ENOLUTION) have nearly the same internal temperature. The Main Series, which comprises the great majority of the stars, includes B type stars several hundred times more luminous than the sun, and red dwarfs, giving a hundredth or a thousandth of its light. It is remarkable that stars differing so widely in mass, in output of heat and light, and in surface

temperature, should be so uniform in internal temperature. The giant stars have lower internal temperature,  $e\,g$ , Capella, which is of the same spectral type as the sun but has only  $\overline{a\,b\,a}$  of its

density, has a central temperature 6,000,000° The temperature gradient from the centre to the surface causes a flow of heat outwards, which is hindered by the opacity of the stellar material; hence, knowing the temperature distribution in the interior, and having observed the total outflow of heat from the star (s.e, sts luminosity reduced to heat units) we can compute the opacity This astronomical opacity may be compared with the theoretical opacity for material of the density and temperature concerned, as calculated from the modern theory of the atom The astronomical opacity is very sensitive to the assumed proportion of hydrogen in the star but, when this is given, the composition of the rest of the material makes very little difference. The luminosity of a star with the mass of the sun can range over seven magnitudes according to the proportion of hydrogen which it contains. Comparison between the astronomical opacity and the theoretical opacity consequently enables the proportion of hydrogen in the star to be estimated. For several stars for which first-class observational data are available, it is found that about one-third part by weight of each star consists of hydrogen There is some evidence that the most massive stars contain

a larger proportion of hydrogen.

In Mass-tuminosity Relation.—Having calculated the temperature distribution in the star by the condition of radiative equilibrium, we find the following formula for the total outflow of heat L (in ergs per second).

## $L=4\pi cGM(1-\beta)/k$ ,

where c is the velocity of light, G the constant of gravitation, M the mass of the star (in grams); k the coefficient of opacity, and  $z-\beta$  the ratio of radiation pressure to the whole pressure, obtained by solving the quartic equation,

$$I - \beta = 0.003 I M^2 \mu^4 \beta^4$$

where M is now expressed in terms of the sun's mass, and  $\mu$ is the average molecular weight in terms of the hydrogen atomic weight. Knowing L and M for any star we can calculate k; for example in Capella we find k=120 C.G.S. units. This means that a screen containing  $\frac{1}{120}$  gram. per sq.cm. (equivalent to about 6 cm. of air) would stop about two-thirds of the radiation passing through it At first sight this is a surprisingly high opacity The old problem as to how the heat is brought up from the interior of a star to replace that radiated from the surface, has completely changed; we see rather that the star has to be constructed of highly opaque material in order to hold back the internal heat and permit it to come to the surface no faster than it does. The high opacity is, however, not so surprising when we realize that at 10,000,000 degrees the radiation in the interior consists of X-rays chiefly of wave length 2 to 6 Angstroms, which are highly absorbed in a few millimetres of air. In fact the stellar opacity is less than the observed opacity in the laboratory-a fact explained by the high ionization of the stellar atoms, which throws a great part of their absorbing mechanism out of order.

According to modern theories of X-ray absorption, the coefficient of opacity should (approximately) be proportional to the density and inversely proportional to the 2 power of the temperature  $(k cc \rho/T_{\frac{\pi}{2}})$ . By the use of this law we can eliminate k from the equation given above and obtain the relation between L and M. The density of the star nearly disappears from this relation, so that the total radiation or absolute bolometric magnitude of a star is a function of the mass and molecular weight only, apart from a trivial correction dependent on the density, which can be calculated and applied when the spectral type is known. This predicted relation between L and M can be plotted as a graph; it is called the mass-luminosity relation. It appears to be well confirmed by all the observational data available; but it must be remembered that accurately determined masses are rare, so that the test is not so complete as we should desire. The mass-luminosity relation cannot conveniently be expressed by an algebraic formula, but as a rough guide it may be stated that the

heat outflow from a star varies as the third or fourth power of the mass in the most important part of the range.

ISTELLAR SPECTRA

These results are mamly independent of the assumed chemical constitution of the stars, owing to the fact that the average molecular weight for all elements except the lightest turns out to be nearly 2 when account is taken of ionization, but for stars composed mainly of hydrogen the mass-luminosity relation would be greatly altered It may be inferred, therefore, that stars of the same mass do not differ widely in their hydrogen content

It is interesting that we should be able to learn anything at all about the chemical composition of the inaccessible interior, but the fact has also a definite bearing on theories of the source of a star's heat. It is probable that the store of energy needed to maintain the star for thousands of millions of years is provided by the evolution of higher elements from hydrogen (Hydrogen which consists merely of protons and elections, is perhaps best regarded as informed matter) By cutting down the admissible proprion of hydrogen to, say, 10%, we reduce the supply from this source to one-tenth, and it becomes very doubtful whether it will suffice. Secondly, if we admit that 90% of the star must consist of "formed" matter, we must suppose that the man process of formation of matter occurs in a prestellar stage Evolution of the elements is, therefore, in the man a low temperature process and, pelhaps still more surprisingly, a low density process

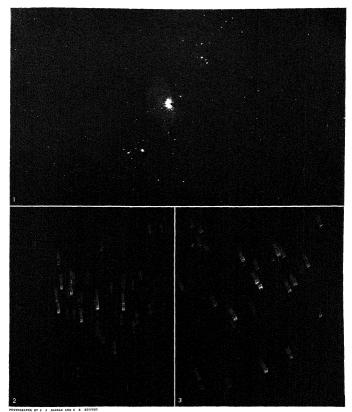
Radiation-pressure.-At any point in a star, gas-pressure and radiation-pressure together support the weight of the lavers above The proportion supported by radiation-pressure  $(i-\beta)$  is found by a quartic equation already given. To a first approximation it is the same in all parts of the interior, and is independent of the star's density; the molecular weight being given, it depends only on the star's mass. It is remarkable that for stellar masses there is no great disparity between radiation-pressure and gaspressure, whereas for masses of a different order  $1-\beta$  would or .99.. It seems clear that the condition of begin oo rough equality of the two pressures has in some way determined the size of the aggregations of the primitive matter of the universe The simplest view is to suppose that, when radiation pressure amounts to say one-tenth of the whole pressure, it renders the aggregation of further material more difficult or makes the mass more liable to break up. Hence larger masses are more and more rare. Gravitation by drawing together the primitive nebulous material will, in general, build up masses to a size at which radiation pressure first begins to offer serious opposition to further increase.

### STELLAR SPECTRA

We deal rather briefly with this branch of the subject since some of the more interesting developments are treated under ASTROPHYSICS; STELLAR CONSTITUTION AND EVOLUTION; SUN By the appearance of their spectra (see Spectroscopy) stars are arranged in a sequence of types O, B, A, F, G, K, M This turns out to be the order of decreasing surface temperature. The "effective" surface temperatures of stars are calculated by Planck's law of radiation (for theory, see Radiation, Rays) from the relative intensity of the continuous spectrum for different wave-lengths, the higher the temperature the more the region of maximum intensity is displaced to the violet. For the sun this method of finding the equivalent black-body temperature is checked by calculating also the temperature corresponding to the absolute intensity of its radiation, so presumably it will apply to other stars, although we have not usually any direct check. Good indirect confirmation of these temperatures has been afforded by studying the spectral indications of ionization of the elements. (See below.) The following temperature scale is a combination from various sources, the results are in degrees absolute

i		Type		Type Temperature		Type				Temperature
ı					-					
1	Во			20,000	Go				5,500	
1	B5 Ao			15,000	G <sub>5</sub>				4,700	
				11,000	Ko				4,000	
	A5 Fo			8,500	K.5				3,300	
1				7,500	Mo				3,000	
ı	F5			6,500						

PLATE STAR



KODACHROME PHOTOGRAPHS OF THE HEAVENS

- 1 Shows the great nebula in Orion, a sloud of dust and gas at least 10 light years in dismeter and at a distance of 600 light years. The older violet relation should be supported by the state of the s

These photographs were obtained with the 24 in. Schmidt-type taisappe at the Warner and Seway observatory of the Gass School of Seway (1994). One of 1994 were made by pisched to the control of the Carlo of the telescope. The light of such star is dispersed into its confined processing as proceedings aspection. The hottat size is star have a preast persentage of their light in the violet part of the spectrum whereast the cooler stars have not of their light in the red region whereast the cooler stars have not of their light in the red region

This refers to grant stars, dwarf stars of the same type are about 500° hotter. The radiating power of the surface in heat units is proportional to the fourth power of the temperature.

In all the later types the stars fall into two groups, the giant or diffuse stars, and the dwarf or dense stars. They are most widely distinct in type M, and converge to coalescence in types A and B If, instead of arranging the stars in order of surface temperature, we put them in order of increasing density, we must start with the giants of type M, follow the giant branch through K, G, F until it coalesces with the dwarf branch in types A and B, and then continue along the dwarf branch in the reverse order A, F, G, K, M. It seemed natural to suppose that the order of increasing density is that of evolution.

Following this supposed order of evolution, the temperature of the surface starts very low, increases to a maximum, and then decreases again, the giant stage being one of ascending temperature, and the dwarf stage of descending temperature. This fact has probably no great significance, since the surface temperature does not correspond at all closely to the internal temperature. It is more important to note that the mass (corresponding closely with the luminosity) is nearly steady in the giant sequence, perhaps decreasing slightly, and then diminishes rapidly as we pass down the dwarf sequence. It seems impossible to retain this idea of stellar evolution without admitting that the mass of a star must decrease substantially during its lifetime Radiation is the principal cause of loss of mass by a star, and hence it would follow that a large part of the mass of a star is convertible into radiation-in short, matter must disappear, its energy of constitution being released as aether waves. Admitting this source of energy, the age of the stars is of the order of a billion (1012) years or more But there is strong evidence against so long a life and in support of a much shorter age of several thousand million years. A large part of the mass of the star could be converted into radiation only if the actual annihilation of matter, by the combination of protons with electrons to produce radiation, were to occur within the star. This would require, however, a temperature very much higher than is found within any star. According to views current in 1945, the main source of stellar energy is provided by the building up of atoms of helium from atoms of hydrogen. In this process, not more than 1% of the mass of the star would be lost. Up to 1945 no plausible theory of the course of stellar evolution had been expounded.

After the first use of spectroscopy to identify chemical elements in the atmosphere of a star, the most important advance was the discrimination of "enhanced lines," i.e., lines strengthened in the spark spectrum as compared with the arc. Much of the early progress in this direction was due to J N. Lockyer and A. Fowler. In general, enhanced lines are those due to the atom with one electron missing (singly ionized atoms), the arc lines being due to neutral atoms. The spectra of all the important elements have now been unravelled, and we can say at once which lines belong to neutral atoms, which to singly ionized, which to doubly ionized atoms, etc Thus it is found that in some stars the atoms of calcium in a position to form an absorption spectrum are neutral, in others they are singly ionized, in others doubly ionized Clearly this is a clue to the physical conditions in the outer layers of a star. The modern thermodynamical theory of ionization was brought to bear on the astronomical observations by M. N. Saha in 1920, and has dominated all later progress. The degree of ionization depends on both the temperature and pressure, the former representing the factor which causes the breaking away of electrons and the latter the factor which determines their opportunity of recombining. By connecting together the data for different elements and controlling the results by reference to other methods of determining stellar temperatures, much information has been obtained as to the temperature and pressure in the reversing layer. In particular it is found that the pressure is generally between 10-3 and 10-4 atmospheres-much lower than used to be supposed.

Spectroscopic Parallaxes.—Since the nature of the spectrum

shown by a star is conditioned both by the temperature and pres-

should be two-dimensional Ordinarily we recognize only a linear series-the Draper sequence of types considered above; but by attention to detail we can recognize also a classification transverse to this. Taking the Draper sequence to correspond roughly to temperature, the transverse classification will correspond to pressure Since low pressure favours ionization, it will be marked in the spectrum by great strength of the enhanced lines relatively to the arc lines The giant and dwarf stars of the same spectral type can easily be distinguished from one another by this method; the reversing-layer pressure is low in the giant stars owing to the small value of gravity at the surface.

It was early recognized by E Hertzsprung that those spectra marked by Miss Maury as having the "c-characteristic" belong exclusively to the giant stars. This characteristic is an unusual fineness of the lines-a feature which also results from low pressure. More precise criteria were found by Adams and Kohlschutter in 1914; and the method has been developed by Adams into a means, not only of distinguishing giant and dwarf stars, but of determining quantitatively the absolute luminosities of stars. At present the procedure is empirical, the curve connecting absolute magnitude with differential intensity of certain selected pairs of spectral lines is deduced from and tested by stars of known trigonometrical parallax, it is then applied to find the absolute magnitudes and hence the distances of other stars. Parallaxes of some thousands of stars determined in this way have been announced, and are known as spectroscopic parallaxes. The underlying principle of the method may be summarized as follows: Stars may differ in mass, and stars of the same mass may differ in density; but, when the mass and density are given, no other important difference can occur, and the luminosity, surface temperature and pressure in the reversing layer should be uniquely determined; hence the spectrum should be determinate. Conversely, a sufficiently close examination of the spectrum (its position both in the Draper sequence and in the classification transverse to it) should fix the mass and density of the star, and hence its other physical properties, including luminosity. Ideally the deduction of luminosity might be made theoretically, but in any case the connection between luminosity and spectrum can be observed experimentally and formulated as an empirical law.

The Interstellar Gas .- In certain spectroscopic double stars the phenomenon of "stationary calcium lines" is observed. Whereas the other spectral lines shift to and fro as the star approaches and recedes in its orbit, the H and K lines of ionized calcium remain stationary. It is clear that somewhere between us and the star's photosphere there must be an absorbing cloud of calcium vapour which does not follow the star in its orbit. The phenomenon was first pointed out by Hartmann in 1904 for the star & Orionis. Later Miss Heger discovered that the D lines containing sodium also remain fixed in & Orionis. The same behaviour has now been observed in a large number of stars. In recent years, T. H. Dunham and W. S. Adams have found stationary lines of potassium, titanium, iron and neutral calcium, as well as of the molecules of CH and CN, in the spectra of a number of stars. The important question to decide is whether the cloud belongs to the double star or whether it is a continuous cloud filling interstellar space. J. S. Plaskett has shown that the latter alternative is correct; the motion of the calcium cloud is often different from that of the centre of mass of the star. After removing the solar motion the velocity of the cloud relative to the mean of the stars is found to be small. Just as there are lines in the solar spectrum which do not share in the sun's rotation and are accordingly to be attributed to absorption during the passage of the light through the earth's atmosphere, so we have stationary lines of elements which do not share in the orbital or individual motion of the star and are to be attributed to absorption in an interstellar "atmosphere." In the spectra of some stars the stationary lines are double or consist of three or four components, giving evidence of the absorption of the starlight by two or more interstellar clouds, which are in motion relatively to one another. The stationary lines are extremely sharp, which often enables them to be distinguished from the ordinary lines in the spectrum; this sure of the reversing layer, a complete classification of spectra sharpness is the consequence of the extremely low density of the

interstellar gas, which is so tenuous that the starlight must pass through a very great length of it to produce an absorption line of sufficient strength to be detected. The fixed lines appear most conspicuously in the spectra of the hottest stars because these stars are highly luminous and are consequently observed at a great distance; the cooler stars, moreover, have strong calcium and other metallic lines of their own, which mask the lines of the cloud. The absorption occurs along the whole track of the light, and though the absorption is not necessarily uniform along the track (as evidenced by double or multiple components) there is a strong correlation between the strength of the lines and the distance of the star

It is probable that many common elements, in addition to those It is produce that many common elements, in adultous or other which have been detected, are present in the interstellar gas; but the gas is so extremely rarefied that only the most abundant elements and compounds can be detected. Many elements must also evade discovery, even though they may be very abundant, because their atoms, when in their state of lowest energy as they must be in the atoms, when in their state of lowest energy as they must be in the interstellar gas, are indifferent to visible light. Thus, for instance, bydiogen has never been detected in interstellar space by its spectral lines, the detection of molecules of CH prove it to be present, and for other reasons it is known to outstrip by far all other elements in abundance.

In order to avoid a huge mass of the stellar system inconsistent with the observed velocities of the stars, it must be postulated that this interstellar cloud is of very low density. About one atom per cubic centimetre is the maximum that can be allowed. It is calculated that centimetre is the maximum that can be allowed. It is calculated that matter so diffuse as the woold take up a high temperature not much lower than the photospheric temperatures of the stars, although a shockite. The density is to small to give any appreciable scattering or absorption of light in pance other than the special line-absorption of calcular and sodium light. The drimming and reddeming of distant objects is caused by interstellar dust; a small quantity of dust can cause appreciable obscuration and the interstellar dust forms but a can cause appreciable obscuration and the interstellar dust forms but a small fraction of the total mass of the interstellar matter.

See also Nova and Supernova; Star Cluster, Algol, Sirius, Siellar Constitution and Evolution; Cosmogony; Constellation BIBLIOGRAPHY -A. S. Eddington, Stellar Movements and the Strucistillation. The A. S. Edmigron, scalar development and the Structure of the Conference of the Confere Üi (1944), Kohlschitter auf Ludendorff, Handbuch der Astrophysik, Dan Stenstystem dut vi. (2 vols. 1928-33), S. Rosseland, Theoretical Astrophysic (1936); W. M. Smatt, Steller Dynamics (1938); A. Unstold, Projit der Stermannspherer (1938); S. Chantlesskhart, Ast. Inch. (1938); A. Unstold, Projit der Stermannspherer (1938); S. Chantlesskhart, Astrophysics (1938); S. Chantlesskhart, Astrophysics (1938); S. Chantlesskhart, Astrophysics (1938); E. Ghantlesskhart, S. L. Jackma, The Sterry of Verlabelt Starts (1941); B. J. Bok and P. F. Bok, The Milly Wey (1941), H. Shaphey, Gelastics (1944); B. J. Bok and P. F. Bok, The Milly Wey (1941), H. Shaphey, Gelastics (1944); B. J. Bok and P. F. Bok, The Millson, Astron. (1944); A. Sterre and Rebuth (1944).

STAR APPLE (Chrysophyllum cainito), an evergreen tree of the family Sapotaceae (q.v.), called also cainito, native to tropical America and cultivated for its edible fruit. The pleasantly flavoured fruit, 2 to 4 in. across, is apple-shaped. In a crosssection of the unripe fruit the seed-bearing cells form a star.

STARAYA RUSSA, a town of the Russian S F.S R. in the Leningrad region, in 58° N., 31° 22′ E., on the river Polista, by means of which and Lake Ilmen it is brought into steamer communication with Leningrad. Pop. 21,511. Brine springs on the east of the town were used as a source for the supply of salt as late as 1865; afterward they were used only as mineral waters (temperature 51°-54° F.), having a great resemblance to those of Kreuznach in Germany. Some thousands of visitors were accustomed to resort to them every summer, and owing to this circumstance Staraya Russa was better built and better kept than any other town in the government of Novgorod. The inhabitants are supported chiefly by the summer visitors. There is a trade in rye, oats and flax. Staraya Russa belonged to the republic of Novgorod, and suffered in the wars between Russia, Lithuania and Livonia. It was afterwards annexed to Moscow.

STARA ZAGORA, the capital of a department of southern Bulgaria lying on the southern slope of the Karaja Dagh, 70 mi. N.W. of Adrianople, with which it is connected by railway. Population (1934), 29,857. The city is surrounded by vineyards. and has flour mills, breweries, brandy distilleries, copper foun-

dries and tanneries The production of silk and attar of roses is carried on in the district, which contains numerous mineral springs, and there is a trade in corn and wine It is the junction of the trans-Balkan and Burgas-Philippopolis railway lines It was destroyed during the Russo-Turkish War (1877-78) and rebuilt on modern lines During the rebuilding, important Thracian, Roman, Byzantine and Turkish antiquities were discovered

Stara Zagora, founded probably by the Thracians, was known to the Romans as Augusta Traiana, but afterward, to distinguish it from a Macedonian town of this name, it was named Beroe or Berrhoea By the Turks the name was changed in the 17th century to Eski-Zagia or Eski-Zaara, whence its Bulgarian name.

STARCH. This is perhaps the most widely distributed substance in the vegetable kingdom and occurs, often in great abundance, in almost every plant. Pure starch has the appearance of a white, glistening, friable powder, and possesses a harsh feel when rubbed between the fingers, it is tasteless, has no smell, is not soluble in cold water and undergoes no change when exposed to the air. When examined under the microscope it is found to consist of granules of definite shape, size and appearance. These show very wide variations, some being minute while others attain a comparatively large size, they are, nevertheless, quite characteristic of the plant from whence they are obtained, and the identification of any particular starch by comparison with those of known origin is a more or less simple matter. Granules or cells which are usually oval in shape are found to be composed of a series of concentric layers arranged around a nucleus or hilum which appears as a dark spot, the outer layers being the oldest in point of growth

Starch belongs to the group of carbohydrates in which are included the sugars, gums and cellulose, and is composed of the elements carbon, hydrogen and oxygen. Its constitution is very complex, but it is built up in the plant from two simple compounds, water and the carbon dioxide gas present in the atmosphere, through the agency of the green colouring matter, chlorophyll, under the activating influence of sunlight. The rôle of starch in plant economy is that of a reserve material, and as such it must be transferred from the leaves and other green parts of the plant, where it is formed, to more permanent quarters. To facilitate this migration it is broken down into sugars which dissolve in the cell juice, in this way passing through the cell walls of the plant finally to become reconverted into starch, either in the fruit or seeds, or in the bulbs and tubers as the case may be. It is thus rendered available as a source of sustenance for the young plant until it is sufficiently advanced to carry on the process of starch formation itself. Starch as it occurs in the granular packages visible under the microscope, is not present as simple molecules of the empirical formula (CaH10Os), but probably as sheaves or groups of molecules of varying density of packing, the individual molecules being associated together by secondary valence forces Starch is a highly organized or "associated" substance. When heated with water it forms a paste, the physical characteristics of the resulting paste being different for each type of starch Aside from the differences in these pastes due to the variety of staich grains, the properties are further modified by mechanical and chemical action. When starch is heated in plain water, it takes on water and hydrates. The granular packages first swell and then rupture to form a paste. The body and consistency of the pastes will vary greatly, depending on the severity and intensity of the cooking and agitating treatments. These modifications are due mainly to mechanical means-that is, merely tearing the granules without materially altering the chemical structure. In the presence of chemicals, however, particularly acids and enzymes, the molecule itself is degenerated, the products formed representing a breakdown of the original molecule. The type of starch degeneration product formed in the presence of these chemicals and the extent to which the original molecules are degenerated will depend on the nature of the chemical substance, concentration, temperature, etc. In this manner are made the thin boiling (low viscosity) starches, dextrins, syrups and sugars. This process is employed in the manufacture of corn or glucose syrups, used extensively in confectionery, and of glucose sugar used in brewing Hydrobytic degeneration is also effected by certain natural ferments or "enzymes" such as those in salva, pancreatic junc, malted grain (diastase)—all germinated seeds, and it is the latter agent which is employed in the fermentation industries brewing, distilling, etc—lonverting starch in the materials used into material capable of fermentation by vesa;

Development of starch in the growing plant already refered to, and the rebuilding of the soluble products fine the cellulous which constitutes the tissues, is caused out by ferments or enaymes elaborated by the plant itself, while a similar process goes on in the human system when starchy foods are eaten and converted into soluble sugars canable of assimilations.

Dry starch heated to upwards of 320° F is transformed into dextrin, a pale, yellowish powder soluble in water, known as British gum Dextrins of lighter colour are also made by spraying with acueous acids and heating to lower temperatures.

A very sensitive reaction of starch is the production of an intense blue coloration with a solution of aqueous iodine, a characteristic much used in its identification. The average starch content of the principal starch yielding plants, together with the temperatures at which the purified starch gelatinizes when heated with water, are, according to Lippmann, as in the following table.

	content %	temp F		content %	temp 0
Potato	18-20	145	Millet .	53-55	
Wheat	54-58	152	Peas	39-49	
Barley	40~46	145	Lentils	39-40	
Oats	35-38		Arrowroot	20-30	158
Rye Marze	44-46	131	Тарюса	25-40	156
Marze	55-65	145	Yams	25-35	
Rice	70-70	142	Sago		158

The storehouse, or starch-containing part of the plant, consists of a network of cells, within the walls of which the starch granules are closely packed together. The process of manufacture involves the rupturing of the enveloping cell walls and separation of the starch from the associated material by levization

Manufacture—The manufacture of starch from roots and tubers is usually carried on in the locality in which they are grown; that from potatoes on the continuent of Europe, principally in Germany, France and the Nethelands; arrownove, cassava and tapioca are prepared from the roots and tubers of the maranta and manioc plants in the Verle Indies and South America; sago is manufactured from the puth of the sago pain and also from the varies or sweet potatoes in the East Indies and Borneo. Cereals can be more readily transported and stored, so locality is a matter of convenence; thus rice is used as a raw material in England, France, Germany and Italy and other parts of Europe, while maize is used very extensively in North America, and in England, France and Germany. Wheat is not largely employed.

The purposes for which starch is manufactured can be classified under three heads: (a) Industrial. These netude sizing yarn and cloth in the textile industries; dressing cloth; thickening mordants and colous in calico pintules; the pieparation of British gums and destrim, confectioners' glucose or corn syrups, and sugars for use in the form of comflour, arrowroot, taploca, sago, etc., or in conjunction with other substances in the preparation of custard and blanc mange powders, sauces, cocoa, confectionery, etc. (c) Loundry, In pipe or crystal form and powders, both "thick" and "thick"

boiling" preparations.

The suitability of starches from various sources for these purposes depends on their cost, putily, the stiffness or viscosity of the paste they make with hot water and the size of the granules. Potato, maize, rice and wheat starches are those chiefly used for industrial purposes; rice, maize, are arroworo, cassava and sage for foodstuffs; and the small granuled starches, rice and maize, are used extensively in the laundry owing to the fact that the granules are required to enter the texture of the linen or cloth before becoming gelatinged by the hot iron.

The general principles for dealing with all types of roots and tubers are substantially the same, but of course vary in their elaboration and efficiency in different parts of the world, and they also only differ to some extent in detail when cereals are being treated. They are briefly as follows:—The tubers first go through

washing machines where earth, stones, sand and grit are removed; they then pass to a rasping machine where all the cells are completely ruptured. The resulting pulp is washed in a fine stream of water on fine-mesh brass seves, which separate the starch from expectable fibre, etc., the resulting milky starch luquor is run lato vats to separate fine sand and grit by settlement, through fine sik seves for further purification, and is finally allowed to run very slowly over long, shallow, wood troughs, runs or tables, where the pure starch settles out and the impuritues pass off at the ends with the water. The pure white starch is washed from the runs by a tof water and is pumped to either filter presses or hydro extractors, which remove all except about 40-45% of the water, leaving the starch in the form of a damo cake.

The cereals contain varying proportions of protein or gluten material associated with the starch, and special methods have to be employed in their prehimmary treatment. The protein contained in nce is found to be rendered soluble by very weak caustic sods solution, and advantage is taken of this in the production of starch from the raw material. Maize in addition to protein contains an oil-containing germ which it is necessary to remove. In this case the grain is first steeped for 2 to 4 days in warm water containing 1% of sulphur doxide, ground in burr stone mills, and the resulting diffuent mass diluted with water is passed through a long V-shaped tank where the sem floats and is skummed off.

Wheat contains gluten which forms an elastic paste with water and cannot be removed by levigation. The procedure carried out in this case is to reduce the grain to flour which is then made into a dough with water, divided into small pieces and placed in a semicircular silk or fine brass sieve where a travelling roller presses out the starch which is removed by a fine spray of water. The starch houor goes through a very similar purification process to that employed for maize, often being treated with dilute caustic soda solution to swell the gluten and assist its removal between the sieving processes. It is necessary to carry out the final drying process at very low temperatures to prevent the gelatinization of the starch granules. Several methods, similar in principle for starches from all sources, are in use in the large factories, and consist of either bringing the starch lumps or blocks in contact with a continuous current of warm air, or evaporating off the excess of mosture in a vacuum chamber. For producing the starch in the form of powder or flour the moist lumps are either placed on an endless band running backwards and forwards in an enclosed chamber through which warm air is drawn, or they are placed on trays mounted on a trolley and passed through a tunnel in contact with warm air. In the tropics drying is usually carried out in the open air.

out in the open air.

Prism or crystal starch is prepared from maize or rice starch for laundry purposes, and is produced by forming the damp starch into blocks by draming off the water from the starch liquor in boxes with perforated bottoms covered with filtering cloths; the blocks are cut into two or more sections which are partly dried in a warm chamber, the yellowish brown crust which forms on the outside is scraped off, and the blocks wraped in paper, returned to the drying chamber and dried very slowly. Under this treatment the blocks break up into irregularly shaped prisms technically termed "crystals." Pearl taploca is made by heating the slightly moist starch from manioc in a steam-heated copper pan with constant stirring, some of the cells becoming gelatinized and adhering together in small, irregular masses. Further drying fol-

lows and the crude lumps are passed through rollers and graded.

Granulated or pearl sago is prepared by drying the starch in
such a way that it forms a plastic dough in which a portion of the
granules have become gelatinized, forcing this through sieves, and
drying the resulting granules in the air.

BIBLIDGMAPHY—T C. Taylor and R. P. Walton, "Characterization of Certain Starches and Their Amyloses," Jour. Amer. Chem. Soc. 15: 4347–440, Nov. 1929; T. C. Taylor and G. M. Salzmann, "The action of aqueous alkali on starches, amyloses and modified starches," Did, vol. 52: 564–725, Jan 1933; G. V. Caesar and E. E. Moore, "Consistency changes in starch pastes; tapoca, corn, wheat, polato, and sweep loates," Ind. ond Eng. Chem. yol. 27: 1447–1451, Dec. 1935; G. V. Čaesar and M. L. Cashing, "Classification of starch electristives; algorithm care of the hardmap hydroden enthod," Polf, vol.

31 921-924, July 1939, C G Caldwell and R M Hixon "A study of the periodic acid oxidation of starches and dextrins as a means of determining molecular size," *Jour. Biol. Chem*, vol. 123 595-606, April 1938 (H. Her., G. V C)

STAR CHAMBER, the name of an apartment in the royal palace of Westminister, a meeting place of the king's councillors, delived for mostars fashioned on the roof, perhaps, of the hall By derivation, later on, the name of councillors and judges sitting there as a court

In 1998 repairs of the "Sterred Chambre" are mentioned. In 1453 a meeting "in concilio nostro" (in our council) was held "in the Sterred Chambre." In 1542 a law provided pumshment for those convicted "in the Starr Chambre at Westmynster before the Kinges most honorable Counsell."

the Aniges miss isonomic Collises.

In the modic ages judicial functions were exercised by the king of England and his council. The corown never parted with superne jurisdiction. The council shared it, and also did the superne jurisdiction is the council shared it, and also did the property of the council shared it. And also which had evolved from the even egis. The king's council in star chamber and elsewhere, was reinfracted by judges of the royal courts and by various others. From time to time partament defined and approved this judicial work. In 145° a statute (3 Henry VIII, e. 1)—for a long time mistakenly supposed to have established the court of star chamber—samed a commission of seven principal councillors and two of the judges, to try offenders too great to be dealt with by ordinary courts.

In the 16th century councillors, judges, persons specially summoned, additional "counsel," and great lords sometimes attending, acted either as a council or a court in star chamber, records being kept by clerks

Councillors and judges sitting in star chamber were more and more thought of as the court of star chamber. They dispensed much justice and heard many cases often by desire of the parties concerned. Hearings were public; there was no jury, torture was sometimes used to get confession. Generally speaking, it was a court of crumal jurisdiction, particularly in respect of volation of royal proclamations; but "all offences may be here examined and punished if the king will." Sentence of death was never pronounced. The court punished with imprisonment and with fine, even with mutilation.

Under Eknabeth attendance at star chamber approximated to that at prity council, with reinforcement of pudges, so that the two bodies were differentiated in function rather than in personnel Under James I and Chanles I star chamber continued as an active, important court, largely respected and liked. As Purtan and parliamentary opposition developed, however, it incurred odum from severe penalties, and the reputation then affixed by enemies has since persisted In fagit it was sobbled by an act of the long parliament (46 Charles I, c. 10) and the judicial power of the councillors in privy council was abridged. (E. R. T.)

STAR CLUSTER. There are regions here and there in the sky where the stars are much more richly strewn than usual. Some of these are clusters, where hundreds or thousands of stars are seen connectinated together in a small field of view, providing show-objects—beauty spots of the celestial landscape. Not only are they impressive to observe, but they have led to remarkable advances in our knowledge. The measurement of the extent of the visible universe and an indication of its organization, information on the existence and distribution of dark diffuse matter in intestellar space are among the contributions to subromory that have been made chiefly through the study of star clusters. The researches have been descriptive, astrometric, photometric, spectroscopic, statistical, mathematical and speculative—often complicated, and more often very tedious.

Discovery and Catalogues of Star Clusters.—Among the few clusters observable with the naked eye the Pleades group is undoubtedly the best known. It attracted the attention of primitive men and became the subject of numerous myths and legends. The Hyndes group surrounding the bright star Aldebaran and the dim star group in the constellation of Coma Berenices were also noticed in ancient times. About a score of the brighter clusters such as the doubtle cluster in Persesua are visible to a keen eye as

diffuse unresolved nebulous spots of light.

The true nature of star clusters as a class of celestial objects was, however, not recognized until after the invention of the telescope and many of the most striking clusters were discovered by the early telescope observes during the 17th and 18th centures A catalogue of nebulae and clusters published in 1754 by the repend astronmer Charles Messer listed 57 sar clusters A systematic search of the whole heavens undertaken by William Herschel at that period and continued by his son John Herschel led to many new discoveries of clusters to which relatively few have been added

Star clusters are in general designated by their number in the catalogue of Messier or in the New General Catalogue (NGC) of John L E Dreyer.

Galactic Star Clusters and Globular Star Clusters.—The amazing varrety in appearance of star clusterings led Herschel to divide them into classes. The principal division into loose or open clusters and densely crowded globular clusters was later recognized to be fundamental, manly through the researches of Harlow Shapley. The two kinds of clusters differ not only in constitution but also in their cosmic relation to our stellar system

The open clusters are easily resolvable, wared in shape and richness and the star population ranges from a few dozen to a few thousand. They are scattered all along the Milky Way, often appearing like nuclei of condensation in the rich star clouds. On account of their close relation to the Milky Way they are now more commonly designated as galactic star clusters. About 350 objects of this class are known.

The globular clusters, about 100 in number, are characterized by their uncommon nchmess in stats (several thousand to several hundred thousand), by the remarkable regularity of structure and nearly globular symmetry. Their stars are faint and generally show a high degree of concentration toward the centre where they often appear so closely crowded that the photographic plate is unable to resolve them.

#### GALACTIC STAR CLUSTERS

Definition .- In the scientific sense of the term, a cluster is a local group of astronomical bodies held together by their mutual gravitational attraction. Its members must have had a common origin and are thus physically related to each other. Wide binary stars, multiple stars, typical star clusters and star clouds are examples of such gravitational organization. Galactic clusters are generally distinguished from star clouds by their subordinate size and greater unity of structure. Between multiple stars and the poorer star clusters, however, there seems to be no real division. The line drawn by the astronomer is merely one of convenience dictated by methods of observation and description. Among star clusters those systems are to be included which contain a sufficient number of stars (not less than about 20) to be described statistically. A star cluster can then be characterized by such data as angular diameter, degree of concentration toward its centre, symmetry, distribution of stars according to brightness, richness in stars, etc. Some of the poorer clusters like N.G.C. 957 consist of a mere sprinkling of faint stars and it is often difficult to decide which of these should be included in a cluster catalogue

Constitution.—To obtain a true idea of a cluster as a system of stars in space three difficulties have to be overcome:

I. When a cluster is examined in a telescope or on a photograph, it appears superposed on the general star field of the sky, and it must be expected that some of the stars seem within the outline of the cluster are in reality located far behind it or in front of it. To study the constitution of the system, it is necessary to identify its individual members by their motion, spectral class or colour or to allow for the probable number of background and foreground stars statistically.

2 The observation of a cluster furnishes a two-dimensional picture, the arrangement of stars in depth escapes our scrutiny. For systems with spherical symmetry the statistical star distribution in space can be calculated from the apparent distribution in the projection.

3. The most difficult problem is to measure the distance of a

cluster from the observer. This knowledge is needed to find the linear dimensions from the observed angular hameler, to gain an idea of the distances separating the individual stars from each other, of the gravitational forces acting between them and to calculate from the apparent brightness of its stars their true lumnosity as compared with the sun

A rich galactic star cluster like the Pleades consists of 300 to 500 stars spread through a sphere about 50 light-years in diameter. The stars, particularly the brighter ones tend to congregate near the centre and thin out very gradually toward the periphety, so gradually that the extreme limit of the system is difficult to ascertain. On mere examination of a photograph only the central core of the cluster (about one-third of the limiting diameter) attracts the attention of the observer, the thinly scattered members of the outer parts are lost among the backeryound stars.

Even in the concentrated central part of a cluster each star is on the average separated from its merset neighbour by the enormous distance of 1½ light years. If we attempted to make a model of a galactic cluster with punheads as stars, the punheads would have to be placed 4 to 5 mi apart; a few hundred pinheads scattered through a sphere 150 m in diameter. Nevertheless, the space density of stars, at the centre of a rich cluster, is more than 100 times greater than in the vicinity of the solar system.

The limiting diameters of galactic clusters vary between 15 and 5 light years. The richer systems are larger than the poorer ones; their average star density therefore shows little variation, but in some the stars are more concentrated toward the centre than in others.

Spectral Classes and Luminosities of Cluster Stars.—Most clusters of the galactic class are so well resolved that spectroscopic and photometric observations of its individual stars can be made The distribution of stars according to spectral class and magnitude or luminosity reveals significant differences between clusters In some, like the Pleiades, all members belong to the Main Sequence, the brightest stars are of spectral classes O. B. or A (high temperature); with decreasing brightness the spectral class advances gradually through F and G to the K dwarfs. In other clusters, like the Hyades, we find in addition to Main Sequence stars also some giant stars of great luminosity and low temperature, and in a few the low temperature giant stars are very numerous The latter clusters seem to form a transition toward globular clusters A system for classifying galactic star clusters according to the magnitude-spectral class distribution of its members has been developed by Robert J. Trumpler.

Compared with the star population in the vicinity of the sun, galactic clusters are relatively rich in stars of high luminosity or candle power. Often the brightest stars in a cluster are several thousand times more luminous than our sun, in fact some of the most luminous stars known are involved in star clusters. Since high luminosity is associated with great mass the presence of such stars is important for the stability of the group. The gravitational attraction of these massive stars which are usually near the centre contributes much toward keeping the cluster together and preventing its stars from escaping into space. According to Bart J. Bok, a cluster must have an average mass density of more than 2,7 solar masses per 1,000 cubic light-years to resist disruption by the rotational motion of the stellar system.

It is not unusual to find that a member of a star cluster is itself.

It is not unusual to find that a member of a star cluster is itself.

It is not unusual to find that a member of a star cluster in itself as a star cluster unusual around double star Vid appetraction with periodic change of brightness, on the other hand, are very rare. It should also be mentioned that many clusters of the galactic class are involved in faintly luminous nebulosity.

alonly unmois decionestly.

Common Medicine of Cluster Stars.—That the individual state in the same motion through space has best and the same motion through space has best and the same motion from the calest in space of a set of the radial velocities (motions in the line of sight measured spectroscopically). For large and near clusters, like the Hyades, the paths of the stars appear to converge to a common point (or diverge from one). This convergence is obviously a matter of perspective. When the convergence is obviously a matter of perspective. When

vergent point is accurately determined and the radial velocities of some stars are measured, the distance of the cluster and the velocity of its motion through space can be deduced

For the smaller and more distant clusters the motions of the stars appear practically parallel and equal. If the proper motions are sufficiently accurate, however, their study makes it possible to distinguish the physical members from the background airs.

This phenomenon of common motion should be interpreted in the sense that the velocity with which the whole cluster travels through the stellar system is much larger than the internal motions of its stars with respect to each other Under the gravitational attraction of all the other cluster stars each member will describe some kind of orbit around the common centre of gravity, but the velocities of these orbital motions are quite small and for their successful study swerral centuries will be required.

Common space motion is sometimes found among stars widely spread over the celestal sphere without any noticeable clustering. The Unsa Major group is an example of such a case. Five of the seven conspicuous stars of the Big Dipper as well as Sirius and other bright stars are ablke in spectral class and move in parallel paths through space. Such groups are called moving clusters They are probably remnants of star clusters in the stage of dissolution

Distances.—Most of the galactic star clusters are so far away that their distances cannot be found by measurement of parallax or by the convergence of the proper motions; more or less induced methods must be resorted to.

The spectroscopic-photometric method takes advantage of the fact that for stars of the Main Sequence (or the Giant Branch) the luminosity is closely related to the spectral class, a relation which has been well established by studies of the nearer stars For any cluster stars whose spectra have been classified this relation will furnish a fair estimate of their luminosity. A comparison of the luminosity with the observed apparent brightness leads to the distance on the assumption that the apparent brightness of a star decreases with the square of the distance. This assumption, however, holds true only if the space through which the light travels is perfectly transparent. In the Milky Way, where most galactic clusters are situated, there is evidence of the presence of dark matter, cosmic dust scattered through interstellar space and the absorption of light caused by this matter must be taken into account for the more distant clusters.

Another method of distance determination is based on the assumption that star clusters of similar constitution have the same linear dimensions. For each homogeneous group of clusters the distances are then inversely proportional to the measured angular diameters. The diameter method must be calibrated by means of distances determined by the other method; it is then applicable to those objects which are too faint for spectroscopic observations. This method has also been valuable for testing the distance scale of the photometric method and for determining the effect of absorption of light in space.

The distances of the known galactic clusters as determined by Trumpler range from 120 to 20,000 light-years and 80% of these are between 2,000 and 12,000 light-years.

Space Distribution and Motion .- When the arrangement in space is considered (see fig. 1), the galactic clusters are found to nestle close to the plane of the Galaxy and to scatter through a disk about 35,000 light-years in diameter. This disk has the sun near its centre but has a very eccentric position compared with the outline of the stellar system. The whole situation suggests that the observed extent of these clusters is conditioned by the observer's location and his range of vision. Our list of galactic clusters is evidently incomplete. The light absorbing interstellar material forming a layer along the galactic plane spreads like a haze throughout the region occupied by galactic star clusters and is responsible for dimming or obscuring the more distant ones. Even a rich brilliant star group like the Pleiades when seen at a distance of 20,000 light-years would be so dim that it would hardly be noticed among the innumerable faint Milky Way stars and would have escaped discovery by the survey methods of the past. Photographs utilizing red light which has a greater penetrating power, however, may reveal many additional star clusters of this class at greater distances

Radial velocity measures are available for many galactic clusters, distant as well as near ones. Their analysis shows these star groups to follow closely the rotational motion of our galaxy as represented by the Ooit-Lindblad theory Each cluster revolves



50 000 LIGHT YEARS

FIG. 1.—SPACE DISTRIBUTION OF GALACTIC AND GLOBULAR STAR CLUSTERS

The figure literates how our stellar system would appear to an outside observer. The official fine indicates it he procedule outline of the flattened because of the flattened because where the flattened because where the procedule of our our in shown by a core. The 550 known pasterio their observations are seathered among the stars through the region marked by inhaling. Absorption of just by complet our searching between the stars prevent be visibility of gatestic observat at greater distances from the sun. The small critical represent the hondred globular cluster which surround the star prevents.

around the centre of the galaxy in an orbit which is nearly circular and parallel to the galactic plane.

By the kind of stars they contain, by their space distribution and motion galactic star clusters are intimately related to the Milky Way star clouds. Like these they probably had their origin and evolution in the highly flattened outer part of our stellar system which by analogy with other galaxies is assumed to have a spiral structure.

#### GLOBULAR STAR CLUSTERS

Distribution and Classification—In their distribution over the sky the jobular clusters are most pecular, they are nearly all found in one hemisphere which is centred in the such Milky Way region of Sagittarius. On both sides of the Milky Way they extend to high galactic altitudes. As we approach the low galactic latitudes, however, they become more numerous, up to the very edges of the stream of Milky Way star clouds. But their number suddenly falls of near the central line of the Milky Way, so that only two or three are found along a central belt seven or eight degrees in width. It is just within this region devoid of globular clusters, that the galactur clusters and rich star clouds are most numerous.

There is a general similarity among globular clusters except for considerable variations in star content and marked differences in compactness. The latter has been made the basis of a classification by Shapley and Miss H. B. Sawyer. The roo globular clusters are divided into 12 approximately equal classes, Class I representing the highest concentration of stars toward the centre, and Class XII the least.

Messier 13 is a rich cluster with considerable central concen-

tration (Class V), while Messier 55 is an example of a loose globular cluster (Class XI).

Many of the objects with little concentration are also relatively poor in stars. They are called giant-poor and are by some considered as a special subdivision of globular clusters.

Size and Structure.—The angular diameters of globular clusters are difficult to measure because of the ill-defined intist Moreover, these clusters appear to grow in size when the exposure time of the photograph is increased. If the distances are known, the linear diameters can be calculated; they vary from about 50 to 50 plgh-vears, not counting the most outlying members. Clusters of the globular class are thus on the average 3 to 4 times larger in diameter than those of the galactic class. Systems very rich in stars are generally larger in size and it has been suggested that the average space density of stars tends to be the same in all globular clusters, but is considerably higher than in galactic clusters.

A typical globular cluster is slightly flattened as though by rotation. This flattening reveals itself through the elliptical form of the projected image and the latter has been established in many cases by detailed counting of stars. It is not possible, however, to evaluate separately both the true flattening of a cluster and the inclination of its equatorial plane to the line of sight The most we can say is that some globular clusters have equatorial diameters at least 40% greater than their polar diameters in no cases do they appear to attain the high degree of flattening observed in spiral nebulae (see NEBULA) or in the Milky Way system itself.

Much work has been devoted to studies of the statistical laws governing the star distribution in globular systems. Assuming radial symmetry the number of stars per unit volume, N, at distance p, from the cluster centre can be calculated from star counts in the projected image, which gives the number of stars per unit area, n, at the projected disance, r, from the centre. The formula (Edward C Pickering, H. von Zepel) is

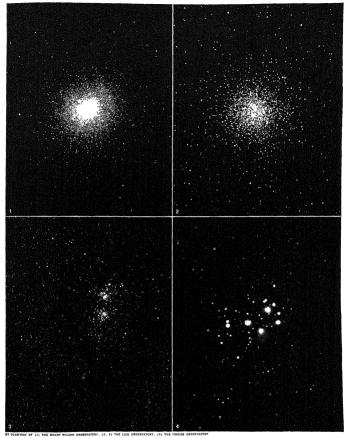
$$N(\rho) = \frac{1}{\pi} \int_{\rho}^{R} \sqrt{(r^2 - \rho^2)} \frac{d}{dr} \left( \frac{1}{r} \frac{dn}{dr} \right) dr$$

Analogies with the kinetic theory of gases have encouraged some of these researches; but no completely satisfactory representation of the observations has been found. It must, however, be realized that the available star counts deal only with the few hundreds or few thousands of the most luminous stars and that they are affected by errors caused by photographic and instrumental effects.

In general, the frequency of giant stars, except near the centre, is (roughly) inversely proportional to the fourth power of the distance from the centre for most of the typical globular clusters Colours and Variable Stars.-Spectroscopic observations of individual stars in globular clusters are very difficult; but colour indices have been determined in several systems. The star distribution according to colour and brightness in globular clusters is undoubtedly different from that predominating in galactic clusters, but its interpretation is still somewhat uncertain. The most luminous stars seem to be red supergiant stars, the fainter ones appear to belong to the normal giants. Remarkable is the absence of Main Sequence stars of high luminosity which are an outstanding feature of most galactic clusters. Dwarf stars of the sun's light and diameter are unattainable with our present telescopic power when at the distance of even the nearer globular clusters.

The presence of great numbers of variable stars in globular clusters was first brought to attention by the work of Solomon I. Bailey at the Harvard observatory. In some systems one star out of six among the giant stars proves to have a periodic variation in brightness, whereas in other clusters of practically the same appearance no variable stars are found.

The overwhelming majority of the several hundred variable stars discovered in globular clusters have periods of less than a day and belong to the class now designated as cluster type variables. They form a subdivision of the Cepheid variables and their light variation is thought to be due to pulsation—that is, periodic



EXAMPLES OF GLOBULAR AND GALACTIC STAR CLUSTERS

- 1. Messier 33 in Hercules, a rich globular cluster with considerable
  2. Messier 55 in Sagitatrius, a loose globular cluster

  2. The Flat of the sagitatrius and the sa

expansion and contraction of the stars.

A few Cepheid variables of periods longer than one day, and a few irregular variables have also been found among the stars of these clusters.

Distances.—The relation between apparent brightness and period for Cephetes in the Small Magellance (Ione), found by Miss Hennetta Leavutt, was generaised by Shapley with the said of galactic Cephetes and the variables of the globular clusters. The period-luminosity curve, which selates the absolute magnitude (untrunsic luminosity) of the Cepheid variable to the logarithm of its period, was thus derived. The zero point of the curve was fixed with the aid of the neares galactic Cepheid variables, for which the distances and absolute magnitudes were determined from studies of their motions

The period-luminosity curve permits the determination of the intrinsic luminosity and therefore of the distance of any Cepheld variable when the period of its variation and its apparent brightness are measured. With its use the distances of all the globular clusters, or other stellar systems, which contain Cepheid variables are simply derived. When the distances of clusters containing Cepheids have been obtained, the distances can be inferred also for the clusters devoid of variables, because of the apparently inherent similarity of all globular systems in linear size, total luminosity and in the real brightness of their most luminosity and in the real brightness of their most luminosity and in the real brightness of their most luminosity and indicators of divitance.

The effect of interstellar light absorption which must be allowed for in the distance determination is relatively small for missing globular clusters because they are situated far from the galactic plane, outside of the absorbing layer. Our list of roog joint clusters should thus be nearly complete except for those in the central belt of the Milky Way which are heavily obscured.

Though subject to considerable uncertainties, the distances of the globular clusters range from 12,000 to more than 100,000 night-years. The evaluation of these tremendous distances with a reasonable degree of reliability constitutes one of the triumphs of modern astronomical investigation.

Cosmic Role of Giobular Clusters.—As shown in fig. 1, the globular star clusters are arranged in a fairly symmetrical group surrounding our stellar system. The centre of this group is at a distance of 35,000 light-years from the sun and in 1795 Shapley suggested that it represents also the centre of the stellar system. This hypothesis has now been generally accepted. The study of globular clusters has thus given the first important clue to the eccentric location of the sun and the extent of our galaxy of which larne parts are hidden from our view by absorption of light.

The proper motions of globular clusters are as yet practically unattainable because of their great distances. The radial velocities of many of these systems, however, have been measured by feeding the total light of the numerous crowded stars near the centre of each object into the spectrograph. The results obtained by Vesto M Shipher at the Lowell observatory and more recently by Nicholas U. Mayall at the Lick observatory show that globular clusters move through space with velocities of 100 to 400 km p.sec., velocities much larger than those of most classes of stars, the centre of gravity of the globular clusters is taken to be at rest with respect to our stellar system, the sun appears to be moving at the rate of 300 km, sec. and this probably represents the speed of the sum's orbital motion around the centre of our galaxy.

The observed radial velocities as well as the spherical grouping of the globular clusters seems to indicate that they do not take part in the rapid rotational motion of the stellar system. Their orbits with respect to the centre of the galaxy are probably much elongated and in planes of varying orientations.

The globular clusters must have separated from the main body of our galaxy at an early period of its evolution and now surround it as satellite systems.

BERLICOLEY, P. Ten Brught only a part of the Bell, 1927) a BERLICOLEY, P. Ten Brught only a part of the Beld; Hallow Shapley, "Sea Class true" Harvard Observatory Monographs (1930) a general treatus on globular and galactic star clusters, containing full bibliography prior to 1930; Harlow Shapley, "Stellar Clusters," Mardudd Shapley, "Stellar Clusters," Mardudd Shapley, "Stellar Clusters," Mardudd Shapley, "Stellar Clusters," American Company, "Stellar Clusters," Mardudd Shapley, "Stella

liminary Results on the Distances, Dismontons and Space Distribution of Open Size Classes, 12-14, 25 per 12-14,

STARFISH. This name covers three classes of the echinoderms, sea stars or Asteroidea, britile stars or Ophiurodea, and feather stars or unstalked Chinoidea. (See ECHINOBERMA, figs 1, 2 and 4) The Asteroidea and Ophiuroidea are free-moving and live mouth downward, the feather stars, though they can swin or crawl, live most of the time attached to some object by their challenges much work that stars of CSE ECHINOPERMY.

dorsal cirri, mouth upward or outward. (See ECHINODERMA.)
The Sea Stars, to which the name "starfish" is usually restricted, include many different forms of which the most familiar are Asterias of the North Atlantic coasts and its relatives in the North Pacific. These animals consist of a central body radiating out into five tapering arms. The flattened upper surface is covered with a leathery skin in which are small lobed plates of carbonate of hme, many bearing prickles, together forming a jointed reticulate skeleton. Multitudes of small pincerlike pedicellanae are present (Cf. SEA-URCHIN.) For further details of structure see ECHINODERMA. A sea star of this type can crawl over any surface and can squeeze its supple body through incredibly narrow crevices. The rate of progress is about 6 in. a minute. The common sea star of the Atlantic coast of North America south of Cape Cod (Asterias forbesz) is very destructive to mussels and oysters, which form its favourite food. No less than 42,000 bu. have been removed from the oyster beds of Connecticut in a single year. They had damaged the beds to the extent of \$631.-500. In attacking oysters and similar bivalves the sea star fixes the suckers of one or two arms to one valve, and those of the opposite arms to the other. It then begins to straighten out its rays. The oyster can withstand a strong sudden pull, but not a continued pull, and eventually it opens its shell. The sea star then extrudes its stomach through its mouth, digests the ovster, and after the meal is fimshed withdraws its stomach Sea stars begin to eat voraciously when very young. One less than \( \frac{3}{4} \) in. across ate over 50 young clams of half that length in six days. A sea star may become sexually mature in less than a year, then producing many thousands of young.

These familias sea stars, however, are scarcely representative of the group as a whole. Sea stars vary in shape from sharply stellate with long tapering rays, or pentagonal with the angles of the pentagon produced into slender spikelike arms, to pentagonal or almost circular; but most of them are stellate. The great majority have normally five rays, but some have six and a number have more, in one type (Heliaster) from 20 to 44. In size they vary from ½ in. to more than 3 ft. across. There are about 1,500 known kinds distributed in 300 genera. Most of them are predacious, feeding on molluscs, barnacles, worms, crustaceans and other smaller creatures which they take into their stomachs, but many are scavengers feeding on detritus or swallowing mud and digesting out of it the organic matter. Most commonly seen of the exotic sea stars is a large one more than a foot across, common in tropical American waters, in shape a low pyramid with a stellate base (Oreaster), which is widely sold as a curio. Related species, smaller, more solid and with large bony tubercles, are also popular with curio dealers; these are from the Pacific and Indian oceans. The cushion stars, also from the Indo-Pacific region, are pentagonal to circular, 6 to 8 in. across, greatly swollen with broadly rounded edges, and look like small cushions. When young they are pentagonal and flat with a border of large plates. Along the sandy or muddy coasts of all warmer seas live two types of sea stars which, though common, are usually unfamiliar. One of these (Astropecten) is regularly star-shaped with stiff arms bordered with large plates. It usually lives just beneath the surface of the sand. The other (Luidia) has five or more broad, flat and brittle sharp-edged arms. It is said sometimes to swim by means of the podia. In these, as in many other kinds, the podia have no crustaceans

The brittle stars or Ophiuroidea ("snake-tails") differ from sea stars in having long and slender arms which are quite distinct from the usually pentagonal or circular body. The digestive and genital organs are wholly within the body, except in a few cases where the latter extend into the arm bases. There is no vent and pedicellariae are never present (See ECHINODERMA, fig 2) There are about 1,500 known kinds arranged in 200 genera In most of them the arms are moved chiefly sideways, though they may coil vertically at the tip. The body varies between 3 and 57 mm in diameter. The arms are usually long, flexible and brittle, but may be rigid and tough. The common shore-living forms all belong to this section They are the most active of all echinoderms They live among seaweeds or eelgrass, in chinks and crevices of rocks or corals, buried in mud, or lying on the sea bottom in deep water. Some are symbiotic or semiparasitic in sponges or on various coelenterates, feather stars or sea urchins. In the tronics many are brilliantly coloured. In another type the arms, which may be more than two feet long, coil vertically These are all semiparasitic on coelenterates and live in deep water To these are related the basket stars or "sea spiders" with their manybranched arms, most of which live clinging to coelenterates. Several brittle stars are hermaphroditic, some live in pairs, male and female, and some brood their young Many brittle stars are important as tood for fishes, in the North Atlantic particularly cod and haddock

The feather stars (unstalked Crinoidea) are distinguished as Comatulida ("hair stars") from various other crinoids that at earlier periods of the world's history lost the stem. (See Echino-DERMA, fig 4) The stem is not really absent, but is reduced to a knob from which arise numerous jointed appendages (cirri) by which the animal clings to some support. From the small body extend five arms (in two genera ten) which may remain undivided, but most commonly fork near the base or branch several or many times. The arms are fringed with slender branches (pinnules) giving a feathery appearance. Though usually sedentary, feather stars can crawl about and some can swim. There are about 600 kinds arranged in 140 genera. They occur from the shore line down to about 18.045 ft, and are most diversified in the Indo-Padific region, most abundant in the north

BIBLIOGRAPHY .-- W. K Fisher, Starfishes of the Philippine Seas and Adjacent Waters, bibl (1919); R Koehler, Ophiurans of the Philippine Seas and Adjacent Waters, bibl (1922); A H. Clark, The Unstalked Crinoids of the Siboga Expedition (1918). (A. H. CK)

STARGARD (Polish Starogród) a town of the former Prussian province of Pomerania, Ger., and after 1945 in Szczecin province in northwestern Poland, on the left bank of the navigable Ihna, 20 mi, E, of Szczecin on the railway to Danzig and at the junction of lines to Posen, Schneidemuhl and Cüstrin. Pop. (1939) 40,334; (1946) 9,733 Stargard, mentioned as having been destroyed by the Poles in 1120, received civic rights in 1229 and became the capital of eastern Pomerania. As a Hanseatic town it enjoyed considerable commercial prosperity, but it had also to undergo siege and capture in the middle ages and during the Thirty Years' War. It suffered heavy damage in World War II,

STARK, JAMES (1794-1859), British painter, was born in Norwich on Nov. 19, 1794, and at the age of 17 was articled to John Crome for three years. He died in London on March 24. 1850. Between 1831 and 1859 most of his pictures were shown at the Royal academy. He undertook in 1827 the publication of a work on The Scenery of the Rivers of Norfolk, which was completed seven years later; the illustrations he prepared for it have topographical and artistic interest. His painting "The Valley of the Yare" was acquired by the National Gallery of British Art.

STARK, JOHANNÉS (1874-STARK, JOHANNES (1874- ), German physicist, was born April 15, 1874, at Schickenhof in Bavaria and studied at the University of Munich. In 1900 he became an assistant at the University of Göttingen. He went as professor in 1907 to the Technische Hochschule at Aix-la-Chapelle, in 1917 to Greifswald and in 1920 to Würzburg; he retired in 1922. Stark devoted him-

suckers, ending in a conical point. Sea stars are eaten by gulls, self principally to the study of the modern theory of radiation crows, ravens, foxes and various fishes. Their chiefs parasites are and the atomic theory. He discovered the Doppler effect in parallel rays, for which the Vienna academy awarded him the Baumgartner prize. Later he discovered the Stark effect, named after him, and in 1919 was awarded the Nobel prize for physics He wrote numerous essays on physical problems, including the Prinzipien der Atomdynamik, in three parts (1910-15), Die elektrischen Quanten, Die elektrische Strahlung, Die Elektrizität in Gasen (1002) and Atomstruktur and Atombindang (1028) Stark was the founder of the Jahrbuch der Radsoaktsvitat und Elektronik (1904), which he edited until 1919, and president of the Reich Physical-Technical institute and German Research association,

1933-39. STARK, JOHN (1728-1822), U.S. soldier, was born at Nutfield, now Londonderry, NH, on Aug 28, 1728 During the Seven Years' War he served under Robert Rogers, first as a heutenant and later as a captain At the beginning of the Revolutionary War he raised a regiment and as colonel did good service in the battle of Bunker hill, the Canadian expedition and Washington's New Jersey campaign in the winter of 1776-77 In March 1777 he resigned his commission. Later in the year he was placed in command, with the rank of brigadier general of militia, of a force of militiamen, with whom on Aug 16 near Bennington. Vt , he defeated two detachments of Burgoyne's army. For this victory, which did much to bring about the capitulation of General Burgoyne, Stark received a commission as brigadier general in the continental army (Oct. 4, 1777) He took part in the operations about Saratoga, and for a short time was commander of the northern department. In Sept 1783 he was breveted major general He died at Manchester, N.H., on May 8, 1822

See Memoir and Official Correspondence of General John Stark (1860) by his grandson Caleb Stark

STARK EFFECT is the splitting of spectral lines observed when the radiating atoms, ions or molecules are subjected to a strong electric field. Soon after P. Zeeman discovered the magnetic splitting of spectral lines the electric analogue of the Zeeman effect (q.v) was sought by many physicists but success came first to Johannes Stark (q,v) in 1913. The earlier experiments failed because a strong electric field could not be maintained in conventional spectroscopic light sources (see Spectroscopy) because of the high electrical conductivity of luminous gases or vapours Stark observed the hydrogen spectrum emitted just behind the perforated cathode in a canal ray tube By placing a second charged electrode parallel and close to this cathode he was able to produce a strong electric field in a space of a few millimetres. At low gas pressure the mean free path of the atoms was much greater than the distance between the plates so that few conducting ions could be produced by collisions In an electric field of the order of 100,000 v per centimetre Stark observed, with a spectroscope pointing across the field, that the Balmer lines of hydrogen were split into a number of symmetrically spaced components, some of which were linearly polarized parallel to the lines of force, the remainder being polarized perpendicular to the direction of the field This transverse Stark effect resembles in some respects the transverse Zeeman effect, except that the separations (in wave numbers per volt in the first case, per oersted in the second) are larger, the number of Stark levels increases with election-shell number (s.e, principal quantum number) and the intensity distribution among the components is different. A satisfactory explanation of the Stark effect in hydrogen, given in 1916 independently by K Schwarzschild and by P Epstein, was a great triumph for quantum mechanics (q.v) since classical electromagnetic theory could not account for it

The Stark effect was also observed in the spectra of metals by employing special (LoSurdo) tubes containing a cathode of the metal under investigation, and viewing the light emitted near the cathode where a large potential gradient exists. In general, the electric splitting in spectra of metals is small compared with that in hydrogen, and unlike the Zeeman effect, which is symmetrical in spacing and intensity distribution of components, the Stark effect is usually only a displacement of unresolved components toward greater or smaller wave lengths. This effect does not depend in a simple way on the nature of the combining atomicenergy levels and for this reason the Stark effect in comparison with the Zeeman effect has little practical value in the analysis of complex spectra or of atomic structure.

See J Staik, "Starkeffekt," Handbuch der Experimental Physik, 21 399-548 (Leipzig, 1927), R Minkowski, "Starkeffekt," Handbuch der Physik, 21 389-428 (Berlin, 1929). (W F M)

STARLING, ERNEST HENRY, PRS (1866–1927), English physiologist, eldest son of H H Starling, was born in London,
April 77, 1866 Educated at King's College school, he entered
Guy's hospital in 1882 and graduated M D in 1890 In the same
year he was appointed lectured in physiology at Guy's In 1900
he became Jodrell professor of physiology at Guy's In 1900
he became Jodrell professor of physiology at University college,
London, where he continued to work throughout his life, although
in 1922 he retired from the Jodrell chair and was appointed Foulerton research rotofessor of the Royal society

Starling was one of the foremost physiologists of his age The subjects for investigation which particularly attracted him were those physiological processes which seemed capable of interpretation in terms of chemistry and physics. The conditions determining transudation from the vessels and lymph flow occupied his attention for several years, and he showed that the hydrostatic and osmotic pressures within the vessels supplied the balance of force necessary to explain the hitherto perplexing experimental facts. His researches on the movements of the intestines, in conjunction with Sir William Bayliss (q v ), demonstrated the neuromuscular mechanisms involved and reduced the previous chaos to order, Their discovery of "secretin" not only laid bare the way in which the secretion of the pancreas was called forth and adjusted but also stimulated further research on the chemical integration of the body functions By ingenious methods of experimentation he was successful in maintaining the mammalian kidney, isolated from all connection with the body, in a state of functional activity, thereby bringing to light new and fundamental facts concerning renal secretion Starling's most important researches, however, were those dealing with the heart and circulation Together with many other important discoveries on the physiology of the circulation, he demonstrated the mechanism by which the heart is able to increase automatically the energy of each contraction in proportion to the mechanical demand made upon it and, apart from the nervous system, to adapt its work in accordance with the needs of the body. Probably no physiologist had so greatly advanced knowledge of the heart's action since the discovery of the circulation by William Harvey.

During World War I Starling was dilector of research at the John Mary Medical Corps college and engaged in devising defensive methods against poison gas Subsequently, 1917-19, Starling was chairman of the Royal society Food committee, scientific adviser to the ministry of food and British scientific dele-

gate on the Inter-Allied Food commission.

STARLING, the name for birds of the passetine family Sturndac, which contains about 103 species. The normal range of the family is Africa, Europe and Asia, to Australan, with most species in the tropics. Certain species have been introduced into vanous other parts of the world such as Madagasca, Hawaii and North America, in which last area the common starling of Europe, Sturnus sudgess, has become common over a wide area.

Dark plumage, iddescent to the point of brilliance, characterizes many startings, but duller birds exist and one species is mostly white. Bare, coloured areas of skin, or wattles, decorate the heads of some. Certain species of the tropical forest are mostly arboral and eat frunt; others of open country walk about on the ground and eat finests. Several species are familiar birds, coming about houses and gardens where they may cause annoyance by usurping the nesting sites of other birds.

Gregariousness is a common trait. The birds may feed or roost in large flocks, and some nest in colonies. The nest may be in a hole in a tree, bank or building or may be an oval, pensile struc-

ture. The eggs are plain or spotted.

A number of starlings are kept as cage birds, notably the mynah or grackle (q.v.) of the Indian region that can learn to talk. The expeckers of Africa, genus Buphagus, that eat ticks off the skin of

hoofed animals are aberrant starlings (A L RD)

STARNBERG, a village and health resort of Germany, situed in upper Bavaria, on the Starnberger See, 16 m. S from Munich by rail Pop (1933) 4.879 The Starnberger See (or Wurnsee) is a fake 12 mi long, 3 mi wide and covering 23 go mi. Its greatest depth is about 400 ft. On the Rosennsel, an island in the lake, remains of lake dwellings were found

See Ulc, Der Wurmsel in Oberbayern (Leipzig, 1901)

STAR-NOSED MOLE (Condylura cristata), a North American species In habits it resembles the other moles, but is distinguished by the presence of a ring of tentacles, probably tactile, round the nostrils (See Insections)

STARODUB, a town of the Bryansk oblast, Russian S F S R, about 7; ml. SW of Bryansk. It is the terminus of a branch railway Fop 10,919 Russian princes contended with one another for it in the 11th and 12th centries. It was destroyed by the Mongois in the 15th entire, In the 15th and 16th centures the Russians and Luthunians struggled for it, it became a Polish stronghold in the 17th century, but was handed over to Russian in the 15th centure 
STARVATION is a state of extreme malnutrition caused by the long-continued deprivation of essential nutrients. It usually tresults from insufficient food intake, either because food is not available or because those person is unable to eat, due to illness or other factors Starvation may also result from disturbances in digestion, absorption or utilization of food. When the food intake in sufficient to supply the energy requirements of the body, the necessary energy must be supplied by a breakdown of the body tissues. The fat depots are first utilized, and when these are exhausted the tissue proteins are broken down. The severity of the starvation is related to the degree of the ensuing protent deficiency. Conversely, starvation is best combated by diets rich in proteins.

STAS, JEAN SERVAIS (1813—1807). Belgian chemist, was born at Lowau no Aug, at, 1813. He studied for a medical career and took his doctor's degree, but soon turned to chamsity, in 1835 the grand admission to, J. B. A. Duman's (n.P.) laboratory in Paris in order to continue a research on phloridsin which he had begun in an atte in his father's house, and he was associated with that chemist in several researches, including his redetermination of the atomic weight of carbon. In 1840 he left Paris on his appointment to the chair of chemistry at the £cole Royale Millitare in Brussels. There he remained for more than a quarter of a century, but he was then obliged to resign because of a malady which affected his speech. He was appointed to a post in connection with the mint, but gave it up in 1872 and spent the rest of his life in retirement in Brussels, where he died on Dec. 13, 1891. Star's lower than the start of the s

STASINUS, of Cyprus, according to some ancient authorities the author of the Cypris (in 11 books), one of the poems belonging to the spit of the measurement of the Hegestas of Salamine the company of the Hegestas of Salamine of the Cyprus of the Hegestas of Salamine events leading up to the Trojan war, such as the judgment of Paris and the rape of Helen. It is probable that the list of the Trojans and their allies (Islad, il, 316-876), which formed an appendix to the catalogue of the Greek shaps, is abridged from that in the Cyprus. Proclus in his Chrestomathia gave an outline of the poem (preserved in Pholius, cod, 240).

See D. B. Monro, appendix to his edition of Odyssey, xili-xxiv (1901); T. W. Allen, "The Epic Cycle," in Classical Quarterly (Jan. 1908, et seq.); and Homesur Posses.

STASSFURT, a town in the former Prussian province of Saxony, Ger., and after 1045 in Saxony-Anhalt, one of the chief seats of German salt producane, it is on the river Bode, 20 mi. S.W. of Magdeburg by rail to Ascheraleben. Pop. (1939) 15,783. The systematic exploitation of the salt beds to which the town owes its prosperity dates from 1856 only Beatles the rock sait, the saline deposits yield deliquescent salts and other saline products, which encouraged the foundation of numerous chemical factories. For about 50 years prior to World War I the bulk of the potasts used throughout the world originated in the Stassfurt mines The deposit underlies an area of about 100 sq mi Production continued to be heavy, although Germany's monopoly after 1918 was no longer complete.

STATE: see Sovereigniy

STATE, ACT OF, the plea of "act of state" in English law means primarily a defense raised by the crown on behalf of a servant of the crown, who is sued in the English courts for some wrongful act ratified by the crown In this sense the plea is not recognized by the English courts who, in rejecting it, have uniformly held that, as the king cannot do a wrong so also "it follows that the king cannot authorize a wrong" The only exception to this rule is in the case of a wrongful act done to an alien who, in such a case cannot sue (Buron v Denman [1848] 2 Ev. 167) if the act was done outside British territory and was ratified by the crown, but it has recently been held in Johnstone v Pedlar 90 LJP.C. 181 that if the act complained of was done to him in British territory he has the same right to sue as a British subject and the defense of "act of state" is, in that case, equally mapplicable But the term is also used in another and less questionable sense. It will be entertained by English courts where the acts in respect of which an action is brought are "transactions of independent states between each other," such as those arising out of the execution, or nonexecution, of a treaty, the succession of the crown to a foreign territory by cession or conquest, and the like For example, a concession granted by the chief of native territory is not enforceable whether by Petition of Right or otherwise in British courts by the grantees against the crown, on succeeding to the territory by annexation (Cook v Sprigg [1897] A C. 572) So too the contractual obligations incurred, whether toward a British subject or an alien, by a foreign state are not binding on the crown, after its conquest and annexation by the crown, unless the crown expressly elects to adopt them (West Rand Gold Mining Co. v. the King [1905] 74 LJK B. 753); for annexation is an "act of state" of an international character. In such cases the title of the subject has originated with a foreign government, not with the crown. If the contract or concession in question had originally been made by the crown itself, it would be another matter. Even in the case of a British protectorate the crown may plead "act of state" as a defense to claims in respect of expropriation of native territory because the crown in such a case is acting in territory which is not British (see the recent case of Sobhuza II, v. Miller [1926] A.C. 518). So too claims arising under a treaty are not enforceable against the crown unless and until the treaty, which is an international act, becomes part of English municipal law by being incorporated in a statute. The negotiation of the treaty is an "act of state" into which, and its meaning, the courts cannot enquire. In this sense the declaration of war and the making of peace by the sovereign is also an act of state As Lord Somer put it in Johnstone v Pedlar (Op. cit. at p. 704) "Municipal Courts do not take it upon themselves to review the dealings of State with State and Sovereign with Sovereign." On the other hand the mere fact that some act, wrongful per se in English law, was done in execution, or alleged execution, of a treaty made by the crown against the person or property of a British subject is a defense that would never be entertained by the courts in action against a servant of the crown, for, while a treaty cannot confer new rights, enforceable at law, upon a British subject, neither can it deprive him of any of his existing rights under English law. This was specifically laid down in Walker v. Baird [1892] A.C. 491 where in an action for trespass an officer of the crown put in the plea of "act of state" in that he was acting in the execution of a convention with the French government

ADTHORETES:—Sir W. Harrison Moore, Act of State in English Law; Bellot's edition of Pitt Cobbett's Cases and Opinions in International Law,

STATE, DEPARTMENT OF: SEE GOVERNMENT DE-

STATE GOVERNMENT (U.S.). At the close of the Revolutionary War in 1783 the 13 British colonies in America be-

once have begun to function in international relations on an equal legal basis with all other sovereign states But they had already created a confederation under a document known as the Articles of Confederation However, this document, and membership in the confederation, did not impair their status as free and independent sovereign states Each had joined voluntarily, and each one was free to withdraw Their sovereign powers as separate states were not affected

This confederation existed until the constitution of the United States was adopted by the 13 states in 1789 By that action they ceased to be free, independent, sovereign states. They were not free to withdraw from the newly created union, they had irrevocably surrendered certain very important powers to the new national government, and they had no status whatever as sovereign states in international relations. Some confusion grows out of the fact that they continued to be called states, for in the terminology of political science the very word state had generally been supposed to imply sovereignty and independence. Certainly by the close of the 19th century this was no longer true, if indeed it ever was, for states like France and Sweden are independent and sovereign while states in the American Union are not.

The constitution brought into being a federal system of government It created a national government usually called the federal government, and it also preserved the integrity of each of the states and their separate governments. An effort was made clearly to divide powers between the federal government and the states. The powers of the federal government are enumerated and delegated, se, the federal government can do only those things which the constitution says it can do. The powers of the states are inherent and residual, se, each of them can exercise within its borders all governmental powers which are not delegated to the federal government, or not specifically forbidden to the states, or reserved to the people. Thus it is impossible to enumerate the powers of the states One can enumerate the powers of the federal government and the things the states are forbidden to do. The states possess all remaining powers

It is to be observed that under this federal system the national government has no power to coerce states, to use force upon them, or to compel a state to do or not to do any particular thing. The national, or federal government has abundant power to compel people, as individuals, anywhere within its jurisdiction, to obey its laws, passed in accordance with the constitution That is all the power the federal government needs-power to enforce its laws upon people who try to resist, however numerous they may be, or in whatever state they dwell. Such power is wholly adequate; and the need for coercing a state cannot arise. If unhappily the people of a given state were to endeavour to resist the enforcement of a federal law, the federal government would proceed to enforce it upon those people, as people, and not upon the state as a state.

This fact is immensely important. It is perhaps the most significant feature of the United States federal system. It is in this way that the authors of the constitution sought to avoid war as between the United States, and one or more of the states composing the union. Armed force applied to a state is war. The federal government has no power to make war upon a state and does not need such power. This feature of the federal system is often misunderstood by people who advocate federalism on the international level and propose to give the international federal government power to police international society and compel states to obey. That is precisely what the authors of the US. constitution sought to avoid. They came close to performing a miracle in the realm of political science. Only once has the system failed to work and that was at the time of the Civil War.

The constitution guarantees the boundaries of each state and provides for the admission of new states to the union There were 48 in 1946. Whether or not the outlying dependencies can be admitted as states is a question which had not been settled. Each of the states has exactly the same power. Once admitted to the union the powers of a state are determined by the provisions of the constitution, and they apply to all in exactly the came 13 independent sovereign states. Presumably they could at same way. There is some confusion about this point because the legislatures of various states do not have the same powers, and governors of some states have much more power than governors of other states. These variations grow out of the fact that each state provides for its own agencies of government in its own constitution. The states as states have equal and identical powers

The federal government cannot deprive a state of powers reserved to it by the constitution. Thus it is improper to say that the federal government has power superior to that of the states. The federal government can do only what the constitution says it can do, but within these limits the federal law prevails, and provisions of state constitutions and state laws which interfere with the enforcement of federal laws are null and void. Beyond these limits the state prevails, and the federal government cannot intefere. This basic theory of the constitution is easily stated. The practical application of it has produced a multitude of harsplitting interpretations which would fill many volumes. Suffice it to say, the supreme court of the United States is the ultimate authority in the matter of determining the dividing line between state and federal power.

Each state may provide for its own government subject only to the few limitations in the federal constitution. Each state has a written constitution, in essential features similar to the federal constitution They all contain bills of rights limiting their own governments. They all provide for the tripartite division of powers into separate branches: legislative, executive and judicial. They all apply the doctrine of judicial review under which the courts interpret and apply the provisions of the state constitution They all provide for popularly elected governors. In every state except Nebraska there is a bicameral legislature-a senate and a so-called lower chamber, usually at least twice as large as the senate. Members of both houses are popularly elected from districts, in many states the counties. No state has provided for a cabinet truly comparable to the cabinet in the federal government, although some states have experimented with the idea. In a great majority of the states the high administrative officers, such as the secretary of state, treasurer, auditor, attorney general and secretary of agriculture, are elected and not subject to the administrative control of the governor.

It is not possible to go much further in describing state government in the United States without qualifying each statement with such words as "usually," "generally," "in most states," or "in a majority of cases" The reason is that although the institutions of state government are very similar, they do differ somewhat. To the casual observer and to the ordinary clitten who travels from one state to another the systems of government are so nearly alike that he is scarcely conscious of the fact that he has moved from one jurisdiction to another. He takes it for granted that the political and legal system which prevails in his own state also prevails in another; and m general he is right.

Thus each state has its own complete system of civil and criminal law. There are variations but they are not particularly significant to the ordinary citizen.

Each state has power to determine who may vote, subject only to the provisions of the federal constitution which say that the right to vote shall not be denied on account of race, colour or sex. The federal constitution does not guarantee the right to vote to anyone—to citizens over 21 years of age, to women, to soldiers or to Negroes. It does not forbid poll tax requirements or property qualifications. One gains a right to vote under state law, But the all-important fact is that the right of all citizens over 21 years of age to vote has been established in all states, with some qualifications is some states, usually involving term of residence and literacy.

The structure of courts is much the same in all the states, and however the closely the model of the federal judiciary. The most notable difference between the federal judiciary and that of the states is that in most of the latter the judges are elected instead of being appointed and hold office for fixed terms.

Administrative departments, offices and agencies to be found in all the states are quite similar but not identical either in organization or as respects relationship to each other and to the governor. A marked tendency in the 20th century has been to reduce greatly the number of independent administrative agencies, to merge them into large departments of administration and to stiengthen the power of the governor over them. Further generalization would serve little purpose. The facts with respect to each of the states can be found in their constitutions and laws and in the texthooks.

The same observations can be made with respect to the structures of local government and the public school systems. They are very similar but not identical.

Throughout the entire history of the United States there has been an apparent tendency for the national government to uncrease its powers and to extend its scope of operations, often, it is said, "at the expense of the states." From 1932 this tendency has been greatly accelerated and some observers have been prompted to predict the ultimate subordination, if not the virtual extinction of the states. Political theorists have often commented upon the instability of a federal system, saying that one of two things is likely to happen: either the national government will acquire such power as to lead to the extinction of the component units—the states; or, the states will be so jealous of their own powers as to lead to the paralysis of the national government and the ultimate collaises of the union

After a century and a half of experience there seems to be no remote possibility that either prediction will be fulfilled in the United States The powers of the national government have indeed been expanded This has come about largely because of the application of the idea of loose or broad construction to the grants of power to congress, chiefly the power to regulate commerce among the states, and the power to tax for the general welfare; while the states have been held in check by the strict application of that provision of the fourteenth amendment to the constitution which says, "No state shall make or enforce any law which shall abridge the privileges or immunities of citizens of the United States, nor shall any state deprive any person of life, liberty or property, without due process of law; nor deny to any person within its jurisdiction the equal protection of the laws But on the other hand the powers of the states have expanded also and seem destined to continue to expand. The states have

also and seem destined to continue to expand. The states have vast power in the realm of civil and criminal law, domestic relations, property rights, taxation, the regulation of busness, agriculture, the professions and commerciar leationships. The states have almost unlimited power in such matters as public education, social betterment, public health and welfars, the building of highways and public works and the control of public withintees and intrastate commerce. Thus the opportunities for the expansion of the profession of the profession of the control of the looked by those who are more impressed by what seem to them to be the encroachments of the federal government upon the states. Many other countries, chiefly in the western hemisphere, have

Many other countries, chiefly in the western hemisphere, have established federal systems of government similar to that of the United States. Serious difficulties frequently have arisen, leading sometimes to a complete breakdown of the system Although many factors have contributed to these failures the wesk spot in the systems means to be the supreme court. It is that agency which passes finally upon questions involving the powers of the states and of the national government. If the court becomes corrupt or incompetent, or if the people are unwilling to accept its decisions, the entire system is in danger of collapse Both the national government and the states must rely on the court to protect them against encroachments.

against encreachments. MadDonald, Amricas State Coverments
Brancoscury—Austri, A. Ather W. Bromese, State Coverments
and Administration in the United States (1936); William Broke
Graves, Amercan State Government (1936); Kiri. H. Porter, State
Administration (1938).
STATEN BLAND, or the borough of Richmond, one of the

STATEN ISLAND, or the borough of Richmond, one of the five countes of New York city, is in New York harbour, south of Manhattan, between New Jersey and Brooklyn. Thangular in shape, the island is 13,9 mil. long, 7,3 mil. across at its widest part, has 35 mil. of water front and a land area of 57 sq.mil. The-population was 191.075 by the 1950 federal census and 174.441 in 1940. The larger communities are Port Richmond, West New Brighton, New Brighton, St. George, Temphinsville, Stauleton,

New Dorp, Great Kills and Tottenville,

The county seat, formerly at Richmondtown, was moved in 1920 to St. George, the northeastern tip of the island and central point of communication with the rest of the city Transportation to Manhattan is provided from St. George by municipal ferries and to Brooklyn by privately operated ferries

Three vehicular bridges connect Staten Island with the state of New Jersey the Outerbridge crossing, extending from Tottenville to Perth Amboy, N J.; Goethals bridge, from Holland Hook to Elizabeth, N J .; and the Bayonne bridge, from Port Richmond to Bayonne, N I.

Transportation facilities on Staten Island itself consist of surface electric trains, steam freight service and an extensive bus

The census of manufactures in 1947 listed 173 industries, the largest being shipbuilding, oil refining, metal working, smelting and refining, and the manufacturing of soap, dental supplies, fireworks, colours and dyes and building supplies The major shipyards are on the north shore; the east shore is the site of shipping terminals including the New York foreign trade zone no 1, or free port, a municipal area used for shipping, storing and packing commodities, now privately operated

About 70% of Staten Island's families own their homes. There are 627 mi. of streets, 126 churches, 83 private and public schools, 5 hospitals, 7 public libraries and 47 city parks and golf courses,

with a total area of 2.86r ac.

There are two liberal arts colleges, the largest being Wagner Memorial Lutheran college, a coeducational institution with a 53-ac campus on Grymes hill, and Notre Dame College of Staten Island, a four-year institution for women, also on Grymes hill Wagner houses the Edwin Markham Memorial library, left to the college in his will by the poet, who lived in Westerleigh, Staten Island, until his death in 1940.

Points of interest are the Barrett park zoo, the museum of the Staten Island Institute of Arts and Sciences, the Richmond Historical museum, U.S. marine hospital. Seaview hospital. Silver Lake park and reservoir, Sailors' Snug Harbor, U.S. coast guard base and lighthouse service and the US quarantine station.

Among the 45 historic houses standing is the Voorlezer's house (1696), Richmondtown, the earliest known elementary schoolhouse in the country. A plan was undertaken to restore that area to its original pre-Revolutionary War state and maintain it as a historic site.

History.-When discovered by Europeans, Staten Island was inhabited by a few Aquehonga Indians, a branch of the Raritans. The first land grant was made by the Dutch West India company

After several settlements by white men, unsuccessful because of Indian attacks, the first permanent settlement was established in

1661 at Oude Dorp (Old Town) at South beach.

The island was named "Staaten Eylandt" during the period of Dutch control, in honour of the states general, the governing body of the Netherlands. The name "Richmond" was derived from the town and dukedom of Richmond in Yorkshire, Eng.

In 1668, according to legend, in order to prove that Staten Island was part of New York rather than New Jersey, the duke of York commissioned Capt. Christopher Billopp to sail around the island in 24 hr. Billopp, according to the story, made the trip within the time limit and was rewarded for this and other services with a grant of 1,163 ac, at the southern end of the island, now Tottenville

In the Billopp, or "Conference," house in Tottenville on the southern shore of the island, Lord Howe on Sept. 11, 1776, met with Benjamin Franklin, John Adams and Edward Rutledge, three representatives of the Continental Congress, to discuss reconciliation with England. The house has been preserved as a historic landmark.

Staten Island did not become part of New York state by law until 1892. In 1896 it became one of New York city's five

BINITOGRAPHY. ... J. J. Clute, Annals of Staten Island (1877); R. M. Bayles, History of Richmond County (1887); I. K. Morris, Memorial

History of Staten Island (1898-1900), C W Leng and W T Davis, Staten Island and Its People, a History, 1609-1929, 4 vol (1930), Henry G Stemmeyer, Staten Island, 1524-1898 (1950). (L Gu)

Henry G Steinmeyer, Staten Island, 1524-1898 (1950). (L. GU)
STATE RIGHTS, a term used generally in political science to denote those governmental rights which belong to the individual states of a federal union, there being a certain sphere of authority in which these individual states may act without interference from the central government Thus, in the United States there were certain rights reserved to themselves by the states when forming the union under the constitution of 1787. These rights the central government is by fundamental law bound to respect, and they can be reduced only by amendment to the con-

For 1,000 years the various German states were so jealous of any curtailment of their individual rights as to prevent the formation of an efficient federal government

In federal unions, such as Mexico and Brazil, where a central authority existed first and created the states, the belief in state rights is much weaker than it is in unions composed of originally independent states

The rights of a state are said to be delegated when, as in Mexico, Biazil and Colombia, the constitution is created by a central national authority which also makes the states, state rights are residuary when independent states unite to delegate by a constitution certain powers to a central government, as in the case of the United States, Switzerland and, until 1905, Sweden-Norway History shows that states forming unions of the second class are certain in aftertime to deny or assert that the sovereignty of the state is one of the rights reserved, according as the state belongs to a stronger or weaker section or faction, state sovereignty being the defense of the weaker state or faction, and being denied by the stronger group of states which controls the government and which asserts that a new sovereign state was created by a union of the former independent ones. This dispute is usually ended by civil war and the destruction of state sovereignty.

The evolution of state rights as shown in the history of the United States is typical. Thirteen independent states formed a union in 1787 under a constitution reserving certain rights to the states The sphere of the state authority embraced most of the powers of government, except, for instance, those relating to foreign affairs, army and navy, interstate commerce, comage and the tariff; the powers of the central government were specified in the fundamental law. Most of the states claimed at one time or another that sovereignty was one of the reserved rights of the states and on this theory the southern states acted in the secession in 1861. The war that resulted destroyed all claims of state sov-

ereignty

The other rights of the states consisted of those not delegated to the central government or forbidden to the states by the constitution. In case of doubt the presumption was in favour of the state. Since the beginning, however, the central government has gained strength at the expense of the states, seldom by direct usurpation (except during the Civil War and Reconstruction. 1861-76), but indirectly through use and custom, as the country and people developed and new conditions of government arose The field of state rights has not increased, while centralization has slowly but surely taken place.

The central authority in the United States, formerly affecting the average citizen but little, now touches him in many of the activities of life and sometimes intrudes even into the domain of local self-government. The history of the decay of state rights makes it seem doubtful if the federal form of government is a permanent one, or 1s only a transient form between independent state governments or loose confederacies and a centralized national government.

uonia government. Braincovernment financia grant Tida et Raferences on Braincosaway.—U.S. Government financiam State Rights, "Select List of References, no. opt. (1926), Woodcovernment State Tida et see 1, 18, 11, Stephens, Constitutional View of the War Between the States (1368-70); A. L. Lowell, Governments and Parites in Constituental Europe (1366); and R. P. Judson, Our Federal Republic Intental Europe (1366); and R. P. Judson, Our Federal Republic

STATE'S EVIDENCE, the term used in the United States for evidence given by an accomplice upon promise of pardon, STATES-GENERAL, the English translation of (1) the states-general of the Duich Netherlands. The name in both cases signifies the assembly of the estates of the realm, as distinct from provincial assemblies of states, it is thus the equivalent of the English parliament, of the Cottes in Spain, or the diet of the Holly Roman empire, which the states-general resembled in their original constitution

In France the states-general were first summoned in 1302 by Philip IV for the purpose of giving him moral support in his quarrel with Pope Boniface VIII They consisted of representatives of the three orders of clergy, nobles and commons (taers état, third estate), an arrangement which survived to the end, though their composition, as well as their effective powers varied greatly at different times. For various reasons (notably the disorganization occasioned by the Hundred Vears' War and the religious wars of the 16th century) they never secured the power over taxation and legislation early obtained by the English parliament, and after 1615 they were never summoned util 1789, when they transformed themselves into the National Constituent assembly This seasombly consisted of the representatives of the three orders sitting together, but the states-general had ceased to east (see Fankor Hustory).

In the Netherlands the convocation of the states-general, consisting of delegates from the provancial extates, dates from about the middle of the 1sth century, under the rule stee dates of Burgundy. The name was transferred, after the extension of the northern Netherlands from the Spanish dominions, to the representatives elected by the seven sovereisp provincial extrate for the general government of the United Provinces. The states-general, in which the voting was by provupors (each province having one vote) was established from 1593 at The Hague. The states-general came to an end after the revolution in 1795, with the convocation of the National assembly (March 1, 1796), but modern Holland continues to use their name for its national legislature, which consists of the first chamber and the second chamber. (See HOLLAND, HARDY)

STATES OF THE CHURCH or PAPAL STATES, that portion of central Italy which, previous to the unification of the kingdom, was under the direct government of the see of Rome. Area in 1859 was 16,000 8 sq mi; pop. in 1853, 3,124,758.

With the exception of Benevento, surrounded by the Neapolitan province of Principato Ulteriore, and the small State of Pontecorvo, enclosed within the Terra di Lavoro, the States of the Church formed a compact territory, bounded on the N.W. by the Lombardo-Venetian kingdom, N.E. by the Adriatic, S.E by the kingdom of Naples, S.W. by the Mediterranean, and W by the grand-duchy of Tuscany and the duchy of Modena. On the Adriatic the coast extended 140 mi, from the mouth of the Tronto (Truentus) to the southern mouth of the Po, and on the Tyrrhenian Sea 130 mi from 41° 20' to 42° 22' N latitude The former papal territories are now comprised within the Italian provinces of Bologna, Ferrara, Forli, Ravenna, Pesaro and Urbino, Ancona, Macerata, Ascoli-Piceno, Perugia, Rome and Benevento. For the origin of the territorial jurisdiction of the pope see PAPACY With the moral and ecclesiastical decay of the papacy in the 9th and 10th centuries much of its territorial authority slipped from its grasp; and by the middle of the 11th century its rule was not recognized beyond Rome and the immediate vicinity. By the Treaty of Sutri (Feb. 1111) Paschal II was compelled by Emperor Henry V to surrender all the possessions and royalties of the church; but this treaty was soon repudiated, and by the will of Matilda, Countess of Tuscany, the papal see was enabled to lay claim to new territories of great value. By the capitulation of Neuss (1201) Emperor Otto IV recognized the papal authority over the whole tract from Radicofani in Tuscany to the pass of Ceperano on the Neapolitan frontier-the exarchate of Ravenna, the Pentapolis, the March of Ancona, the bishopric of Spoleto, Matilda's personal estates, and the countship of Brittenoro; but much of the territory described remained for centuries an object of ambition only by the popes. The actual annexation of Ravenna, Ancona, Bologna, Ferrara, etc., dates from the 16th century.

ground-swell of the French Revolution, but they reappeared in 1844. In 1849, they received a constitution of the kingdom of Italy in 1860 they were reduced to the Comraca of Rome, the legation of Velletin, and the three delegations of Viterbo, Cività Vecchia and Frosinone, in 1870 they disappeared from the political map of Europe From that time, the popes retired within the Vitican as self-constituted prisoners. This stitution was changed by the Latenan tresty between the Holy See and the kingdom of Italy (signed Feb 11, 1939), which recognized Pope Pins XI as sovereign of a clearly defined territory, entitled "Original Control of the Vatican". Therein the Holy See has full and care control of the Vatican".

STATE SUCCESSION. The extent to which a succession

State is bound by the obligations of its predecessor constitutes one

of the most difficult problems in international law. The clearest statement is probably that contained in the report of the Transvaal Concessions Commission, see Parl Pap South Africa, 1901 [Cd 623]. The principles which the commissioners regarded as applicable to the determination of questions relating to various concessions granted by the Transvaal Government in view of the conquest and annexation of the Transvaal by Great Britain are as follows :- (1) "It is clear that a State which has annexed another State is not legally bound by any contract made by a State which has ceased to exist, and that no court of law has jurisdiction to enforce such contracts if the annexing State refuses to recognize them, see Cook v. Sprigg (1899) A C. 572 But the modern usage of nations has tended in the direction of the acknowledgment of such contracts After annexation, it has been said the people change their allegiance, but their relations to each other and their rights of property remain undisturbed, U.S. v. Pencheman, 7 Pet. 51, and property includes rights which lie in contract, Soulard v U S, 4 Pet 54" Concessions of a mixed public and private character probably continue to exist after annexation until abrogated by the succession State There would not appear to be any distinction between cession and annexation. Private rights should be respected, but this is based rather on ethics than law (2) "Though we doubt whether the duties of an annexing

State towards those claiming under concessions or contracts . . . have been defined with such precision in authoritative statement or acted upon with such uniformity in civilized practice, we are convinced that the best modern opinion favours the view that as a general rule the obligations of the annexed State towards private persons should be respected. Manifestly the general rule must be subject to qualification, as that an insolvent State could not by aggression which practically left to a solvent no other course than to annex it, convert its worthless into valuable obligations; again an annexing State would be justified in refusing to recognize obligations incurred by the annexed State for the immediate purposes of the war against itself, and that probably no State would acknowledge private rights the existence of which caused or contributed to cause the war which resulted in annexation." (3) The principle to be adopted was that proclaimed by the Prussians upon the annexation of Hanover "we will protect every one in the possession and enjoyment of his duly acquired rights." (4) "The acceptance of this principle clearly renders it necessary that the annexing Government should in each case examine whether the rights which it is asked to recognize have, in fact, been duly acquired. (5) Thus a concession may properly be cancelled when "(a) the grant of the concession was not within the legal powers of the late Government, or (b) was in breach of a treaty with the annexing State, or (c) when the person seeking to maintain the concession acquired it unlawfully or by fraud, or (d) has failed to fulfil its essential conditions without lawful excuse," (6) A concession may be cancelled when its maintenance would be injurious to the public interest.

to the public interest.

See A. B. Keith, Theory of State Succession (1907); Max Huber, Die Staatensuccession (1898); Westlake, Collected Papers; Pitt Cobbett, Leading Cases on Intern. Law You, III, 4th ed. (1924).

STATESVILLE, a city of North Carolina, U.S.A., county

much of the territory described remained for centuries an object STATESVILLE, a city of North Carolina, U.S.A., county of ambition only by the popes. The actual annexation of Ravers, east of Ireedell county; 130 ml. W. of Raleigh, on federal high-na, Ancona, Bologan, Ferrara, etc., dates from the 16th century, ways 21, 64 and 70; served by the Southern rallway. The popular of the Church were submerged for a time by the lation was 16,765 in 1950; 11,440 in 1940 by federal census,

The city is in the upper Piedmont section of the State, at an inglitude of 960 feet Statesville was laid out in 1790 as the capital of Ireeld county organized 1783, hear old Ft. Dobes, which was twice defended against the Indians by Damel Boone, which was twice defended against the Indians by Damel Boone, the most famous of American backwoodsmen During the Cvil War Govennor Zebulon Vance took refuge in Statesville when Sherman entered Raleigh (April 13, 1865).

STATIC, a term in radio denoting conduction or charging current in an antenna (q v) resulting from physical contact between the antenna and charged bodies or masses of gas In America this term is synonymous with atmospherics

STATICS, the branch of mechanics which discusses the conditions of rest or equilibrium of forces (from Gr. root στα, stand) (see Mechanics)

STATIONARY MACHINERY: see Processing Ma-

STATIONARY MACHINERY: See PROCESSING MA-

STATIONERY. The word now covers all writing materials and implements, together with the numerous appliances of the desk and of mercantile and commercual offices. The principal articles and operations of the stationery trade are dealt with under such headings as BOOKENDRING; OPPICE APPLIANCES; INK, LITTROGRAPHY, PREFE PER and PENOT.

LITHOGRAPHY; PAPER, PEN and PENCIL.
STATIONS OF THE CROSS, a series of 14 pictures or images representing the closing scenes in the Passion of Christ, viz., (1) the condemnation by Pılate, (2) the reception of the cross, (3) Christ's first fall, (4) the meeting with His mother, (5) Simon of Cyrene carrying the cross, (6) Veronica wiping the face of Jesus, (7) the second fall, (8) the exhortation to the women of Jerusalem, (9) the third fall, (10) the stripping of the clothes, (11) the crucifixion, (12) the death, (13) the descent from the cross, (14) the burial. Sometimes a 15th-the finding of the cross by Helena-is added; on the other hand in the diocese of Vienna, the stations were at the end of the 18th century reduced to eleven The representations are usually ranged round the church; sometimes they are found in the open air, especially on the ascent to some elevated church or shrine. The normal form of the devotion, which began among the Franciscans, is to visit the stations of the cross wherever represented, and exercise a devout meditation on passing from station to station

See article "Stations of the Cross" in the Catholic Encyclopaedia

STATISTICS. The name statistics was first applied to collections of data relating to matters important to the State, such as the numbers of the population, the yield of taxation, the value of trade carried on within the territory of the State or between that territory and other parts of the world, the mortality from particular diseases and from all causes together, etc., and to the study and interpretation of such data. The data were not at first numerical and later not exclusively numerical, but the precision and convenience of data expressed in numbers, as compared with other forms of statement, have led to the more general cultivation of arithmetical data and to the common use of the term "statistics" as if it related exclusively to data expressed in numerical form. At the same time, the numerical data to which the name "statistics" is generally applied are not limited to such as have some connection with the organization or administration of the State, the methods appropriate to the study of statistics being, broadly speaking, the same whether the data under consideration relate to human communities or are concerned with any other branch of knowledge or investigation

Statistical Tables.—The simplest way of arranging numerical records is to set them out in tabular form. We may, for example, ascertain the amount of sugar consumed in a given country in each year of a given period. A table may be drawn up in which each line contains the figures for the year the date of which is shown at the beginning of the line If each line relates to the year next following that dealt with in the preceding line, the sequence of figures of consumption will enable us to determine whether, and at what rate, the yearly consumption of sugar increased in successive intervals of years. The increase of population from year to year observed in most countries is an obvious influence tending to increased use of any popular article of consumption, and it will be advantageous to add, to the figures show

ing the total consumption of sugar in the country, another series of figures showing the number of persons luving in that country in each of the years covered by the table. To the columns containing (1) the dates of the years to which the information relates, and (2) the total amounts of sugar consumed in the respective years, there will thus be added (3) a column showing the numbers of persons concerned in the consumption of these quantities of sugar. The significance of this last column in relation to the preceding may be made clearer by the addition of a fourth column (4) deduced from the two preceding by dividing the quantity of sugar shown in any line of the table by the number of the population shown in the same line, thus obtaining the average amount of sugar consumed per head of the specified population. The form of the table is sufficiently indicated by means of the lines relating to the United Kingdom in ten years, 1903 and 1913, given below:

Consumption of Sugar in the United Kingdom											
(1) Year	(2) Total con- sumption thou- sand cwt.	(3) Population thousands	(4) Consumption per head, lb								
1903 .	28 847	42 247	76 5								

If to this table further columns are added or a new table is drawn up, in which data relating to the consumption of tea in the same country and in the same years is set out, we obtain two sets of facts the comparison of which may prove of intest and importance. We can ascertam whether the variations in the consumption of sugar and of tea were related.

Graphs.—It is frequently of advantage to set out in diagrammatic form such tabulated results as those referred to, as at least the broader features of the comparison of two or more series of

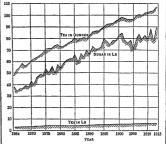


FIG 1—GRAPH SHOWING CONSUMPTION PER HEAD OF TEA AND SUGAR IN THE UNITED KINGDOM IN EACH YEAR, 1864—1913 Quantities in stock at the end of each year are not taken into account

figures can often be seen more clearly in this form. Such simple graphical comparisons are familiar through their use in meteorological reports where readings are shown by the upward and downward movements of a line crossing from left to right a series of vertical lines marking the house of the day or the days of the week. The particulars of the consumption, per head of the population of the United Kingdom, of sugar and of tea in each of the years from 1864 to 1913, are thus shown in Fig. (1). A necessary precaution in planning such graphical comparisons is also ullustrated in the same diagram. The figures which are plotted relating to sugar show the average consumption year by year in lb. per head. The consumption of tea in lb. per head yields the

line at the foot of the diagram, the variations of which are so manner in which the individual observations are distributed is in slight as to suggest no similarity with those of the line showing sugar consumed If, however, the consumption of tea per head is expressed in ounces, it becomes clear that, though in individual vears the variations shown are by no means similar for sugar and for tea, over the whole period the increase was in approximately the same proportion for these two commodities1. The fluctuations were more considerable in the case of sugar, and the diagram suggests that, up to 1901, the quantities of sugar increased somewhat more rapidly than, and thereafter failed to maintain as great an increase as, those of tea

Even though graphs fall short, in the matter of precision of statement, of the numerical tables, they have the great advantage of enabling a large mass of figures to be grasped as a whole much more readily than is possible when those figures are presented in one or more tables

Averages and Dispersion.—A second illustration of statistical series is seen in the following summary of the heights of a number of men .-

Height in inches Number recorded	61 2	62	63	64	65	66	67
Height in inches Number recorded	68 126	69	70 87	71 75	72 23	73	74

The table may be interpreted as meaning that 126 were found between 5 ft. 72 in and 5 ft 82 in and similarly for other heights In tables such as this some method of dealing with cases falling exactly on the dividing line between two adjacent groups must be laid down, and a common method is to assign half the number found on the dividing line to each of the classes of which it forms the limit. This procedure may, of course, result in numbers in some of the groups which are not integers. The true average height of the 730 men covered by the table can be ascertained only by reference to a more detailed statement showing the height of each man exactly, instead of in a number of groups. It will be observed that 297 were not taller than 5 ft. 74 in., while 307 were 5 ft. 81 in. or more, the distribution being not quite symmetrical on both sides of the numerically largest group. The approximate average height was about  $\frac{1}{20}$ in less than 5 ft 8 in.

A table of this kind tells us, however, something more than the average height of the individuals represented. We note that 191 were not more than 5 ft. 61 in. in height and 198 were not less than 5 ft 94 in. in height. By calculation from the figures shown, assuming that the individual heights were distributed with approximate regularity along the intervals from inch to inch, the points representing 5 ft 6.3 in, and 5 ft, 9.7 in, would divide the series of heights so that one-quarter of the whole number fell below the former, and one-quarter of the whole number above the latter A similar calculation gives, as the point dividing the series into two equally numerous groups, 5 ft. 8-04 in. This last point is called the median of the series, and the two others are the lower and upper quartiles, the three points serving to divide the whole number examined into four groups of equal numbers of cases The distance between the upper and lower quartiles, in the case in question 3.4 in., gives the range within which the middle half of the instances recorded lay. This distance expresses much more definitely the degree of concentration of the individuals in the neighbourhood of the median height than, for example, the whole range (14 in.) within which all the measurements lie If a more exact description of the nature of the distribution than is afforded by the specification of the median and quartiles, but of the same general character, is desired, the group may be divided into a number of parts, e.g., into ten equally numerous

parts, the points of division being then known as deciles.

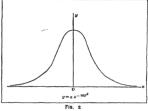
In many varieties of statistical problems it is found that the observations are distributed in a manner similar to that shown in the above illustration, and the question arises whether the form of the distribution is of a recognizably definite character, the determination of which can be of use in the interpretation of the results obtained. It is found that, in numerous cases, the

<sup>1</sup>Ci. Jubilee Vol. of the Royal Statistical Society, p. 257, where the late Professor Marshall used this illustration. The figures are based on imports less exports of sugar, excluding sugared goods.

close accordance with that of events dependent on pure chance. Such a case is presented by the following A number of balls, indistinguishable in size, weight or form, are placed in a bag, half of the balls being white and half black. If one ball be drawn from the bag, its colour, whether white or black, may be noted. The ball being replaced and the bag shaken, another drawing will give a result wholly independent of the first. The repetition of such drawings will furnish a record of runs of white and of black balls, some short, some long. The numbers of cases (a) of a change of colour in consecutive drawings (b) of sequences of the same colour of two, three, four, etc , in number, being noted, the material for a table is furnished, and this table would have a general similarity with that of the men's heights used above for illustration. It is possible to determine theoretically the relative frequency with which the various sequences would recur in a series of trials indefinitely extended

If, in a large number of drawings, sequences of  $x_r$  white (or of  $x_r$  black) balls are recorded on  $Y_r$  occasions, the total number n of drawings will be expressed by  $n=x_1Y_1+x_2Y_2+x_3Y_4+...$ +xrVr+... The relative frequencies of the different series are  $y_1$ ,  $y_2$ , etc., where  $ny_1 = Y_1$ ,  $ny_2 = Y_2$ , etc., and, when n is indefinitely increased, the relation between the x's and the v's is expressed by the formula  $y = a e^{-m\pi^2}$ , which represents a curve of the shape shown below in fig (2), known as the probability curve.

It is not proposed to enter into discussion of the character of the probability curve, or the interpretation of the variations. It will be sufficient here to point out that the equation given relates to a curve symmetrical in form to right and left of the position represented by x=0 The part to the right may be supposed to show the record of white sequences, and that to the left the



exactly similar record of black sequences, ie, of sequences in which white balls failed to appear

In any actual series of observations (e.g., of the colours of

balls drawn from, and returned to, a bag) the observed numbers expressing the frequency of different events will be found to differ more or less from those expressed by the curve, of the form given by the above equation, which is appropriate to the circumstances of the experiment. Prolonged trials would give results approximating to those derived from theoretical calculations and expressed in the shape of the probability curve. Thus, in the case of the heights of 730 men, it is probable that records covering larger numbers of men, of the same race and social condition and within the same limits of age as those from which the 730 were selected, would give a distribution of heights more closely corresponding to that shown by a typical probability curve than the numbers cited. If, for example, for every one actually covered by our table, 10 or 20 or 50 or 100 had been measured, closer correspondence with a suitably selected theoretical series would have been probable.

In considering the meaning of changes in the observed frequency of events, it is generally of considerable importance to ascertain what is the extent of variation that is as likely to happen as not, since the significance of actual variations can only be judged in relation to those which may have no significance at all in reference to the problem under consideration

Skew Distributions .- The normal probability curve, referred to above, is not the only form resulting from the theoretic consideration of chance events, and presenting close correspondence with statistical records of various kinds. The study of these forms, and of their theoretical bases, has been particularly active since the last decade of the 19th century. It will suffice here to mention that particular statistical problems are found to yield distributions of observations, not only symmetrical on either side of their mean, as with the normal probability curve, but also grouped more closely on one side of the mean than on the other The illustration from men's heights showed some small tendency to a skew shape, though it appears possible that the apparent deformation would, on extending the field of observation, be found to disappear and be shown to result from the fact that, in so small a number of cases as 730, the even representation of men of all heights in the population from which these cases were drawn had not been exactly secured. The following records of weights of men of 25 and less than 30 years of age and within half an inch of 5 ft. 6 m in height, shows a more marked skewness

i	Weight in lb. Number of cases	105	120	135	150	165	180	195 33	210
ı	Number of cases	17	722	2,175	1,346	485	155	33	3

In this case the average (or arithmetic mean) of the weights of the 4,956 mn is, on the assumption of continuous distribution, approximately 14,15 lb The median is at about 1 lb less, viz., 14c jb ln In the previous illustration of heights, the median was greater than the mean, so that the skewness shown is of opposite direction in the two cases.

This illustration serves also to show a third characteristic of statistical distributions of this kind Nearly four of every nine cases are included in that one of the eight groups of which 135 lb is the central point, this group being notably more numerous than any other. The weight 135 lb may be called, so far as the figures furnish a ready indication, the most generally occurring weight or the "modal" weight. The point in the distribution thus determined is called the "mode." A table like the above does not, however, give a very close measure of the central point of the group (covering a range of 15 lb) which would prove largest if we compared various groups such as 1271 to 1421 lb (the group shown) 127 to 142 lb, 128 to 143 lb., and so on. If the curve be found which represents the distribution in question, its highest point is the point the weight corresponding to which is the "mode" of the distribution, the most prevalent weight in the distribution under examination. Various problems in probability lead to curves of the distribution of chances which show the skewness that marks groups of statistical observations

Groups That Are Not Homogeneous.—A case that may, however, be mentioned is that in which the measurements obtained relate, not to a homogeneous group, but to a mixture of two or more groups. The manuer in which such a mixture might affect the characteristics of a distribution may be illustrated from the figures given below for the heights of a particular group of men. Suppose two such groups were found differing in the heights of multiple and the property of 
the individuals of which were half an inch taller than those of the original group If the distribution of the original group were such as could be precisely represented by an appropriate theoretical formula, the compound group would not be, in general, represented by the same formula. In some instances, it has been found possible to show that an observed group was so distributed as to be consistent with the assumption that it was made up of two groups of different characteristics, the members of which were mediaded within one and the same series of observations Such an analysis can clearly be of considerable importance with reference to the deductions to be drawn from the examination of the observed data.

Three Variable Elements .-- In what precedes, the statistical material considered has consisted of series of pairs of quantities, the values of the two quantities in each pair being related; for example, where one of the quantities is the height of a man, the other the relative frequency with which men of that height were observed We pass now to the consideration of series of three quantities, for example, where two of the quantities express the measures of different phenomena (which may be connected in some way, or may be independent) and the third expresses the relative frequency with which any combination of the other two occurs Such a series is represented in the table given below, which shows the proportions in which, over a period of years, in a particular country, marriages in which both bride and bridegroom had been married previously were distributed according to the ages of the brides and of the bridegrooms. The particulars might advantageously be set out in fuller detail, but the condensed table will serve quite well to illustrate the nature of the problems connected with the analysis of data of this kind

Ages of wives	Age	Ages of husbands at date of marriage									
at date of marriage	Under 25	25-34	35-44	45-54	55-64	65 and over	Total wives				
Under 25 25-34 35-44 45-54 55-64 65 and over	10 20 5	75 175 54 5	46 167 104 18 1	13 65 79 36 5	3 17 29 33 13	3 7 9 5	147 447 278 101 24 3				
Total husbands	35	300	336	198	96	26	1,000				

The table is to be read as follows: Of each thousand women married for the second (or later) time to men who had been married before, 447 were between 25 and 35 years old, and of these so married men under 25 years of age, 175 married men between 25 and 35, 169 married men between 35 and 45 and 17 men between 45 and 55. The other rows of figures will be read similarly, and the columns are to be read in corresponding manner, with the words "Subsand" and "wife" interchanced.

The columns, and also the rows, representing the age distributions of particular sections of the wives and of the husbands, are examples of skew distribution of numbers. It is clear, from the clustering of numbers in the neighbourhood of a band crossing the table from its upper left side towards its lower right side, that there is some association between the ages of the wives and the husbands, which are more often relatively inght logether, or relatively low together, than in other relations. The average age of the husbands is near 4x years and that of the wives somewhat

						-											
	Height in inches. Numbers in	60-61	6x-62	62-63	6364	64-65	65-66	66-67	67-68	68-69	69-70	70-71	71-72	72-73	73-74	74-75	
	Group I.	4	20	22	76	114	146	212	252	218	174	150	46	18	8		ı
	Numbers in Group II. Numbers in		, 2	ro	11	38	57	73	106	126	109	87	75	23	9	4	
,	the two groups		22	32	87	152	203	285	358	344	283	237	121	41	17	4	

The numbers in the last row represent a compound of two groups as numerous as the original group, the individuals of each of which were half an inch shorter than those of the original group, and another group, equal in number to the original group,

in excess of 34 years

Correlation.—If the average ages of the husbands shown in each row of the table be computed, and also those of the wives shown in each column, the two series of figures thus obtained show

hands and wives They furnish the measures of what are known as the regression of the ages of husbands on those of wives. and the regression of the ages of wives on those of husbands The two regressions would be complementary if the distribution represented complete linear correlation of husbands' ages and wives' ages When this complete correlation is not shown, a measure of the degree in which the distribution diverges from that corresponding to complete correlation is afforded by the socalled coefficient of correlation Between two series of quantities

$$x_1, x_2, x_3$$
 and  $y_1, y_2, y_3$ 

if the sums of the squares of each series,  $S(x^2)$  and  $S(y^2)$  be calculated, and the sum of the pairs of products x1y1, x2y2, x3y3 ie. S(xy) be also calculated, the fraction S(xy)/ $\sqrt{[S(x^2) S(y^2)]}$  gives the coefficient of correlation.

In the case represented by the final row and the final column of the last table, the calculation gives a fraction exceeding o The highest possible value for the coefficient is I The coefficient is a measure of the divergence between the two lines of regression in cases like that illustrated, those two lines coalescing when the correlation is complete. If the series compared are such that decreases in the one correspond to increases in the other, the calculated coefficient is negative. The range of values for the coefficient lies between o and 1 for positive correlations and between o and -1 for negative correlations Small values of the coefficient mean that the connection between the series is slight, and, in view of the extent to which, in actual observations, the records obtained are affected by disturbances having no relation to the matter under examination, no great significance can generally be attached to the occurrence of correlation coefficients of small magnitude

The class of problem of which the figures given in the last table furnish an illustration is one of great importance in statistical work. Thus the variation of the height and weight of men with their age, the questions relating to the transmission of characteristics from parents to children, the association of different diseases or defects and the results of combinations of treatment of diseases or defects, the interpretation of the results of variation in different features of the weather, for example rainfall and temperature, on crop yields and many other problems give rise to such dis-tributions, while the limitation of the illustration to the case of three kinds of variation should not be taken to imply that larger numbers of elements may not be considered

The practical application of the procedure of calculating coefficients of correlation is not confined to cases such as that in connection with which the nature of correlation was illustrated It may also be applied to determine, in cases such as that of the consumption of sugar and of tea, illustrated earlier, the closeness with which the variations in the two series of figures coincide In some cases it is of importance to compare, not two series the trends of which are, on the whole, similar, but two series of which the trends are different, though the variations from the general trend may prove to be similar in the two cases. Whether for diagrammatic representation, or for preliminary arrangement of material for testing by the calculation of coefficients of correlation, it is desirable to isolate the important features as far as possible. The relation between economic prosperity and the marriage rate is a problem that has attracted much attention, and in using as a measure of economic prosperity the value of the exports year by year, or of imports and exports together, the connection which appears in some periods may be obscured in later periods by other conditions which cause one or other, or both, of the curves compared to diverge from the trend previously shown. To a considerable extent the effect of these disturbing elements in obscuring the significant relation may be evaded by using for comparison, not the absolute measures, e.g., of the value of trade and of the marriage rate, but the proportion in which the figures for a given year are in excess or defect in comparison with those of the average of a series of several years of which the year under consideration is the middle year, or the final year.

the variation of the average ages of corresponding groups of hus- variations in time of phenomena under examination, are tested for closeness of fit by the calculation of correlation coefficients, it is possible to test whether one of the two series differs from the other mainly in respect of the time at which variations are greatest or smallest. In comparing two series such as

the sum of products used in calculating the correlation coefficient was conceived of as

$$x_1 y_1 + x_2 y_2 + x_3 y_3 +$$

It may be found that such product-sums as  $x_1 y_2 + x_2 y_3 + x_3 y_4 +$ 

$$x_2y_1 + x_3y_2 + x_4y_3 +$$

show significantly larger resulting coefficients than the productsum first named. If so, it may be taken as meaning that of the two phenomena the variations of which are compared, those variations are not contemporaneous, but the members of one series follow, or precede, those of the other by a roughly constant in-terval. The repetition of the calculations for several different intervals may furnish a measure of the lag of one of the two phenomena on the other

It has been stated that the lowest value of the correlation coefficient is zero. It may be added that when, in practice, a calculation of such a coefficient gives a result practically equal to zero, it is not to be concluded that there is no correlation between the quantities. The form given for the correlation coefficient was based on the assumption that the lines of regression were sufficiently nearly straight lines to render it unnecessary to call attention to their divergence from that form. In some cases in which a high correlation with non-linear regression exists, the coefficient calculated by the formula given will be small On the other hand, there are cases in which large correlation coefficients result from the formula of calculation, though the phenomena compared are, in fact, not related to each other. The principal cause of such apparently strange results is found in the fact that actual series of observations may be but small samples of the universe of phenomena of which they are taken as representative, and in small samples the securing of really representative results is not easily achieved We turn, therefore, to the consideration of some questions relative to sampling.

Sampling.-Two principal reasons lead to the use of statistics of samples in place of complete statistics of an exhaustive character covering the whole of the so-called universe of instances. One is that only portions of that universe may be accessible as sources of data, the other that the labour and expense involved in handling very large masses of statistics render it expedient to seek representative selections of moderate extent as the basis of the data to be submitted to detailed examination. In the latter case, it is to be supposed that the selection of instances is at the discretion of the investigator, and the practical question involved is the devising of a means that will ensure that the instances selected should give, as far as is possible, a picture in petto of the whole field of enquiry.

The most common method is to choose the instances in a manner that shall ensure that there is no concentration on those possessing any particular characteristic in preference to those lacking that characteristic. All cases are to be given an equal chance of selection; the sample is to be a random selection. It is only necessary to illustrate the kind of procedure that will secure that result. Suppose we have to select 200 cases from a total of (say) 20,000. We may, if the 20,000 are arranged in any kind of sequence, take the first, pass over 99 and take the case then next following, again pass over 99 and take the case then next following, and so on. Another method would be to place in a bag cards bearing the series of numbers from 1 to 20,000 and to draw from the bag 200 cards in succession, shaking the bag between each pair of drawings The numbers of the cards drawn would show what choice of cases from the complete series should be made, and any effect produced by the arrangement of the cases in a particular order, which might influence the result of the method of selection first named, would It may be noted that when two series of quantities, showing the tend to be avoided by the second procedure.

Random sampling has, as its object, as already stated, the securing of a comparatively small group possessing the same general characteristics 10, showing the same proportions in which each special feature is present or absent, as the complete series of cases. This may, in some conditions, be secured more effectively by deliberate selection of instances in which a number of characteristics are distributed in a manner similar to that in which the same characteristics are distributed in the mass from which the sample is taken This involves, of course, that, in respect of the characteristics used as guides, available records exist covering the mass.

Another mode of testing a sample in respect of its representative character is to divide it into two or more parts at random, and compare the characteristics of the separate parts Agreement between the parts is commonly taken as an indication that the sample is representative in character, though such agreement, or its absence, is not a final test. To illustrate, suppose the special case of random samples of men of specified age from a defined race and locality. Suppose a sample of 1,000 such men taken, and their characteristics examined for example, their average height, median height, the dispersion of these heights and other features of the distribution of heights may be determined. The process may be repeated for a second, third, etc., sample of 1,000 until we have (say) 1,000 sets of results derived from 1,000 samples each consisting of 1,000 units Taking one of the characteristics, say the average height, we may examine 1,000 results from the separate samples. It will almost certainly happen that these differ from one another but slightly as compared with the differences between the heights of the individuals in any one sample. But these averages would themselves generally possess a degree of variation, and their grouping according to their order of magnitude would furnish a frequency distribution having its own mean, median, dispersion, etc. This latter distribution would, in fact, indicate the degree of variability of the results obtained by sampling,

The study of the mathematical theory relating to the problems thus illustrated furnishes estimates of the answers to such questions as: what is the probability that the divergence of the mean value of a specified feature of the sample from the (unknown) mean value of the same feature of the universe from which the sample is drawn shall not be greater than a specified amount? The answers may be a guide to a decision on the questions of whether procedure by sample 1s satisfactory, and what size of sample may

be desirable to justify the use of the sampling method.

When procedure by sample is adopted because only data derived from samples are procurable, the investigation of the entire mass of cases being excluded, the use of methods aimed at securing that the samples are random or are representative is, generally if not universally, not a matter for consideration. It is, therefore, of the greatest importance to examine the conditions affecting the selection of the sample. It may be found that some bias in the selection is unavoidable, while the extent to which that bias affects the results may not be capable of estimation. To apply to the results of biassed sampling the tests and limitations determinable by theory for the case of random sampling may lead to error.

The relative stability of the relations between different groups of statistics relating to human communities and their organization was a feature that attracted attention at a very early stage of statistical enquiry. Changes in habits of masses of men are generally of slow development. The consequence is that any well ascertained sequence of phenomena in economics may be expected to be repeated, that is, the repetition of certain conditions may be expected to be followed by consequences of a definite character. The underlying assumption is the permanence of the essential determining features of the organism with whose manifestations we are concerned. The introduction of new conditions, not all of which may be obvious or ascertainable, may destroy that stability of relations on the faith of which future changes might be expected when observed conditions show particular mutual relations Not only new conditions, but also the deviations from uniformity recognizable in the comparison of different samples of one and the same universe of phenomena, must be kept in mind in forming any judgment of the probable future based on observations of the course of events in the recent past.

Sources of Statistical Data .- In the work of administration. the governments of most civilized countries are able to make exhaustive enumerations of various classes of events occurring within their territory A few examples are -the number of buths in successive weeks, months of years, the deaths in the same periods, the causes of deaths and the sexes and ages of the persons dving the amount of property or income serving as the basis of assessment to taxation of individual citizens, the value and quantity of each of various kinds of merchandise imported from or exported to other countries during any determined interval of time, the numbers of various kinds of animals existing in the country at selected dates, the length of the roads maintained at the public expense and of the railway tracks existing from time to time, the numbers of various kinds of vehicles for the use of which licences are required, the quantities of certain dutiable articles of food and drink on which duties are paid in successive months or years.

From time to time, generally at intervals of ten years, the total number of persons of each sex, the age of each being also recorded. is ascertained for each administrative subdivision of the country. and either simultaneously or on other, and possibly less frequent. occasions the number of persons engaged in each principal class of

occupation is also generally ascertained

Organizations of a private character, including corporate bodies, obtain, like the public administrative bodies, much information for their own guidance, some of which is made public. In some cases there results an exhaustive enumeration of events of certain kinds occurring within the country, in other cases a series of more or less representative illustrations of what has happened is furnished Thus the total weight of goods carried by railway may be available, while the quantities of gas, water or electricity supplied may only be made public by some of the undertakings supplying them. and the extent to which the ascertained aggregates fall short of the actual aggregates supplied may be variable in a degree that cannot be determined and may be of importance.

In addition to the data arising out of the general administration of a country, and those published by business organizations. statistical data may be obtained as the outcome of special enquiries by either of these classes of bodies or by private bodies or persons The latter class of data generally presents the characteristic just referred to as affecting some of the data obtained by business organizations, namely, that an exhaustive enumeration covering the whole country is not secured What is obtained is a record relating to a part, more or less typical of the whole so far as the matter under examination is concerned The principles to which attention was directed in the paragraphs relating to sampling apply to the statistics thus secured. (A. W F.)

apply to the statistics thus secured.

BERLEGRAPH.—Herbert Spencer, Frinciples of Sociology (1877);

M. Block, Truité théorique et praique de statistique (1878); R. Mayosmith, Science of Statistic (1895); A. I. Bowley, Ellement of Statistics, 1895; A. I. Bowley, Ellement of Statistics, 1895; A. I. Bowley, Ellement of Statistics, 1895; A. I. Bowley, Ellement of Statistics, 1995; A. I. Bowley, Ellement of Statistics, 1997; J. Koren (editor), Buttory of Statistics (N.Y., 1918); J. G. Frederick, Butmess Research and Statistics (N.Y., 1924); J. G. Frederick, Butmess Research and Statistics (N.Y., 1924); J. E. Day, Statistical Analysis (N.Y., 1935), R. W. Burgess, Introduction to the Mainemaise of Statistics (Boston, 1925); G. U. Yule, Introduction to mained of the Statistical Methods for Research Workers (and ed. 1928), see also, Fourmed of the Statistical Society (1893), in prog.). cal Society (1893, in prog).

STATIUS. PUBLIUS PAPINIUS (c. A.D. 45-96), Latin poet, was born at Naples. His father was also a poet, and Statius seems to have been trained as one from the start. Of events in the life of Statius we know little. From his boyhood he was victorious in poetic contests-many times at his native city Naples, thrice at Alba, where he received the golden crown from the hand of the emperor Domitian. But at the great Capitoline competition (probably on its third celebration in A D. 94) Statius failed to win the coveted chaplet of oak leaves. Perhaps the emperor's favour had failed him; in any case, he withdrew to Naples (Silv. iii. 5).

The rôle of court poet seems to have suited Statius. His flattery is as far removed from the gentle propitiatory tone of Opintilian as it is from the coarse and crawling humiliation of Martial. It is in the large extravagant style of a nature in itself healthy and generous, which has accepted the theme and left scruples behind In one of his prefatory epistles Statius declares that he never allowed any work of his to go forth without invoking the godhead of the divine emperor Statius had taken the full measure of Domitian's gross taste, and, presenting him with the rodomontade which he loved, puts conscience and sincerity out of view, lest some uneasy twinge should mar his master's enjoyment

As a poet, Statius unquestionably shines in many respects when compared with most other post-Augustans He was born with exceptional talent, and his poetic expression is, with all its faults. richer on the whole and less forced, more buoyant and more feheitous, than is to be found generally in the Silver Age of Latin poetry Statius is at his best in his occasional verses, the Silvae, which have a character of their own, and in their best parts a charm of their own The subjects of the Silvae are very various. Five poems are devoted to flattery of the emperor and his favourites, but of these enough has already been said. Six are lamentations for deaths or consolations to survivors Another group of the Silvae give picturesque descriptions of the villas and gardens of the poet's friends In the "Kalendae decembres" we have a striking description of the gifts and amusements provided by the emperor for the Roman population on the occasion of the Saturnalia In his attempt at an epithalamium (Silv , i, 2) Statius is forced and unhappy But his birthday ode in Lucan's honour (Silv, ii, 7) has, along with the accustomed exaggeration, many powerful lines, and shows high appreciation of preceding Latin poets Some phrases, such as "the untaught muse of high-souled Ennius" and "the lofty passion of sage Lucretus," are familiar words with all scholars

The epic poems of Statius are less interesting because cast in a commoner mould, but they deserve study in many respects. They are the product of long elaboration The Thebass, which the poet says took 12 years to compose, is in 12 books, and has for its theme the old "tale of Thebes"-the deadly strife of the Theban brothers There is also preserved a fragment of an Achilleis, consisting of one book and part of another. In the weary length of these epics there are many flowers of pathos and many little finished gem pictures, but the trammels of tradition, the fashionable taste and the narrow bars of education check continually

the poet's flight.

The edito princeps of the epics is dated 1470, of the Silvae 1472. Notable editions since have been those of Bernartius (Antwerp, 1593, Conowins (1633) and Barth (1664). Later texts are the Telephot (the Achileis and Thebas by Kohlmann, the Silvae by Bashrean) and that contained in the new cellular, the Silvae by Bashrean's and that contained in the new cellular (1648). Silvae by Bashrean's and the contained in the new cellular (1648) and Veillner (1588), the latter with an explanatory commentary. Among editions of positions of Statis' works, that of the Silvae by Malkland (1778) deserves special attention. A translation of the Silvae with introduction and notes was published by D. A. Stater in 1968 (Oxford Lafolties was been by O. Miller (Telephot). The Telephot of Translations). A translation of the Telephon and Achillers was been by O. Miller (Telephot). The Telephot of Translations of the Telephon and the Silvae (Telephot). The Telephot of Telephot (1648) and the Telephot of Telephot (1648) and the Telephot (1648) and

STATUE OF LIBERTY. See LIBERTY, STATUE OF.

STATUTE. A statute was defined by Sir Edward Coke as "an Act of Parliament made by the King, the Lords and the Commons," This definition is still apt in English law, save that in certain cases, provided for by the Parliament act, 1911, a bill may become an act even though the house of lords has not consented to it. The procedure for the enactment of statutes is regulated mainly by usage and the standing orders of parliament. Church assembly measures passed under the Church of England Assembly (Powers) act of 1010 and presented for the royal assent after a favourable resolution of both houses of parliament have the power and effect of acts of parliament. The earliest English statute is the Statute of Merton, 1235. Acts were engrossed upon the statute roll from the time of the Statute of Gloucester (6 Edw. I) but this practice has long been discontinued. Official copies of acts are now made on vellum and lodged at the public record office and in the house of lords. In the case of Church assembly measures, a third vellum copy is printed and sent to the Church assembly.

Classification of Statutes.—Acts of parliament are classified

as (1) public general acts; (2) local (or "local and personal") acts, including public acts of a local character; (3) private personal acts; (4) Church assembly measures (see above).

With the exception of certain classes of private personal acts (such as naturalization and divorce acts), which are virtually obsolete, all acts of parliament are printed by the queen's printer There are two separate series of volumes, one containing the public general acts and Church assembly measures, the other containing local and personal acts together with certain statutory orders (see below)

For the purposes of the law of evidence, however, a different classification applies, and by section 9 of the Interpretation act, 1889, every act passed after 1850 is a public act unless the act expressly provides to the contrary. Such acts are judicially noticed and no proof of them is required. Acts which are stated not to be public acts are usually provable by the production of a queen's printer's copy.

Acts may also be classified according to their object by such terms as penal, beneficial, imperative, directory, enabling, disabling, taxing, codifying, consolidating, perpetual, temporary and so forth This last classification is important for the purposes of

interpretation (see below).

Penal acts are those which impose a new disability; beneficial, those which confer a new favour An imperative statute (often negative or prohibitory in its terms) makes a certain act or omission absolutely necessary, and subjects a contravention of its provisions to a penalty A directory statute (generally affirmative in its terms) recommends a certain act or omission, but imposes no penalty on nonobservance of its provisions. To determine whether an act is imperative or directory the act itself must be looked at, and many nice questions have arisen on the application of this rule of law to a particular case Enabling statutes are those which enlarge the common law, while disabling statutes restrict it Declaratory statutes, or those simply affirming the common law, once not uncommon, are now practically unknown, the Treason act is an example Statutes are sometimes passed in order to overrule specific decisions of the courts Examples are the Territorial Waters Jurisdiction act, 1878, the Married Women's Property act, 1893, and the Trade Disputes act, 1906

Every act has a short title by which it may be cited; e.g., the

Transport act, 1953.

Interpretation of Statutes.—The Interpretation act, 1889, provides an authentic interpretation for numerous words and phrases of frequent occurrence in statutes Moreover, most modern acts contain an interpretation section which explains particular expressions in that act. The main body of the law on this subject is, however, to be found in judicial decisions, i e, the common law The main rules are as follows: (1) The meaning of an act is primarily to be sought in the act itself. (2) The words of an act are to be construed in their ordinary and natural sense, unless in the case of particular expressions there is something to the contrary in the context or in the scheme of the act. (3) The act is to be construed as a whole and acts in pari materia are to be construed together as forming one system. (4) Contemporaneous circumstances may be taken into account where the intention of the legislature cannot otherwise be ascertained. What is known as the rule in Heydon's case (1584) (3 Coke Rep., 7a) provides that the factors to be ascertained in this connection are (a) what was the common law before the act; (b) what was the mischief or defect for which the common law did not provide; (c) what remedy parliament has resolved and appointed to cure the disease, and (d) the true reason for the remedy. (5) Where words can be interpreted in two different ways the inconvenient, unjust or absurd consequences of adopting the one way may guide the court to adopt the other. (6) The full title and the preamble but not the short title, heading or marginal note may be used for the purpose of interpreting the act as a whole, or in order to resolve any ambiguity. (7) Acts which purport to interfere with existing rights must be clearly expressed. (8) Statutes are to be so interpreted as far as their language admits as not to be inconsistent with the comity of nations or with the established rules of international law. (9) Some acts are, to be liberally or benevolently construed, others strictly. Instances of those which fall into the former category are acts which are remedial, amending; explanatory; for the maintenance of religion,

the advancement of learning and the relief of the poor, directory as distinguished from mandatory or imperative enactments; and those in favour of the liberty of the subject. The acts to be strictly construed include those restricting the liberty of the subject; penal acts, fiscal and revenue acts; acts creating statutory powers and duties; private acts; acts affecting the prerogative of the crown, existing private rights or the jurisdiction of the courts In the case of penal statutes, for instance, strict construction means that the thing charged as an offense must be within the plain meaning of the words used, and must not strain the words on any notion that there has been a slip, that there has been a casus omissus, or that the thing is so clearly within the mischief in the mind of the legislature that it must have been intended to be included and would have been included if thought of. Great care must be taken not to extend penal laws beyond what the legislature has clearly meant and adequately expressed Similarly in the case of taxation statutes the court is not to be guided so much by the objects which it thinks such acts are to achieve, as by considering whether the words of the act have reached the alleged subject of taxation. There is no presumption as to a tax; nothing is to be read in; nothing is to be implied One can only look fairly at the language used. (10) Codifying and consolidating acts give rise to an inference that it is intended to reproduce the existing position and not to alter the law. A codifying act is, however, in the first instance, to be looked at without reference to the previous law if it is unambiguous, whereas reference is to be made to the previous law to ascertain the intention of the legislature in the case of an amending or consolidating act. (11) In construing acts, such as taxing acts, which apply to both England and Scotland, it is well settled that a construction should, if possible, be adopted which will make the incidence of taxation the same in both countries, (12) A special act which imposes mutual obligations on several parties so that it has a contractual operation should as between parties be construed in the same way as a contract to the same

Operation of Statutes.—The date of the "passing" of an act is the date when it becomes law. This is the date when it receives the royal assent This date is also, in the absence of a provision to the contrary, the date of the "commencement" of the act; i.e., the date when its provisions come into effect

An act of the United Kingdom parliament is to be construed prima facle as applying to the whole of the United Kingdom and not to any place outside. The United Kingdom does not include the Channel Islands or the Isle of Man.

An "extent" or "application" clause will, however, vary the effect of this rule. Acts are extended to apply to waters adjacent to the United Kingdom and other parts of her majesty's dominions for certain purposes For the application of statutes outside the United Kingdom, see below.

An act generally applies only to those within the allegiance of the crown and does not extend to foreign subjects out of the queen's dominions. An act applicable to the queen's dominions is, if the context permits, to be construed as applying to all British subjects wherever they may be.

It is a clear rule of law that the crown is not bound by an act of parlament, unless it is expressly named or clear words of implication are used. The crown for this purpose includes the great departments of state, but bodies such as the British Transport commission have been held not to be the servant or agent of the crown for this purpose. The crown may, however, be held to be bound by implication if it be hencenet purpose of the act would be otherwise wholly frustrated. The crown is, however, entitled to the benefit of an act although not named.

Generally speaking the courts will hold that statutes are not retrospective, if it is possible so to construe them. This fundmental rule of English law involves another to the effect that a statute is not to be construed so as to have a greater retrospective operation than its language renders necessary. Where an act is repeated the repeat does not in general affect its previous operation.

The provisions of a public act can be overridden or varied only by express enactment or clear implication. Where the common law is to be changed, and especially the common law which a statu-

tory provision has secognized and enforced, the intention of any new enactment to abrogate it must be plain to exclude a construction by which both may stand together. Similarly, existing rights are not destroyed by a statute unless there are express words or the plannest implication to that effect. The principle applies whether the rights be common law rights, rights of action, rights of wordership or rights snanng under a contract. Again, the jurisdiction of the superior courts over matters originally cognitable by them cannot be taken away except by express words or necessary implication. On the other hand, it has been settled for a long time that the creation of a right of appeal is an act requiring legislative au-

Temporary acts may be made perpetual or may be continued from time to time The latter is now achieved largely by periodic Expiring Laws Continuance acts The Army and Air Force acts are instances of temporary acts specifically re-enacted annually

Enforcement of Statutes—Crimes created by statute are tried either summarily or by indictment and there are some which are tried by courts, such as courts-martial, having jurisdiction over a hinted class of persons. Again, a breach of a statutory command in a matter of public concern is indictable at common law, and in the absence of a special statutory remedy the performance of a public duty may be enforced by indictment or by information filed the threach may be entired by indictment or by information filed the breach may be granted in appropriate as continuates of mandanus lies for the enforcement of a public duty provided there is no more appropriate.

In some cases a person dammified by a breach of statutory duty may bring proceedings to recover his loss. This holds only where no remedy for the breach by way of penalty or otherwise is prescribed, or where it appears that the duty is imposed for the benefit of particular persons.

The operation of an act may be suspended by a subsequent statute. Many instances of this occurred during World War II by means of emergency legislation. Similarly, an act may be repealed or amended by a later act. Repeal by implication may occur where the provisions of a later enactment are repugnant to the earlier, but such repeal is never to be favoured. An act in its application to England cannot be repealed by non-user (see below as to Scotland). There is a presumption that, where special statutory provision has been made for a specific class of cases, a subsequent general enactment is not intended to interfere with such provision. The Interpretation act, 1889, contains many provisions relating to

legislate Legislation.—Modern statutes tend increasingly to provide that a particular authority shall have power to make ortunder that a particular authority shall have power to make ortunder that act. Power may read to operate the matter at rain under the act. Power may not provide the control of the con

Scotland.—Much of what has already been said applies to Scotland has big it must be emphasized that Scotland has its own courts whose decisions are often quite different from those of the English courts. A public general statute applies generally to Great Britain and Northern Ireland, which includes Scotland, unless otherwise stated. By the Private Legislanto Procedure (Scotland) act, 1936, which applies to Scotland only, where any public authority or persons desire a private act they may apply to the secretary of state for Scotland for a provisional order. In the absence of any opposition the secretary of state for Scotland is directed to introduce into parliament a confirmation bill, and any resulting act is a public act for parliament.

In the 17th and 18th centuries the court of session promulgated acts of sederunt amounting to general legislation. In modern times

these acts relate exclusively to procedure and are usually passed in virtue of a specific authority in some particular statute. In 1943 an act of sederant approved new consolidated rules and repealed the provisions of any previous act inconsistent with them. An act of adjournal is an act passed by the high court of justiciary for regulating procedure in that court and in inferior criminal courts.

A statute may be impliedly repealed by falling into desuctude. This rule is not applicable except to Scots acts, i.e., those passed before 1707. There is no analogous principal in England, and even in Scotland no statute passed after the union in 1707 has been held by the Scottish courts to have fallen into desuctude.

Scots acts, which are usually expressed briefly and without detailed provisions, have been interpreted in a very liberal spirit. In their construction it is a recognized rule that, whatever the literal meaning of the statutory words, they are to be read as interpreted by decisions pronounced shortly after the act was passed Apart from this important difference, the rules of interpretation in Scotland are similar to those decisions of the properties of the properties of the state of the s

Northern Ireland.—The parlament of Northern Ireland consists of the queen, the senate of Northern Ireland and the house of commons in Northern Ireland. The Government of Ireland act, 1920, edals with Egislation in Northern Ireland and gives power to make laws for the peace, order and good government of Northern Ireland with certain matters reserved to the United Kingdom parliament. Parlament at Westminster does not as a matter of practice legislate for Northern Ireland un matters within the jurisdiction of the Northern Ireland parlament although it has power to do so

British Dominions, Colonies and Dependencies.—Acts of the imperial parlament do not extend to dominons, colonies or dependencies unless these are specially named therein. Moreover, the United Kingdom parliament cannot legislate for the self-governing dominions without their onsent. Colonies are either self-governing dominions. By the Colonial Line velf-governing of crown colonies. By the Colonial Line velf-governing of crown colonies. By the Colonial Line velf-governing or crown colonies. By the Colonial Line velf-governing the properties of any act of parliament extending the repugnant to the provisions of any act of parliament extending law is to be voud by repugnancy to the law of England unless it is repugnant to such an act of parliament For colonies without representative legislatures the crown usually legislates. The relationship between the United Kingdom parliament and the dominion legislatures is dealt with by the Statute of Westminster, roas:

Other Countries.—In most other countries, with the exception of the United States (see below), there is a code of law. The assent of two chambers and of the head of the state is generally necessary to legislation.

The term "statute" is used by international jurists to denote the whole body of the municipal law of the state. In this sense, statutes are either real, personal or mixed. A real statute is that part of the law which deals directly with property, whether movable or immovable. A personal statute has for its object a person and deals with questions of status such as marriage, legitimacy and infancy. A mixed statute affects both property and persons and it is said to deal with acts and obligations. Personal statutes are of universal validity; real statutes have no extractritorial authority. (See also Acr or Parliament, Parliament, (F. E. L.)

## UNITED STATES

"Statute" in U.S. law is generally confined to an act of the legislature, though the term is occasionally used to apply to municipal ordinances and the rules and regulations of administrative agencies passed in the exercise of delegated legislative functions. The concurrence of the executive is demanded for the efficacy of the legislative act. The executive is accorded a veto over legislature action which can, however, be overridden by concurrence of a sufficient majority in the houses of the legislative action which can, however, be overridden by concurrence of

Any consideration of statute making in the United States must bear in mind the federal character of the nation. Not only does each of the states possess statute-making powers for that state, but the national government within the ambit of its delegated powers may pass statutes effective throughout the nation. The

device of judicial review over legislation is the scheme by which conflict between the various statutes is resolved. As the supreme law of the land stand the constitution, treaties and laws of the United States, and state statutes passed in contravention of them are unenforceable. Not only are state and the lower tederal courts obliged to refuse to enforce a state statute contravening federal constitutional or statutory law, but, by providing for an appeal to the US supreme court, the validity of state statutes can be brought for judgment to that ultimate tribunal. The supreme court thus occupies the position of arbiter in the eternal conflict between states and nation State statutes must also comply with the provisions of the state constitution but the final arbiter of their compliance is the state supreme court and not the U S supreme court (See Constitution and Constitutional Law.) State statutes in violation of the state or federal constitution are void, but state statutes contravening federal statutes are suspended during the operation of the latter

The fact that there are many different statute-making bodies in the United States makes for an immense mass of legislation Despite the fact that most state legislatures have only breintal sessons, their legislative activity produces a vast number of statutes. The first thorough attempt to keep in buch with their activity by mechanism of an index to state legislation was originated in 1938 by the Library of Congress. Periodic revisions of their statutes are made by each state but upon plans that lack any unformity. No revision of the statutes of the federal government was made until 1847. Thereafter, several there were published.

Statutes commonly take effect from the date that they receive the executive assent. In some states constitutional provisions prescribe that they shall not be effective until after the expiration of a certain time after their passage, unless the legislature shall designate that the matter is one of such public urgency as to require their immediate operation. The result of these restrictions has been simply to induce the legislature to append an urgency clause to each statute irrespective of its subject matter. Two other common constitutional provisions deserve notice. To avert the process of Togerolling for the inclusion of particular legislation that the process of Togerolling for the inclusion of particular legislation deal with more than one subject, to be plainly and specifically expressed in the life to the act.

The complexity of federal and state legislation focused attention on the development of means to improve the quality of statutory law. Since legislative drafting requires special qualifications, the federal and many state governments provide specially trained legislative counsel to prepare measures. In addition to technical problems of drafting, the substantive aspects of legislation are matters of concern. For example, under the Legislative Reorganization act of 1946, important committees of the congress were provided with professional staffs to do research In other instances, commissions aided by experts prepare particular statutes such as codes of procedure, workmen's compensation laws and tax measures. Continuity of legislative policy is sometimes attained through the device of the legislative council. In recognition of the need for the constant scrutiny of legislation to keep the law abreast of current problems, the state of New York created a law revision commission in 1934, charged with the duty of continuously revising the statutes.

A movement toward uniformity in state statutory laws was initiated by the organization of the Commissioners on Uniform State Laws in 1892. Commissioners appointed by each state meet analyt to frame legislation on subjects upon which uniformity is believed essential and recommend its enactment by state legislatures. Their most successful achievements were in the field of commercial law, though their endeavours embraced subjects of wide variety. The Council of State Government prepares legislation in areas of general interest, not necessarily for enactment in uniform style but for the purpose of suggesting models to guide particular state legislatures. Other efforts to promote uniformity have been midde by praviate interest groups and public welfare organizations. Interpretation statutes upon the British model were also enacted in some states, atthough they have been of doubtful

Another peculiar American problem relates to the extent to which courts take cognizance of statute law. All courts are bound to take judicial notice of the federal laws and the statutes of the state in which sail is brought. But different doctrines are in force as to the extent to which they will take notice of the statute law of other states. In many states statutes require the courts to take notice of such laws. In others they must be specially pleaded or proved or the courts will assume that the law of the other state is identical either with their decisional or statutory law. After 1936 most states adopted the Uniform Judicial Notice of Foreiga Law act requiring judicial notice of the common and statute law of other states but not other countries.

Statutes have different forms, being either acts of the legislature or joint or concurrent resolutions of both houses of the legislature or joint or concurrent resolutions of both houses of the legislature Treaties of the national government have the force of statutes and stand on a parity with them. Like statutes they are the "supreme law of the land" and supersede conflicting state legislation. Just as a subsequent statute may repeal an earlier on, a later statute repeals an earlier treaty. States are forbidden to conclude treaties but may make compacts with one another with the assent of congress. Such compacts also have the effect of statutes. They have been used to deal with problems that demand a regional treatment greater than a single state can give and yet less than is desirable for nation-wide control.

Codification of the law in the European sense has been periodically urged in the various states since 1848, when the Field code was adopted in New York. This code attempted to recognize and simplify procedural law. A proposed codification of substantive law was not enacted Procedural and substantive codes were, however, adopted in numerous states That the hope-for results of simplifying and clarifying the law have not been realized was attributable, perhaps, to the unwillingness of judges to treat codes as ultimate sources of the law, as is done by those trained in the civilian legal system. Limited attempts to codify certain segments of the law met with more success. The restatements of the law by the American Law institute were somewhat analogous to codes and were undertaken for similar purposes but were not adopted as statutes.

Statutes,

BERLIOGRAPHY.—E. Freund, Standards of American Legislation
(1971), P. S. Reinsch, American Legislatives and Legislative Methods
(1931); C. I., Dones, Statute Low Making in the United States (1971);

J. G. Sutherland, Statutes and Statutory Construction, 3rd of by
F. E. Horick, Jr. (1943); W. J. Brown, Underlying Principles of
Modern Legislation, 6th ed. (1920); J. P. Chamberian, Legislative
Processes, Asiands and State (1932); R. Luck, Legislative Processes
(1922); A. Bentley, The Process of Government (1933); C. B. N)

STAUNTON, HOWARD (1810-1874), English Shakespearian scholar and writer on chess, supposed to have been a natural son of Frederic Howard, 5th earl of Carlisle, was born in 1810.

Settling in London, he soon spent the small fortune left him under his father will and began to make his living by journalism. He gave much of his attention to the study of the English dramatists of the Elizabethan age. As a Shakespearian commentator he showed the qualities of acuteness and caution which made him excell in chess. He possessed, moreover, a thorough mastery of the literature of the period, shown in his papers in the Athenaeum on "Unsuspected Corruptions of Shakespeare's Text," begun in Oct. 1872. These formed part of the materials which he intended to utilize in a proposed edition of Shakespeare which never became an accomplished fact.

In 1864 he published a facsimile of the Shakespeare folio of 1623 and a facsimile edition of *Much Ado About Nothing*, photolithographed from the quarto of 1600.

Staunton died in London on June 22, 1874. Staunton's services to chess literature were very great, and the game in England owes much of its later popularity to him. For his important works on the subject 596 CHESS.

STAUNTON, a city of Virginia, U.S., 1,385 ft. above sea level, in the heart of the beautiful and fertile Shenandoah valley, 210 ml. N.W. of Richmond, the county seat of Augusta county, but administratively independent of it. It is at the intersection of ideral highways 11 and 250 and is served by the Chesapeake-Western and the Chesapeake and Ohio railways Pop (1930) 19,997 (1985, Negroes) by federal census It is a city of beautiful residences and numerous schools and institutions, including two state mental hospitals

The former ministers' home or manse of the First Presbyterian church, birthplace of Woodrow Wilson, was dedicated as a national shrine in 1941. About 20 mi. S. of the city is the homestead of

Cyrus McCormick, where he invented the reaper

Within 50 mi are five great caverns, Natural bridge, Natural chinneys, the George Washington National forest and the Shenandoah National park, which is traversed for its entire length by the Skyline drive. In the city are antional cemetry and a large Confederate cemetery. Staunton was the first city in the United States to adopt the city manager form of government, in 1908. There are large textile, hosiery, furniture, lumber and flour mills located in and near the city.

The first settlement in the vicinity was made in 1731, 2 mi E of the present city A county courthouse was bull in 1745, and the name Staunton (the family name of the wife of Sir William Gooch) was adopted about 1748. In 1751, when Colonel Tarleton drove the general assembly of Virginia across the Blue ridge, it took refuge there, holding its sessions for a time in the old Trinity Episcopal church. During the Civil War Staunton was an important supply base for the army of northern Virginia and for Jackson's Valley campaign, and it was twice occupied by Federal troops. It was chartered as a city in 1870.

STAUROLITE, a mineral consisting of basic aluminum and ferrous iron slineate with the formula HFebAjshofa. The material is, however, usually very impure, the crystals enclosing sometimes as much as 30% or 40% of quants and other minerals as well as carbonaceous matter. Crystals are orthorhombic and have the form of six-saded prisms. Interpenentaing cruciform twinned crystals are very common and characteristic, they were early known as pierress de crois or laphs crussifer, and the name "staurolite" has the same meaning (Greek, σταμός, a cross, and Milora, stone). In fig. it the twin plane is (302) and the two prisms intersions.





FIGS. 1 AND 2.-TWIN CRYSTALS OF STAUROLITE

cross at an angle of 9x° 2x'; in fig. 2 the twin-plane is (232) and the prisms intercross at nearly 6o°. The mineral is translucent to opaque and dark reddish brown in colour. Waterworn pebbles of material sufficiently transparent for cutting as gem stones are occasionally found in the diamantiferous sands of Brazil. The hardness is 75, specific gravity 375. Staurolite is a characteristic mineral of crystalline schists, and it is also a product of contact-metamorphism. It is found at various points in Virgina, North Carolina and Georgia embedded in schist or weathered loose in the soil, often as fine twinned crystals that are prized as good luck charms (fairly stones).

STAVANGER, a seaport of Norway, capital of Rogaland yike (county), on the west coast on the Bukken four? Pop. (1946) 49,173. The town is one of the oldest in Norway, founded in the 8th or ofth century, but the greater part of the present own is modern and built of stone. It became the seat of a bishoppir in the 13th century, and though the see was removed to Christian-

sand in 1685, it was restored in 1925 The cathedral church of St Swithun, founded by the English bishop Reinald at the end of the 11th century, and rebuilt after being burned in 1272, 18, next to the cathedral of Trondheim, the most interesting stone church in Norway The old episcopal palace of Kongsgaard is now a Latin school The fisheries are important-for herring, mackerel, sprats, cod, salmon, lobsters and anchovies. The extraoidinary growth of Stavanger was mainly due to its fish-canning industry Other industries are the making of jodine from seaweed.

and shipbuilding It was occupied by Germany in April 1940 STAVELEY, town and urban district of Derbyshire, England, 12 mi SE. of Sheffield, on the LMS and LNE railways Pop (1951) 17,941 Area, 10 2 sq mi The ancient church of St John the Baptist contains a 12th century font Staveley hall. formerly the home of the Frechevilles, was built in 1604 and is

now the rectory. Coal mining is the dominant industry, though there is also an

old established brush manufactory

STAVELOT, town on the Amblève, province of Liége, Belgium. Pop (1939) 4,792. Here Charles Martel gained a signal victory over Neustria in 719 The prince-abbot of the monastery of Stavelot (established 7th century) exercised secular authority over many towns in the Amblève and Warche valleys, including Malmédy, and had a seat in the old German Diet

STAVROPOL, a former province of Russia, now in the Caucasian Area, North (q v)

STAVROPOL, a town of Russia see Voroshilovsk.

STAWELL, a municipality of Borung county, Victoria, Australia, 179 mi by rail W N W of Melbourne. Pop. (1947) 4,840 The quartz reefs of the Pleasant Creek goldfields near by are worked at very deep levels and there are cyanide plants, It lies near the Wimmera river just north of the Grampian and Pyrenees plateaus, in an important sheep and fruit district

STEAD, WILLIAM THOMAS (1849-1912), English journalist, was born at Embleton, Northumberland, on July 5, 1849, the son of a Congregational minister He was early apprenticed in a merchant's office at Newcastle-on-Tyne; he soon graviassistant editor of the Pall Mall Gazette under John Morley, and when the latter retired he became editor (1883-1889). 1885 he had distinguished himself for his handling of public affairs, and his brilliant modernity in the presentation of news. He introduced the "interview," made a feature of the Pall Mall Gazette "extras," and his enterprise and originality exercised a potent influence on contemporary journalism and politics

In 1885 he entered upon a crusade against vice by publishing a series of articles on the "Maiden Tribute of Modern Babylon" Though his action undoubtedly furthered the passing of the Criminal Law Amendment act, it made his position on the paper impossible; and he was imprisoned in Holloway jail for three months on a charge arising out of his crusade On leaving the Pall Mall Gazette he founded the monthly Review of Reviews (1890)

He started cheap reprints (Penny Poets and Prose Classics, etc), conducted a spiritualistic organ, called Borderland (1893-1897), in which he gave full play to his interest in psychical research; and became an enthusiastic supporter of the peace movement, and of many other movements, popular and unpopular. He wrote with facility and sensational fervour on all sorts of subjects, from The Truth about Russia (1888) to If Christ Came to Chicago (1893), and from Mrs. Booth (1900) to The Americanization of the World (1902). In private life his keen sense of merit and kindly interest influenced many aspirants to journalism and literature

Stead went down in the "Titanic" on April 15, 1912. See Life of W. T. Stead (1913), by his daughter; and F. Whyte, Life of W. T. Stead (1925).

STEAM, the vapour of water. In the pure state it is a dry invisible gas Often, however, as in a jet escaping from the spout of a kettle or the funnel of a locomotive, it is mixed with minute particles of water which are produced by condensation of portions of the gas. In such a mixture the suspended particles of water

constitute a visible cloud Any mixture of steam with water, whether in such a cloud or in the working chamber of an engine or turbine, is often spoken of as wet steam.

Its properties are most conveniently described by imagining an experiment in which steam is formed by applying heat to a small quantity of water contained at the bottom of a large upright cylindrical vessel Suppose that the vessel is fitted with a piston which rests on the water to begin with and can rise when the fluid below it is made to change from water into steam by applying heat. Imagine further that the piston is frictionless and carries a definite weight so that, as the piston rises, the fluid continues to be subjected to a constant pressure, say, p lb per square inch

Saturated Steam .- When heat is applied, no steam is formed until the temperature of the water is raised to a value T which depends on p Steam then forms, raising the piston, and this goes on without further rise of temperature until all the water is converted into steam, when it occupies a certain volume V During this stage the steam is said to be saturated T is the temperature of saturation corresponding to the pressure p, and is the lowest temperature at which steam can exist in stable equilibrium at that pressure

Superheated Steam.-Suppose now, after all the water has turned into steam, that we go on applying heat. The temperature will rise and the volume will increase beyond V if we keep p constant, or the pressure will increase beyond p if we then fix the piston so as to keep V constant. In either case the steam is said to be superheated.

Steam is superheated when its temperature is raised in any manner to a value which exceeds the temperature of saturation corresponding to the actual pressure. Thus for example steam may change from the saturated to the superheated condition by being compressed (without loss of heat), or by passing (without loss of heat) through a throttle valve into a region of lower pressure When steam is so "throttled" its temperature falls to some extent, but remains higher than the temperature of satura-

tion corresponding to the reduced pressure Properties of Steam: Callendar's Tables.-The physical tated, however, into journalism, and in 1871 became editor of Properties of Steam: Callendar's Tables.—The physical the Darlungton Northern Echo. In 1880 he went to London to be properties of steam have been the subject of systematic experimental enquiry by Regnault and many later observers. Our modern knowledge of them is largely due to H. L. Callendar who, with the help of formulas the basis of which is partly theoretical and partly empirical, has rationalized the experimental data and has compiled comprehensive tables for the use of engineers Callendar's tables, published in 1915 and in an enlarged form in 1924, set forth all the important properties throughout a suitable range of pressures and temperatures From the principles of thermodynamics (q v.) it is known that certain relations hold between various properties, in steam or any other vapour, the values stated by Callendar, besides being founded on the best available data, are consistent with these relations. They apply to the superheated as well as to the saturated state; saturation is to be regarded as only a limiting case.

So long as steam is saturated the relation of temperature to pressure is definite But steam may be superheated to any temperature above the saturation temperature at which it is formed in the boiling of water, and the temperature then becomes an independent variable. This affects certain other properties with which the steam engineer is concerned, namely .-

The volume V, The internal energy E, The total heat I. The entropy φ,

all of which are to be reckoned per lb of the substance Each of these quantities has a definite value for steam or for water in any assigned state of pressure and temperature. Steam tables usually follow a convention, according to which quantities such as the energy or the entropy are treated as zero for water at o° C: the tabulated numerical value accordingly expresses the amount by which the quantity in question has changed when the substance passes from that zero condition to the actual state.

Internal Energy.-When steam is formed (starting, say, from

work is done by the expansion of the substance The difference, which depends simply on the final state and not on the manner of formation, is called the internal energy E

Total Heat.-The total heat I is conveniently defined by the equation

$$I=E+APV$$

where P and V are respectively the pressure and volume of the substance, and A is a factor which converts units of work into units of heat Hence when the substance is heated under constant pressure the change of I is measured by the quantity of heat that is taken in, for it is then equal to the gain of internal energy plus the work done. In a process of throttling it is easy to show that I does not change, provided there is no loss of heat to other bodies

Entropy.-To define entropy, it may be said that when the substance takes in heat in a reversible manner (namely a manner which excludes the existence of any turbulent movement) its entropy changes by the amount  $\frac{Q}{T}$  where Q is the heat taken in and T is the temperature (on the absolute scale) at which it is taken in If T is itself changing while the heat is being taken in, we must write this change of entropy as  $\int \frac{dQ}{T}$ · Thus when steam is formed in a quietly steaming boiler, at a constant temperature T, from water at the same temperature, the entropy  $\phi$  changes by the quantity  $\frac{L}{T}$  , where L is the "latent heat." Like the other quan-

tities, the entropy of water at oo C is reckoned as zero for convenience in tabulation Both the entropy of steam and the total heat are quantities of great importance in the theory of the steamengine (q.v.)

Critical Temperature .- Imagine a quantity of superheated steam at any usual temperature to be compressed while the temperature is kept constant. When the pressure reaches a certain value condensation begins, and we are then dealing with a substance which is partly water and partly saturated steam. The pressure in question is that which corresponds to saturation at the assumed constant temperature This pressure will not rise further until all is condensed after that the pressure on the water may of course be increased to any extent. The process is discontinuous, with three distinct stages. Suppose this experiment to be repeated at various temperatures: it will be found that when the temperature is sufficiently high there is no stage during which both water and steam are present together When this temperature is reached or exceeded, the substance passes, as its pressure is increased, from the condition of steam to that of water-from vapour to liquid-in a continuous manner without ever being a mixture of the two The lowest temperature at which this can happen is called the critical Temperature, and the limit of pressure above which the substance cannot exist as a non-homogeneous mixture of liquid and vapour is called the critical Pressure. These conditions of pressure and temperature constitute the "critical point" The critical temperature of steam is about 374° C and the critical pressure about 3,158 lb. per square inch.

The properties of steam in the neighbourhood of the critical point are less exactly known than at lower and more usual pressures. The "characteristic equation" on which Callendar founds many of his tabulated values applies with sufficient exactness within the lower range of pressures commonly met with in engineering practice. It takes the form

$$V = \frac{RT}{P} - c + b$$

where V is the volume (per lb ), T is the absolute temperature, P is the pressure, R is a constant relating to the ideal volume of a gas, b is a constant which expresses the additional volume of the molecules, and c is a term, depending on the temperature, which expresses the loss of volume through "coaggregation" or temporary association of molecules. The equation is applicable to the superheated as well as the saturated state,

Super-saturation.-When steam is cooled to a temperature at

the state of water at o° C) heat is taken in, and some external which condensation should occur, it is found, when no nuclei are present about which water droplets may form, that the temperature may fall some way below the temperature of saturation before condensation begins A temporary and unstable state may accordingly be produced, called super-saturation The vapour in this condition may be described as supercooled its state is analogous to that of a liquid cooled below its melting point without crystallization

Water-vapour in Air .- Water vapour is one of the constituents of the atmosphere, the proportion depending not only on the temperature but on other causes which affect local dryness At any given temperature air is said to be saturated with water vapour when the proportion present is such as to exert a partial pressure equal to the pressure of saturation corresponding to the given temperature Any excess tends to be thrown out as mist or rain any less quantity than that required for saturation is held as an invisible constituent, namely, in the state of super heated steam The quantity of water-vapour present in air may be expressed as a fraction of the quantity which would cause saturation this fraction is called the "relative humidity" of the air The "dew-point" is the temperature to which air must be cooled to allow a deposit of water to take place

Air is often dried for industrial uses by cooling it to a very low temperature This causes it to deposit nearly all its contained moisture, which is then drained away, leaving only the triffing quantity that suffices to produce saturation at the low temperature When the air returns to normal temperature without taking up more water its relative humidity is very small

See Regnault, in Mém. Inst. France (1847, Vol. XXI); H. L. Callendar, Properties of Sleam (1920), and The Callendar Steam Tables (1915); J. A. Ewing, Thermodynamics for Engineers (1920) (IAE)

STEAM ACCUMULATORS are devices for equalizing steam flow and steam demand They are inserted between the source of steam supply and the point where it is used for the purpose of absorbing steam at times of low demand and releasing it when needed; several types have been developed. One of the earliest was the Rateau accumulator or regenerator Its primary purpose was to utilize the intermittent exhaust from prime moverssuch as steel rolling-mill engines-for driving low-pressure turbines carrying a fairly constant load; installed in the steam line between these two units, it served to equalize supply and demand, the turbine governor being designed to admit live steam when necessary Another type is the Smoot accumulator, designed primarily for use in gas manufacturing plants. It collects, or accumulates, in a steel tank the exhaust from pumps and auxiliaries and from the

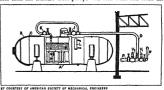


Fig. 1.-MECHANICAL DRAWING OF A COMPLETE ACCUMULATOR IN-STALL ATION

hot-water drips; by decreasing the pressure in this tank steam is made available for the intermittent operation of the water-gas apparatus, and deficiency in supply is taken care of by a live steam "make-up" valve The latest development is known as the Ruths steam accumulator, and while it operates on the same general principle as the others, it has been applied over a wider field of usefulness. Specially designed governor valves make its operation entirely automatic up to 200 lb, per sq in, and through greater pressure ranges (fig 1). The tank A is filled with water to 90% of its capacity, and the regulating valves V-r and V-2 automatically control the charging and discharging of the accumu-

lator The accumulator must be placed between the high and the low pressure steam line, and its pressure varies between these limits, accumulated steam is made available by the regulating valves in such a way as to maintain uniform steam pressures in the low pressure steam lines Any steam generated by the boilers and not used by the high pressure consumers overflows through valve V-r into the accumulator V-2 maintains a uniform pressure in the line P carrying the low pressure steam, so that if the valve V-1 is passing more steam than is required in the low pressure line, the excess is stored in the accumulator. Charging nozzles G are equipped with circulating pipes H which permit a uniform and noiseless heating of the water Should a sudden demand for high pressure steam arise the boiler pressure would drop slightly, V-1 would close and a certain amount of steam would become available at or near this higher pressure. This diversion to the high pressure line of steam intended for the lower pressures would cause a deficit in the low pressure line. V-2 would then open and the heat energy previously stored in the accumulator would instantly flash into steam to meet this deficit. Should the sudden increase in demand be caused by low pressure consumption and the flow through V-1 not sufficient, the accumulator would sup-(R A L) ply it.

STEAM-CHEST is a box cast on or attached to the sade of a steam cylinder, and contraining the side-valve which slides over the steam and exhaust ports, and uncovers these in turn A stuffingbox maintains the valve-rod steam-tight Some engines have two valves, one sliding upon the top of the other, for the purpose of gying expansive working of the steam Cylinderical or piston valves are used extensively in marine and locomotive cylinders, as they give a balanced effect all around in locomotive practice these valves have to be placed above the cylinders in many cases for reasons of design

STEAM COAL: see COAL AND COAL MINING.

STEAM ENGINE. A steam engine is a heat engine in which the working substance is steam By a heat engine is meant a machine for doing mechanical work through the agency of heat: it does this by taking in heat at comparatively high temperature, converting part of the heat into another form of energy, and rejecting the remainder of the heat at a lower temperature. The working substance is the vehicle by which heat is taken in and rejected In a steam engine, the substance takes in heat mainly in a separate vessel-the boiler-in the process of being vaporized: it does work by expanding under pressure and thereby converts part of the heat that is taken in; finally the remainder of the heat is rejected, either by allowing the steam to escape into the atmosphere, as in locomotives, or by condensing it at a comparatively low temperature and pressure, as in marine and many other engines. This gives a broad distinction between non-condensing and condensing steam engines. The latter have the great advantage that they allow the effective expansion of the steam to be carried much farther; the substance rejects heat at a lower limit of temperature, and this enables the engine to convert into work a larger fraction of the heat which it has received. That fraction expresses what is called the efficiency of the engine as a contrivance for converting heat into work. The addition of a condenser, while it increases the efficiency, of course complicates the mechanism: it requires a supply of cooling water or some equivalent means of keeping down the temperature by absorbing the heat which the steam gives up in the act of being condensed, and also a pump or other means of removing the condensed substance together with any air that may be present. But the advantage which it brings about in respect of efficiency is so great that all engines of large power, where economy of fuel is an important factor, and where the use of a condenser is practicable, are of the condensing kind.

Given the upper limit of temperature, at which heat is taken in, the efficiency which the engine may attain is determined by the lowness of the temperature at which heat is rejected. Similarly, when the lower limit of temperature, at which heat is rejected, is assigned, the efficiency which the engine may attain is increased by raising the temperature at which the working substance takes in heat. To secure high efficiency there must be a

wade range through which the temperature of the working substance talks, as a consequence of expansion within the engine, from the level of temperature at which heat is received to the level at which heat is rejected. Thus in the steam engine the most efficient performance, that is to say the greatest output of work in relation to the heat supplied, is secured by keeping the condenser as cold as the available cooling water will allow, and at the same time using a high bolier pressure, so that the working substance is very hot while it receives heat in the act of charging substance is very hot while it receives heat in the act of charging outwarders are to seem for the pressure, as the mechanical difficulties of boiler construction and high pressure working are overcome.

After conversion into steam the working substance may take in a supplementary supply of heat on its way from the boiler to the engine, by passing through a superheater, in which its temperature is raised above that of the boiler A common form of superheater is a group of parallel piose with their surfaces

exposed to hot gases of the boiler furnace

Steam engines are classified into two general types according to the manner in which the steam does work during its expansion. In the first, or piston-and-cylinder type, the steam, in a confined space, namely the part of the cylinder behind the piston, enlarges the volume of that space by pushing the piston forward. It does work by exerting a static pressure on the moving piston, the movement of the steam itself is of no significance. In the second class, to which belong all kinds of steam turbines, the action is less direct. The pressure of the steam is first employed to set the steam itself into motion, forming a let or group of iets, the momentum of which causes work to be done on a moving part of the machine, either by the impulsive action of the jet or jets on revolving vanes, or by the reaction on revolving guideblades during the formation of the jets, or, as in Parsons bine, by a combination of impulse and reaction. In any turbine the action of the steam is kinetic, in contrast with its static action m an engine of the piston type In both types there is progressive expansion of the steam from the high pressure and relatively small volume at which it is admitted, to the low pressure and relatively very great volume at which it is discharged. The principle already stated, that a large range of temperature and pressure, between admission and exhaust, is essential to efficiency applies equally to both types. In practice, the turbine has a notable advantage over the piston-and-cylinder engine in this respect, that it allows the last stages of the expansion, when the volume of the steam has become very great, to be effectively utilised, to a degree which is impracticable in the other type, because of the enormous size which the cylinder would have to assume and the waste of work that would be caused by piston friction, if the steam were expanded down to a very low pressure by the piston method. The turbine method escapes these difficulties; mainly for that reason it has become the most efficient way of converting heat into work, on a large scale, through the agency of steam. It has further advantages in compactness, in simplicity of working, and in the facility with which it can be adapted to take steam of exceptionally high mitial pressure and high superheat.

### HISTORICAL.

In any historical sketch of the steam-engine, stress must be laid on the work of James Watt. But a process of evolution had been going on before his time which prepared a crude and primitive device for the immense improvements it received at his hands. The labours of Watt stand in natural sequence to those of Newcomen, and Newcomen's to those of Papin and Savery, Savery's engine, in its turn, was the reduction to practical form of an ancient scientific toy. Along another line of development, the modern steam turbune, which we owe to the gentus of Charles Parsons, can be traced back to an early prototype.

In the Prounation of Hero of Alexandria (a. 130 nc.) there is described the acolipile, which may be called a primitive steam reaction turbine. It consists of a hollow globe pivoted so that it can turn on a pair of central truminos, and supplied with steam through one of them, which is hollow. The steam escapes from the globe to the outside air through two bent pipes facing tan-

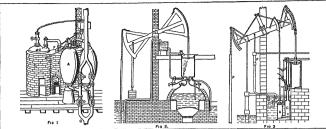


FIG 1 SAVERY'S STEAM ENGINE (1698). FIG. 2. NEWCOMEN AND CAWLEY STEAM ENGINE (1705). FIG 3 THE WATT PUMPING ENGINE

gentially in opposite directions at the ends of a diameter perpendicular to the axis. The globe revolves by reaction from the escaping steam. Here's volume also mentions (Greenwood's translation of Hero's Pnessmatics) another device which may be described as the prototype of the pressure engine. A hollow altar containing air is heated by kinding a fire on it, the air explanation and by its pressure directs some of the water in a vessel below into a hanging bucket, which then descends, opening the doors of a shrine. When the fire is extinguished the air contracts, the bucket emtiles, and the doors close

In a treatise on pneumatics (160r) by Giovanni Battista della Porta there is shown a somewhat similar apparatus, but with stam for working substance. Its pressure forces up water from a separate vessel. He also points out that the condensation of the steam may be used to produce a vacuum and thereby suck up water from a lower vessel. His suggestions go far to anticipate the engine which, a century later, in the hands of Savery, became the first commercially successful steam engine

Meanwhile Edward Somerset, second Marquis of Worcester, described in lie Century of Justicians (25 Section 18 of S

Savery, 1698 .- The earliest steam-engine to take a practical form and find employment in industry was that of Thomas Savery, who, in 1698, obtained a patent for a water-raising engine, shown in fig. 1. Steam is admitted to one of the oval vessels A, displacing water, which it drives up through the check-valve B. When the vessel A is emptied of water the supply of steam is stopped, and the steam already there is condensed by allowing a jet of cold water from a cistern above to stream over the outer surface of the vessel. This produces a vacuum and causes water to be sucked up through the pipe C and the valve D. Meanwhile steam has been displacing water from the other vessel, and is ready to be condensed there. The valves B and D open only upwards. The supplementary boiler and furnace E are for feeding water to the main boiler; E is filled while cold and a fire is lighted under it; it then forces a supply of feeding-water into the main boiler F. The gauge cocks G, G are an interesting detail. Another form of Savery's engine had only one displacement-chamber and worked intermittently. In the use of artificial means to condense the steam, and in the application of the vacuum so formed to raise water by suction from a level lower than that of the engine, as well as in practical features, Savery's engine marked an inventive advance. It found considerable employment in pumping mines and in raising water to supply houses and towns, and even to drive water-wheels. A serious difficulty which prevented its general use in mines was the fact that the height through which it would lift water was limited by the pressure the

boiler and vessels could bear. Pressures as high as 8 or 10 atmosphers were employed—and that, too, whthout a safety-valve —but Savery found it no easy matter to deal with high-pressure steam Apart from this drawback, the waste of fuel was enormous, from the condensation of steam which took place on the surface of the water and on the soles of the displacement-chamber at each operation, the consumption of coal was, in proportion to the work done, some twenty times greater than in a modern engine

Before Savery's engine was displaced by its successor, Newcomen's, it was improved by J. T. Desaguilers who applied the the safety valve (invented by Papin), and substituted condensation by a jet of cold water within the vessel for the surface ondensation used by Savery. To Savery is ascribed the first use of the term 'Borse-cowerd' as a measure of performance

In 1690 Denis Papin suggested that the condensation of steam should be employed to make a vacuum under a piston previously raised by the expansion of the steam. Papin's was the earliest cylinder and piston steam engine, and his plan of using steam was that which afterwards took practical shape in the atmospheric engine of Newcomen But his scheme was made unworkable by the fact that he proposed to use but one vessel as both boiler and cylinder A small quantity of water was placed at the bottom of a cylinder and heat was applied When the piston had risen the fire was removed, the steam was allowed to cool, and the piston did work in its down-stroke under the pressure of the atmosphere After hearing of Savery's engine in 1705 Papin turned his attention to improving it, and devised a modified form, with a floating diaphragm or piston on the top of the water to keep the water and steam from direct contact with one another Papin's engine may be described as a non-condensing single-acting steam pump. with steam cylinder and pump cylinder in one Newcomen's Atmospheric Engine, 1705.—While Papin was

thus going back from his first notion of a piston engine to Saveery's cruder type, a new inventor had appeared who made the piston engine a practical success by separating the boiler from the cylinder and by using (as Savery had doop artificial means to condense the steam. This was Thomas Newcomen, who in 1705, with his assistant, John Cawley, gave the steam engine the form shown in fig. 2. Steam admitted from the boiler to the cylinder by the opening of a valve allowed the piston to be raised by a heavy counterpolse on the other side of the beam. Then the steam valve was shut and a Jet of cold water entred the cylinder and condensed the steam. The piston was consequently forced to the steam valve was shut and a Jet of cold water entred the cylinder and condensed the steam. The piston was consequently forced from the cylinder through an escape valve. The piston was kept tight by a layer of water on its upper surface. Condensation was at first effected by cooling the outside of the cylinder, but an accidental leakage of the packing water past the piston showed the advantage of condensing by a jet of injection water, and this plan took the place of surface condensation. The engine used steam whose pressure was little if at all greater than that of the

atmosphere

About 1711 Newcomen's engine began to be introduced for pumping mines It is doubtful whether the action was originally automatic, or depended on the periodical turning of taps by an attendant The common story is that in 1713 a boy named Humphrey Potter, whose duty it was to open and shut the valves of an engine he attended, made the engine self-acting by causing the beam itself to open and close the valves by suitable cords and catches This device was simplified in 1718 by Henry Beighton, who suspended from the beam a rod called the plug-tree, which worked the valves by means of tappets By 1725 the engine was in common use in collieries, and it held its place without material change for about three-quarters of a century in all Near the close of its career Newcomen's engine was much improved in its mechanical details by John Smeaton, who built many large engines of this type about the year 1770, just after the great step which was to make Newcomen's engine obsolete had been taken by James Watt.

Compared with Savery's engine. Newcomen's had (as a numping engine) the great advantage that the mtensity of pressure in the pumps was not in any way limited by the pressure of the steam It shared with Savery's, in a scarcely less degree, the defect already pointed out, that steam was wasted by the alternate heating and cooling of the vessel into which it was led. Though obviously capable of more extended uses, it was in fact almost exclusively employed to raise water-in some instances for the purpose of turning water-wheels to drive other machinery. Even contemporary writers complain of its great consumption of fuel.

James Watt, 1763, 1769, 1781, etc.—In 1763 James Watt, an instrument maker in Glasgow, while engaged by the University in repairing a model of Newcomen's engine, was struck with the waste of steam to which the alternate chilling and heating of the cylinder gave rise. He saw that the remedy, in his own words, would lie in keeping the cylinder as hot as the steam that entered it. With this view he added to the engine a new organ-namely the "separate condenser"—an empty vessel separate from the cylinder, into which the steam should be allowed to escape from the cylinder, to be condensed there by the application of cold water either outside or as a jet. To preserve the vacuum in his condenser he added a pump called the air pump, whose function was to extract from it the condensed steam and water of condensation, as well as any air which might come in by leakage or by solution in the steam or the injection water. Then, as the cylinder was no longer used as a condenser, he was able to keep it hot by clothing it with non-conducting bodies, and in particular by the use of what is called a steam-jacket-a layer of hot steam between the cylinder and an external casing. Further and still with the same object, he covered in the top of the cylinder, taking the piston-rod out through a steam-tight gland or stuffing-box, and allowed steam instead of air to press upon the piston's upper surface. After much experiment Watt patented his improvements in 1769; they are described in a specification from which the following extracts are taken:-

"My method of lessening the consumption of steam, and conse-"My method of lessessing the consumption of steam, and consequently risk, in irre-suppase, consists of the following principles—quently risk, in irre-suppase, consists of the following principles—to work the engine, which is called the cylinder in common firenges, and which I call the steam vessel, must, during the whole line the engine as at work, be kept as hot as the steam that enter the steam that the st

time. "Secondly, In engines that are to be worked wholly or partially by condensation of steam, the steam is to be condensated in vessels distinct from the steam-tested or cylinders, although occationally communicating with them; these sense that the condensate of the steam-tested or the steam of the st

stam to press on the pistons, or whatever may be used instead of them, in the same manner in which the pressure of the atmosphere as now employed in common fire-engines I nesses where cold water cannot be had in plenty, the engues may be wrought by this force of steam only, by dividiarigm the steam into the air after it has done

The "common fire-engine" alluded to was the steam engine of Newcomen Highly important as Watt's first inventions were, they resulted for a time in the production of nothing more than a greatly improved engine of the Newcomen type, much less wasteful of fuel, able to make faster strokes, but still only suitable for pumping, still single-acting, with steam admitted during the whole stroke, the piston, as before, pulling the beam by a chain working on a circular arc. The condenser was generally worked by intection, but Watt has left a model of a surface condenser made up of small tubes, in every essential respect like the condensers now used

Fig. 3 is an example of the Watt pumping engine of this period. It should be noticed that, although the top of the cylinder is closed, and steam has access to the upper side of the piston, this is done only to keep the cylinder and piston warm. The engine is still single-acting, the steam on the upper side merely plays the part which was played in Newcomen's engine by the atmosphere; and it is the lower end of the cylinder alone that is ever put in communication with the condenser. There are three valves, the "steam" valve a, the "equilibrium" valve b, and the "exhaust" valve c. At the beginning of the down-stroke c is opened to produce a vacuum below the piston and a is opened to admit steam above it. At the end of the down-stroke a and c are shut and b is opened. This puts the two sides in equilibrium and allows the piston to be pulled up by the pump-rod P, which is heavy enough to serve as a counterpoise C is the condenser, and A is the airpump, which discharges into the hot well H, whence the supply of the feed-pump F is drawn.

In a second patent (1781) Watt describes the "sun-and-planet" wheels and other methods of making the engine give continuous revolving motion to a shaft provided with a flywheel. The crank and connecting-rod-already a familiar mechanical device from its use on the treadle of a lathe-would have been the natural means of doing this, but its application to the steam engine in a particular manner had been made the subject of a patent by James Pickard, and Watt, rather than make terms with Pickard whom he regarded as a plaguarist of his own ideas, made use of his sun-and-planet motion until the patent on the crank expired. The reciprocating motion of earlier forms had served only for pumping; by making the steam engine drive a revolving shaft Watt opened up for it many other channels of usefulness. The engine was still single-acting; the connecting-rod was attached to the far end of the beam, and that carried a counterpoise which served to raise the piston when steam was admitted below it.

In 1782 Watt patented two further improvements of the first importance, both of which he had invented some years before. One was the use of double action, that is to say, the application of steam and vacuum to each side of the piston alternately. The other (invented as early as 1769) was the use of steam expansively, in other words the plan, essential to economy of fuel, of stopping the admission of steam when the piston had made only a part of its stroke, and allowing the rest of the stroke to be performed by the expansion of the steam already in the cylinder 'To let the piston push as well as pull the end of the beam Watt devised his so-called parallel motion, an arrangement of links connecting the piston-rod head with the beam in such a way as to guide the rod to move in a very nearly straight line. He further added a throttle valve, for regulating the rate of admission of steam, and a centrifugal governor, in the form of a double conical pendulum, which controlled the speed by a throttle-valve.

Among other important devices associated with Watt was the "indicator," by which diagrams showing the relation of the steam pressure in the cylinder to the movement of the piston are automatically drawn: its invention seems to have been mainly due to his assistant Tohn Southern.

In partnership with Matthew Boulton, Watt carried on in Birmingham the manufacture and sale of his engines with great success, and held the field against all rivals in spite of severe assaults on the validity of his patents. Notwithstanding his knowledge of with hot and cooler steam. The introduction of compound exthe advantage to be gained by using steam expansively, he continued to employ only low pressures-seldom more than 7 lb per square inch over that of the atmosphere. His boilers were fed, as Newcomen's had been, through an open pipe which rose high enough to let the column of water in it balance the pressure of the steam. He gave a definite numerical significance to the term "horse-power," defining it as the rate at which work is done when 33,000 lb are raised one foot in one minute

In the fourth claim of Watt's first patent, quoted above, the second sentence describes a non-condensing engine, which would have required steam of a higher pressure. This, however, was a line of invention which Watt did not follow up, perhaps because so early as 1725 a non-condensing engine had been described by

Jacob Leupold in his Theatrum machinarum.

It was not till much later that the thermodynamic principles underlying the action of the steam engine came to be understood Engineers were consequently slow to appreciate the fact that to obtain economy of fuel it was advantageous to employ a high initial pressure, in combination with much expansion in the cylin-

der and with the separate condenser of Watt.

Trevithick, Bull and Evans .- The introduction of the noncondensing and, at that time, relatively high-pressure engine was effected in England by Richard Trevithick and in America by Oliver Evans about 1800. Both Evans and Trevithick applied their engines to propel carriages on roads, and both used for boiler a cylindrical vessel with a cylindrical flue inside containing the fire -the construction now known as the Cornish boiler In association with Edward Bull, Trevithick had previously made direct acting pumping-engines, with an inverted cylinder set over and in line with the pump-rod, thus dispensing with the beam that had been a feature in all earlier forms But in these "Bull" engines, as they were called, the steam was condensed by a jet of cold water in the exhaust-pipe, and Boulton and Watt successfully opposed them as infringing Watt's patent. To Trevithick belongs the honour of being the first to use a steam carriage on a railway, in 1804 he built a locomotive in the modern sense, to run on what had formerly been a horse-tramway, in Wales In this connection it may be added that as early as 1769 a steam carriage for roads had been built in France by Nicolas Joseph Cugnot, who used a pair of single-acting high-pressure cylinders to turn a driving axle step by step by means of pawls and ratchet-wheels. To the initiative of Evans may be ascribed the early general use of highpressure steam in the United States, a feature which for many years distinguished American from English practice. (See Loco-

Compound Engine and Cornish Engine.—Among contemporaries of Watt the name of Jonathan Hornblower deserves special mention. In 1781 he constructed and patented what would now be called a compound engine, with two cylinders of different sizes. Steam was first admitted into the smaller cylinder, and then passed over into the larger, doing work against a piston in each. In Hornblower's engine the two cylinders were placed side by side, and both pistons worked on the same end of a beam overhead. This was an instance of the use of steam expansively, and as such was earlier than the patent, though not earlier than the invention, of expansive working by Watt. Hornblower was crushed by the Birmingham firm for infringing their patent in the use of a separate condenser and air-nump. The compound engine was revived in 1804 by Arthur Woolf, with whose name it is often associated. Using steam of fairly high pressure, and cutting off the supply before the end of the stroke in the small cylinder, Woolf expanded the steam to several times its original volume. Mechanically the two-cylinder compound engine has some advantage over a onecylinder engine with the same amount of expansion, in exerting a more uniform driving effort. But another and more important merit of the system lies in the fact that by dividing the whole range of expansion into two parts the cylinders in which these are separately performed are subject to a reduced range of fluctuation in their temperature. This helps to limit a source of waste which is present in all piston engines, namely the waste which results from the heating and cooling of the metal by its alternate contact

pansion forms the most outstanding improvement which steam engines of the piston and cylinder type have undergone since the time of Watt

Woolf introduced the compound engine somewhat widely about 1814 as a pumping engine in the mines of Cornwall But here it met a strong competitor in the high-pressure single-cylinder engine of Trevithick, which had the advantage of greater simplicity in construction. Woolf's engine fell into comparative disuse, and the single-cylinder type took a form which, under the name of the Cornish pumping-engine, was for many years famous for its great economy of fuel In this engine the cylinder was set under one end of a beam, from the other end of which hung a heavy rod which operated a pump at the foot of the shaft. Steam was admitted above the piston for a short portion of the stroke, thereby raising the pump-rod, and was allowed to expand for the remainder Then an equilibrium valve, connecting the space above and below the piston, as in fig 3, was opened, and the pump-rod descended, doing work in the pump and raising the engine piston The large mass which had to be started and stopped at each stroke served by its inertia to counterbalance the unequal pressure of the steam, for the ascending rods stored up energy of motion in the early part of the stroke, when the steam pressure was greatest, and gave out energy in the later part, when the pressure was much lowered by expansion The frequency of the stroke was controlled by a device called a cataract, consisting of a small plunger pump, in which the plunger, raised at each stroke by the engine, was allowed to descend more or less slowly by the escape of fluid below it through an adjustable orifice, and in its descent liberated catches which held the steam and exhaust valves from opening A similar device controlled the equalibrium valve, and could be set to give a pause at the end of the piston's down-stroke, so that the pump-cylinder might have time to become filled.

The final revival of the compound engine did not occur until about the middle of the 19th century, and then several agencies combined to effect it. In 1845 John M'Naught introduced a plan of improving beam engines of the original Watt type, by adding a high-pressure cylinder whose piston acted on the beam between the centre and the fly-wheel end Steam of higher pressure than had formerly been used, after doing work in the new cylinder. passed into the old or low-pressure cylinder, where it was further expanded. Many engines whose power was proving insufficient for the extended machinery they had to drive were "M'Naughted" in this way, and after conversion were found not only to yield more power but to show a marked economy of fuel. pound form was selected by William Pole for the pumping engines of Lambeth and other waterworks about 1850; in 1854 John Elder began to use it in marine engines; in 1857 E. A. Cowper added a steam-jacketed intermediate reservoir for steam between the high- and low-pressure cylinders, which made it unnecessary for the stroke of the low-pressure piston to be just beginning when that of the other piston was just ending. As facilities increased for the use of high-pressure steam, compound expansion came into more general use, its advantage becoming more conspicuous with every increase in boiler pressure. In marine practice, where economy of fuel was from the first an obviously important factor in design, the principle of compound expansion was extended by the introduction of triple and even quadruple expansion engines

Application to Locomotives and Steamboats,-The adaptation of the steam engine to railways, begun by Trevithick, became a success in the hands of George Stephenson, whose engine, the "Rocket," when tried along with others in 1829, distanced its competitors The principal features of the "Rocket" were an improved steam-blast for urging the combustion of coal and a boiler (suggested by Henry Booth) in which a large heating surface was given by the use of many small tubes through which the hot gases passed. Further, the cylinders, instead of being vertical as in earlier locomotives, were set at a slope, which was afterwards altered to a position more nearly horizontal. To these features there was added later the "link motion," a contrivance which enabled the engine to be easily reversed, and the amount of expansion to be readily varied. In the hands of George Stephenson

and his son Robert the locomotive took a form which in the main is retained by the far heavier locomotives (q.v.) now in use.

The first practical steamboat was the tig "Charlotte Dundae," built by Wilhiam Symington, and tred in the Forth and Clyele canal in 1802. A Watt double-acting condensing engine, placed a shaft at the stern, which carried a revolving paddic-wheel The trail was successful, but steam towing was abandoned for fear of injuring the banks of the canal Ten years later Henry Bell built be "Comet," with side paddic-wheels, which ran as a passenger steamer on the Clyde, but an earlier inventor to follow up Symington's success was the American, Robert Pullon, who, after unsuccessful experiments on the Seine, fitted a steamer on the Hudson in 1807 with engines made to his designs by Boulton and Widon in 1807 with engines made to his designs by Boulton and Widon in 1807 with engines made to his designs by Boulton and Widon success

Rise in Steam Pressure and in Piston Speed,-With improvements in the details of design and construction it gradually became practicable to use higher steam pressures and higher piston speeds, and consequently to obtain not only greater efficiency, but also a greater amount of power from engines of given bulk The triple expansion engine, introduced by A. C. Kirk in 1874, did not come into general use until after 1881. It became the normal type of marine engine, with pressures ranging, as a rule, from 150 to 200 lb per sq inch, piston speeds generally of 500 or 600 ft per minute, but sometimes as high as 900 or 1,000, and coal consumption of about 14 lb per hour per indicated horsepower It continues to be very largely used in steamships which are not driven by turbines In some instances quadruple expansion has been preferred, with somewhat higher pressures, but when the pressure is much raised the tendency is to abandon the piston type in favour of the steam turbine. This is true both in marme and in land practice. The gigantic concentration of steam power that is found in a great steamship or in a power station has been made practicable by the turbine. The selection of Parsons turbines in 1907 as the motive engines of the Cunarders "Lusi-tania" and "Mauretania" constituted a new departure in steam engineering. It was then a novelty to develop some 70,000 horsepower in the engine room of a single ship. Many of the turbines in power stations now exceed this figure

introduction of the Steam Turbine.—The invention of the steam turbine has revolutionized marme engine practice, in respect especially of the largest and fastest vessels. For the generation of electricity the turbine has a notable advantage in directly developing the high speed of rotation which a dynamo requires, and, when designed on a large scale, its efficiency is unnvailed by steam engines of other kinds To Sir Charles Parsons we owe not only the main idea of the modern steam turbine, but also the invention of many mechanical features and details essential to its

practical success and general adaptation In the steam turbine, as we have seen, pressure, instead of being exerted on a piston, is employed in the first instance to set the fluid itself in motion. There is a conversion of pressure-energy into velocity-energy as a preliminary step towards obtaining the effective work of the machine. If this were done in a single step it would involve immensely high velocities in the steam jet and in the vanes on which the jet acts Attempts to design a steam turbine were made by numerous inventors, but fell short of practical success mainly because of the difficulty of arranging for high enough velocity in the working parts to utilize a reasonably large fraction of the kinetic energy of the steam. There was a further difficulty in getting the energy of the steam into a suitable kinetic form, namely, to get the stream of issuing particles to take a single direction, without undue dispersion, when steam was allowed to expand through an orifice from a chamber at high

pressure into a space where the pressure was greatly less.
In 1869 Dr. Gustaf de Laval introduced a form of steam turhin in which both of these difficulties were, to a considerable degree, overcome, partly by the special form of the nozzle used to
produce the isteam jet and partly by features of design which allowed an exceptionally high speed to be reached in the wheel carrying the vanes against which the steam impinged.

Parsons attacked the problem at an earlier date and in a different way, by his invention of the "compound" turbine He divided the whole expansion of the steam into a great number of successive and separate steps and thereby limited the velocity acquired at each step to such an extent as to make it comparatively easy to extract the greater part of the kinetic energy as work done upon the moving blades, without making the velocity of these blades inconveniently high Moreover, in Parsons's compound turbine the range of pressure through which the steam expands in each separate step is too small to cause any difficulty in the formation of the jets. The guide blades, which form the jets, are distributed round the whole circumference of the revolving wheel and all the revolving blades are consequently in action at once The steam streams from end to end of the turbine through an annular space between a revolving drum and the casing which surrounds it Parallel rings of fixed guide blades project inwards from the casing at suitable distances, and between these are rings of moving blades which project outwards from the drum and revolve with it At each step in the expansion the steam streams through a ring of fixed guide blades, and the streams so formed impinge on the next ring of moving blades, and so on. The construction, which is of great simplicity, is described, along with others, in the article TURBINE. STEAM. It lends itself well to the generation of power on a large scale, especially where a fairly high speed of rotation is wanted Parsons introduced his compound steam turbine in 1884. For

355

some years it was made in small sizes only, and the steam was discharged to the atmosphere without condensation. So long, however, as this was done the steam turbine was sacrificing one of its most important advantages, namely, its exceptional capacity for utilizing the energy of low-pressure steam down to the lowest vacuum obtainable in a condenser. In 1891 it was first fitted with a condenser, and it then began to be used in electric supply stations The first application to marine propulsion was in the "Tur-binia," in 1897 The success of this little experimental vessel of 100 tons, which, with its horse-power of 2,100, made what was then a record in speed for any ship, was soon followed by the application of the turbine to war-ships and other steamers. In merchant vessels its use was at first limited to those of the highest speed, for the turbine shaft was directly coupled to the shaft of the screw propeller; but in 1910 Parsons introduced a mechanical reducing gear between the two, which allowed the turbine shaft to run much faster than the propeller shaft, to the great advantage in efficiency of both turbme and propeller. Later he followed this up by a "double-reduction" gearing which admitted of a still greater difference in speed of rotation between the propeller and the turbine. In most ships the single reduction system is sufficient for the purpose: its introduction greatly extended the range within which the turbine could be advantageously substituted for the three-cylinder or four-cylinder compound engine of the piston type in ocean-going steamships.

Enough has been said to show that the invention of the steam turbine is by far the most important step in steam engineering since the time of Watt. It solved the problem of using steam efficiently in an engine without reciprocating parts.

Early Theory .- In the early development of the steam engine inventors had little in the way of theory to guide them. Watt had the advantage of a knowledge of Joseph Black's doctrine of latent heat; but there was no philosophy of the relation of work to heat until long after the inventions of Watt were complete. The theory of the steam engine as a heat engine may be said to date from 1824, when N. L Sadi Carnot published his Réflexions sur la buissance motrice du feu, a remarkable essay in which he showed that heat does work only by being let down from a higher to a lower temperature. But Carnot was not then aware that any of the heat disappears in the process, and it was not until the doctrine of the conservation of energy was established in 1843 by the experiments of James Prescott Joule that the theory of heat engines began a vigorous growth. From 1849 onwards the science of thermodynamics was developed with extraordinary rapidity by Rudolf Clausius, W. J. Macquorn Rankine and William Thomson (Lord Kelvin) and was applied, especially by Rankine, to practical problems in the use of steam Rankine's Manual of the Steam Engine, published in 1859, was the first attempt at a systematic treatment of steam-engine theory It involved the simplifying assumption that the cylinder and piston might be treated as behaving to the steam like non-conducting bodies, in other words, that the transfer of heat between the steam and the metal might generally be disregarded. One effect of this was to treat the volume of steam consumed per stroke as corresponding to the volume of the cylinder up to the point of cut-off When steam enters the engine cylinder it finds the metal chilled by the previous exhaust, and a portion of it is at once condensed. This has the effect of increasing, often very largely, the volume of boiler steam required per stroke. As expansion goes on, the water that was condensed during admission begins to be re-evaporated, and this action is often prolonged into the exhaust. It is now recognized that exchanges of heat between the steam and its metal envelope cannot be ignored They cause the actual performance to fall short, in some cases very much short, of the ideal limit They may be reduced by suitable design

# ACTION OF RECIPROCATING ENGINES

Most, though not all, reciprocating engines are double-acting: that is to say, steam from the boiler is alternately admitted to each side of the piston. In each double stroke, or revolution, there are four events for each end of the cylinder -(1) Admission, which begins by the opening of a steam-valve when the piston is at or very near the limit of its travel; (2) Cut-off, at which the steam-valve is closed and admission ceases. This may take place early in the stroke. The steam which is enclosed behind the piston then expands, with falling pressure, while the stroke continues, until (3) Release occurs; that is to say, an exhaustvalve opens, allowing the steam to escape from the cylinder Its discharge generally continues for a large part of the back-stroke, until event (4), at which the exhaust-valve closes, and Compression begins. from there to the end of the back-stroke, the steam remaining in the cylinder is compressed into the clearance space behind the piston This compression of the residue of steam, which is called cushioning, assists smoothness of working as the piston passes what is called the dead-point, at the limit of its stroke; and the cushioning effect is often augmented by giving the steam-valve what is called "lead,"—that is, causing it to open a little before the piston reaches the dead point. Distribution of the Steam: Indicator Diagram.—Together,

these various events of the stroke constitute what is termed the distribution of the steam They are conveniently exhibited by drawing an indicator diagram of the action, such as that illustrated in fig 4 There, on a base PQ which represents the stroke, lines are drawn to show the continuous changes of pressure that go on within the cylinder during the whole action. Starting from the beginning of the stroke at a, for one side of the piston, steam is admitted up to the point b which shows the cut-off. At (or near) the end of the forward stroke, at c, the steam is allowed to escape. Compression, in the return stroke, begins at d. From b to c the steam confined in the cylinder is expanding, with falling pressure, doing work on the piston. The whole work done in the revolution.

namely the integral of the force acting on the piston and the distance through which it moves, is represented by the enclosed area of the indicator diagram, abed

The diagram is idealised in the sense that the events are shown as if they happened suddenly, Fig 4.—INDICATOR DIAGRAM giving sharply defined changes snowing distribution of Steam



from admission to expansion and so on. In any real engine the events are necessarily gradual, for no valve-whatever its type -can close or open quite instantaneously. A real indicator diagram accordingly has a smoother outline with rounded corners to mark the places of cut-off, release, compression and admission. In practice release always occurs before the piston has quite completed its stroke.

The distance PO which represents the stroke may (by the use of an appropriate scale) be interpreted as a volume, namely the volume swept through by the piston, and a point O behind P may be so taken that OP represents, on the same scale, the volume of the clearance The distance measured horizontally from the line OY to any point of the curve represents the whole volume of steam behind the piston at that point, and the curve between admission and release exhibits the relation of the pressure to the

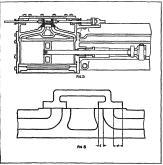


Fig 5 .- CROSS SECTION DIAGRAM OF A SLIDE-VALVE SHOWING EXHAUST AND INLET PORTS BELOW IT, AND CYLINDER AND PISTON FIG 6 .- CROSS SECTION OF SLIDE-VALVE IN MIDDLE POSITION, (1) INTERNAL LAP, (E) EXTERNAL LAP

total volume of the steam enclosed behind the piston throughout its process of expansion

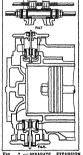
Actual indicator diagrams may be automatically drawn by attaching to the cylinder of the engine a device in which a pencil is made to rise or fall proportionally to the variations of steam pressure, while a paper, on which it inscribes a record, moves back and forth horizontally through distances proportional to the movement of the engine piston Many forms of indicator have been designed to give, in some such way, a diagram in which the coordinates represent respectively the displacement of the piston and the pressure of the steam against it. From such diagrams it is easy to infer the mean effective pressure throughout the stroke. and also to observe how the valves are working By connecting the instrument successively to each of the two ends of the cylinder, in a double-acting engine, a complete record is obtained for the two strokes which make up a revolution The "indicated horse-power" is determined by the formula

I.H.P. = 
$$\frac{nL(p_1A_1 + p_2A_2)}{33,000}$$

where A1 and A2 are the areas of the two sides of the piston, in square inches; p1 and p2 are the mean effective pressures on the two sides, in lb. per sq inch, as determined from the diagrams, n is the number of revolutions per minute, and L is the stroke in feet. In trials of a steam engine such diagrams are taken during a considerable period. The amount and condition of the steam passing through the engine is observed, by measuring either the quantity of water discharged from the condenser (if of the surface type), or the quantity of feed-water required to be supplied to the boiler to keep the water level constant From these data it becomes possible to compare the power developed with the heat supplied. Measurements of the heat rejected may also be made by observing the quantity of condensing water used and its rise in temperature; and together these figures give material for drawing up a balance sheet of the disposal of thermal energy.

each end of the cylinder, may be controlled by separate valves, but very commonly a single moving piece, called a slide-valve, serves to control the events for both ends. The slide-valve was invented by William Murdock, an assistant of Watt A common form of it is illustrated in section in fig 5, which also shows the cylinder, with the piston, and the steam ports and passages leading to each end of the cylinder. The face on which the valve slides is a plane surface on one side of the cylinder with three ports or openings which extend across the greater part of the cylinder's width The central opening is the exhaust port, through which the steam escapes after doing its duty in the cylinder. The others, which are narrower, lead to the two ends. The valve itself is a box-shaped cover, sliding on the face, and contained in the valve-chest, or chamber to which steam is admitted from the hoiler. When the valve moves a sufficient distance to either side of the middle position steam is admitted to one end of the cylinder, past the outer edge Similarly steam escapes from the other end of the cylinder, through the cavity of the valve, to the exhaust port The valve takes its motion from an eccentric on the engine shaft, which is set more than goo ahead of the crank, so that the valve has already begun to uncover the port on one side when the piston is at the corresponding dead point, with the result that steam passes from the steam chest above the valve into the space behind the piston Figure 6 shows a slide-valve in its middle position, and illustrates the internal lap s and the external lap e which the valve must have to make expansive working possible. At the beginning of the stroke it has already passed its middle position by an amount at least equal to e, so that steam may enter. It contimues to move further, opening the port more widely, and then begins to return, while the piston is still advancing in the cylinder, At a particular point in its return the outer edge of the valve closes the port; this determines the instant of cut-off. The piston continues to advance, with expansion of the steam confined in the cylinder, while the valve continues to move back, until the inner

edge of the valve begins to uncover the port, allowing steam from the cylinder to escape to the exhaust channel. This point, which depends on the internal lap s, determines the instant of release. The port then opens more widely to exhaust, and remains open during most of the back stroke of the piston, until the valve, again moving in the original direction, brings its inner edge again over the port and compression begins. Similar events for the other end of the cylinder are determined by the other side of the valve The positions of the piston when the several events occur depend on the amounts of the laps e and i, and of the "angular advance" which is the excess over 90° in the angle by which the eccentric stands ahead of the crank. If there were no laps and no angular advance steam would be admitted during the whole forward stroke and exhausted during VALVE



the whole backward stroke. By Fig. 8 .- cross section of one giving the valve laps and angular END OF A CYLINDER SHOWING DROP VALVES advance expansive working be-

comes possible. But the slide-valve is not well adapted to effect a cut-off early in the stroke, and when much expansion is desired, a device called a separate expansion valve is added, or valves of a different type are used to control the distribution of the steam.

Separate Expansion Valves.-Fig. 7 shows Meyer's expansion valve, which consists of two blocks sliding on the back of a slide-valve. It is caused to reciprocate by an eccentric, generally

The Slide-valve.—The admission and exhaust of steam, for set directly opposite the crank, so that it moves to the left while the piston moves to the right, and vice verse. The admission of steam ceases when the relative displacement of the expansion blocks over the slide-valve amounts to the distance I, and this can be arranged to happen early in the piston's stroke without affecting the release or the compression

In this example the rod which carries the two blocks is fitted with right- and left-handed screws, so that by turning the rod the distance between the blocks may be adjusted, and the distance I consequently altered This allows the valve to be set to give an earlier or later cut-off when I is increased by bringing the blocks nearer together, the cut-off comes later in the stroke The adjustment may be made while the engine is running. Another way to change the cut-off with a valve of the Meyer type is to alter its travel Increasing the travel of the expansion valve, while I remains constant, makes the cut-off come later

In many engines the events are controlled by using, at each end of the cylinder, separate valves for admission and exhaust (fig 8). Sometimes these are drop valves which are "doublebeat" in the sense that the valve when it drops into its seat closes simultaneously two passages. These are so arranged that the steam pressure tending to close or open the valve remains balanced, and no large force has to be exerted. Such valves are often worked by cams and levers from a lay shaft alongside the cylinder, driven from the main shaft so as to turn in unison. In many examples the valves giving admission are caused to close by a tripping device, that is to say they spring suddenly into the closed position, at the instant when cut-off is desired, through the action of a trigger which brings a closing spring into play; and the tripping device is connected with the governor of the engine in such a manner that the cut-off comes earlier or later when the speed exceeds or falls short of the normal. In this way the engine automatically adjusts the amount of power it develops to suit changes in the demand made upon it by the mechanism which it drives,

Balanced Valves .- Fig. 5 shows a slide-valve form usual in locomotives and small engines but in large sizes the objection is that the unbalanced pressure of steam on the back of the valve would cause much friction and wear in the movement of the valve over the working face on which it slides. In large engines, such as those of steamships, it is usual to relieve the pressure of the valve on the working face by fitting the back of the valve with what is called a relief frame, extending between the valve and the steam-chest cover, the effect of which is to prevent the steam of the steam-chest from having access to the whole back surface of the valve. Another device, often resorted to, is to substitute for the flat form of slide-valve a piston form in which the effective sliding portions of the valve extend all round the surface of a cylinder and slide over cylindrical fixtures in the valve chest, round which the steam-ports extend

Reversing Gears,-The slide-valve is a particularly convenient means of controlling the admission of steam when, as in locomotives or marine engines, etc., the engine's direction of motion has frequently to be reversed. It is only necessary to provide means by which the valve may be actuated by either of two eccentrics, one set at the angle suitable for forward running and the other set at the angle suitable for backward running

In Stephenson's link motion which is an early and familiar device for this purpose, the engine shaft carries two eccentrics. one of which is set ahead of the crank at a suitable angle for one direction of running, and the other at a suitable angle for the other direction. Their rods are connected to the ends of a link which gives its name to the contrivance. The link is a slotted bar curved to a circular arc, and capable of being moved up or down, being suspended from a rod which can be raised or lowered by means of the hand lever above. The valve rod ends in a block which slides within the link. This device allows either the forward eccentric or the backward eccentric to determine the motion of the valve, and so allows the engine to be reversed But it does more, for if the link be set to an intermediate position, in which it takes its motion chiefly from one eccentric but partly from the other, the valve receives a motion virtually the same as that which it would get from a single eccentric of shorter travel and greater angular advance. The effect is to give a distribution of steam in which the cut-off is hastened and the expansion and compression are increased. Thus besides allowing of 'full forward' and "full backward gear", the link may be 'noticised up' to give a much shorter admission of steam along with more compression, a matter of practical value in the running of a locomotive, where frequent large variations in the demand for driving effort have to be met. Various other forms of inha-motion have been devised which

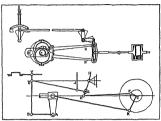


FIG. 9 — (ABOVE) STEPHENSON'S LINK MOTION. (E, L') ECCENTRICS.

share this advantage. It is also shared by a group of equivalent mechanical devices, called by the general name of "radial valve gens," in which only one eccentric is employed but the valve is caused to take a motion capable of being varied in the same way. Of these the most widely used is the Walscharer's gent, very common in bocumotives, a skeleton diagram of which is shown in fig. which is shown in the value of the same way. Of these the motion partly from it, through even  $\delta A$  and B V by B V but B V has a fulcrum at D, the position of which varies through the movement of the rod D C. That rod is supported by a suspension rod I, and its end at G can slide in a link B I rocking about a faceful cut and O. There is one eccentric, C V, set at right angles to the crank C K, and giving motion to the rocking link B V by the rod B I. The block G can be shifted from near B I to I V praising the suspension rod I. This reverses the motion, and allows also of notching up to any intermediate position.

Governing.-To keep a steam engine running at a uniform speed, notwithstanding variations in the demand for nower, hand regulation may to some extent serve, but in very many cases an automatic regulator called a governor is provided. Regulation. whether by hand or by automatic governor, may be effected in two ways: the steam may be throttled more or less on its way from the boiler to the engine, so that the pressure of admission is reduced when the speed tends to rise, and increased when the speed tends to fall; or the point of cut-off may be varied, with the result of admitting a greater or less volume of steam in each stroke. In small engines the governor often acts on a throttle valve, but at engines which aim at efficiency it is preferable to govern by altering the cut-off. In such engines, to secure in any case a proper amount of expansion, there is an early cut-off, and a small change in its position largely affects the amount of steam admitted and consequently the amount of work done.

Wait's original governor was a pair of halls revolving about a vertical spindle, as conical pendulums under the combined effect of their own weight and the "centrifugal force" due to their speed of revolution. Any increase of speed sufficient to overcome the slight friction of the attached gearing made them take up a higher position, and in so doing they partially closed a throttle valve. This went on till, at a slightly greater speed than before, equilibration was established between the supply of steam and the demandram was established between the supply of steam and the demand as strictly constant special meteors, the effect is not to maintain a strictly constant special prevent the variation, either way.

In modern governors the "centrifugal force" of the balls generally acts not simply against their own weight, but against an extra load or against the force of a spring.

In many factory and other engines the governor determines the position of cut-off by means of a trigger action of the type already mentioned: the dunision valve, which has been opened and held open by a cam turning with the engine shaft, is suddenly disconnected by the release of a trigger, at a point depending on the each height of the governor balls.

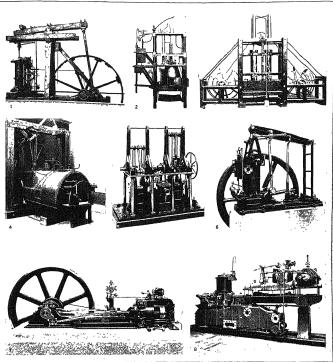
Function of the Fly Wheel.—The function of the governor is, generally, to keep the engine running at a nearly uniform rate, measured in turns per minute, the function of the flywheel is to keep the rate nearly uniform within the limits of any one revolution. For this purpose it must act as a reservoir of energy, alternately storing and restoring the excess amounts which result from periodic variations of turning moment in the operation of the piston on the crank. At the dead points the piston's rate of doing work is zero, and it rises to a maximum at an intermediate point the position of which may be much affected by an early cut-off The flywheel is drawn upon for energy during those parts of the revolution in which the work done by the piston (or pistons) on the engine shaft is less than the work done by the shaft on the mechanism which the engine drives; and it takes up the surplus during the other parts of the revolution. To effect this alternate give and take of energy the flywheel must undergo small variations of speed, the magnitude of which may be kept down to any assigned amount by giving the rim a sufficient mass and speed

Inertia of Reciprocating Parts.—The effective effort on the crank is greatly influenced, especially in high-speed engines, by the inertia of the piston, piston-rod and connecting rod. At the beginning of the stroke, when the piston is coming towards the crank-shaft, these reciprocating masses are acquiring motion, from a point near the middle to the end of the stroke they are losing motion. Hence in the early part the effort on the crank is reduced below what is due to the steam-pressure on the piston and in the later part it is increased. In a high-speed engine the forces due to acceleration become so large as seriously to affect part of the crank of the cran

Balancing of Engines.—Another aspect of the acceleration of reciprocating parts is its effect on the balance of the engine as a whole. This is specially important in locomotives and marine engines. In a locomotive he forces on the engine frame arising from the inertia of the pistons and rods tend to make the engine sway laterally; this is to some extent prevented by placing "balance masses" on the wheels But such masses, although they may be adjusted nearly to balance the horizontal forces, include unbalanced vertical forces, causing what is called hammerblow In extreme cases these vertical forces might even lift the wheels from the rails; short of that, however, they are objectionable in causing periodic variations in the pressure on the rails, which tend to set bridges into oscillation and may add substantially to the stresses for which the railsway engineer must provide.

# TYPES OF RECIPROCATING ENGINES

In classifying engines with regard to their general arrangement of parts and mode of working, account has to be taken of a considerable number of independent characteristics. We have first a general division into condensing and non-condensing engines, with a subdivision of the condensing class into those which act by surface conciensation and those which use injection. Next there is the division into compound and non-compound, with a further classification of the former as double, triple, or quadruple-expanion engines. Again, engines may be classed as single or double-acting, according as the steam acts on one or alternately on both sides of the plston. Again, a few engines—such as steam hammers and certain kinds of steam pumps—are non-rotative, that is to say, the reciprocating motion of the piston does work is might on a reciprocating piece; but generally an engine does work on a continuously revolving shaft. In most cases the crank-pin of the



BY COURTEST OF THE SCIENCE MUSEUM, LONDON

## THE PROGRESS OF THE STEAM ENGINE

- One of Boulton and Watt's early (1789) rotative steam engines, among the first to utilize the double acting principle
- Model of Newcomen's steam engine (1719), the precursor of Watt's engine, and successfully used in pumpling and mine drainage. Newcomen created a vacuum within the cylinder by the condensation of steam.
- 3 Symington's original marine steam engine (1788), first used to propel a paddle-boat on Dalswinton Loch, Scotland, at a speed of about 4 m per hour
- 4 Trevithick's high-pressure, or non condensing engine (1811)
- 5 Quadruple piston-rod steeple paddle engine (1842)
- 6 Grashopper engine (1862), so-called because of the obvious resemblance of its upper and right-hand portions to that insect
- Model of single-cylinder horizontal engine (1898), with Coriliss valve gear A sectional view at the right end of cylinder reveals the piston and valve construction
- 8 Parsons' turbo-generator (1902), with upper turbine essing lifted to show roter

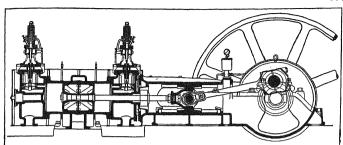


FIG 10.-UNIFLOW ENGINE IN WHICH THE PISTON ACTS AS EXHAUST VALVE AND THE ADMISSION VALVES ARE IN THE CYLINDER ENDS

revolving shaft is connected directly with the piston-rod by a connecting-rod, and the engine is then said to be direct-acting: in other cases, of which the beam engine is an historical example, a lever is interposed between the piston and the connecting-rod. The same distinction applies to non-rotative pumping engines, in some of which the piston acts directly on the pump-rod, while in others it acts through a beam. The position of the cylinder is another element of classification, giving horizontal, vertical and inclined cylinder engines In most vertical engines the cylinder is above the connecting-rod and crank In oscillating cylinder engines (a type still found in some river boats) the connecting-rod is dispensed with; the piston-rod works on the crank-pin, and the cylinder oscillates on trunnions to allow the piston-rod to follow the crank-pin round its circular path. In rotary engines there is no piston in the ordinary sense; the steam does work on a revolving piece, and the necessity is thus avoided of afterwards converting reciprocating into rotary motion.

Beam Engines—In the single-acting atmospheric engine of Newcomen the beam was a necessary feature, the use of water-packing for the piston required that the piston should move down in the working stroke, and a beam was needed to let the counter-poise pull the piston up Watt's improvements made the beam no longer necessary; and in one of the forms he designed it was discarded—namely, in the form of pumping engine known as the Bull engine, in which a vertical inverted cylinder stands over and acts directly on the pump-rod. However, the beam formed a convenient driver for pump-rods and valve-rods; and the parallel motion invented by Watt as a means of guiding the piston-rod, which could easily be applied to a beam engine, was, in the early days of engine-building, an easier thing to construct than the plane surfaces which are the natural guides of the piston-rod in a direct-acting engine. In modern practice the direct-acting type has almost wholly displaced the beam engine.

Direct-acting Engines .- Of direct-acting engines the horizontal arrangement has in general the advantage of greater accessibility, but the vertical economises floor space. In small forms the engine is generally self-contained, that is to say, a single frame or bedplate carries all the parts including the main bearings in which the crank-shaft with its flywheel turns. The frame often takes what is called a girder shape, which brings a portion of it into a favourable position for taking the thrust between the cylinder and the crank-shaft bearings and allows two surfaces to be formed on the frame to serve as guides for the cross-head. When a condenser is used with a horizontal engine it is often placed behind the cylinder, and the air-pump, which may be within the condenser, has a horizontal plunger or piston on a "tail-rod" or continuation of the main piston-rod through the back cover of the cylinder. In large horizontal engines the condenser generally is in a well below, and its pump is driven by a mechanism linked with the crosshead.

Coupled Engines.—When uniformity of driving effort or the absence of ead points is important, two independent cylinders often work on the same shaft by cranks at right angles to each other. Such engines, which are called "coupled," can start readily from any position; the ordinary locomotive engine is an example in some engines three cylinders, set to work on cranks 120 apart, co-operate in giving a still more uniform drive. Winding engines for mines and collieres, in which ease of starting, stopping an reversing is essential, are very generally made by coupling a pair of cylinders on opposits eights of the winding drum.

Compound Engines, Coupled or Tandem—Large directing engines are usually compounded either by having a highand a low-pressure cylinder side by side, with cranks at rightangles, or by putting one cylinder behind the other with a common centre line. The latter is called a tandem arrangement. In a tandem engine, since the putsons agree in phase, the steam may expand directly from the small into the large cylinder. But the connecting-pipe and steam chest form a receiver of considerable size, and it is preferable to cut off the supply of steam to the the compound tandem and conspound coupled types of engine are very usual. The high-pressure cylinder is often fitted with some form of trip-car.

The chief advantage of compounding, as was pointed out in the historical section, is that it reduces the condensation which hot steam undergoes in the cylinder through contact with metal which has been chilled by the exhaust of the previous stroke. Compound working acts beneficially by narrowing the range through which the temperature periodically by furturates in the metallic surfaces exposed to contact with the operative steam. The amount of steam that is at once condensed on admission depends on on the extent to which the surfaces with which it comes in contact has been chilled during the previous exhaust. For this reason there is less loss through initial condensation in a compound engine giving the same total ratio of expansion.

the same total ratio of expansion.

Uniflow Margine.—The periodic give and take of heat between the steam and the metallic surfaces, which is a serious source of loss in any reciprocating engine, can be reduced by having separate valves for admission and exhaust, so that the same port-surfaces and valve-surfaces are not hrought into contact with hot and comparatively cold steam. This idea is carried further in what is called the "uniflow" engine, by an ingenious arrangement which secures that the ends of the cylinder, where the steam is admitted, shall always be kept hot, the exhaust taking place at the middle of the cylinder through ports in the circumference which are uncovered by the motion of the piston.

The uniflow design is a recent but conspicuously successful departure from earlier practice. It allows high pressure steam to be expanded in a single cylinder without the drawbacks ordinarily exchange of heat between the metal and the steam to make superheating highly advantageous.

Condensation.-In land engines a jet form of condenser is common, but surface condensation is resorted to when the available water-supply is unsuited for boiler feed. When there is no large supply of condensing water a very fair vacuum can be obtained by using an evaporative condenser, consisting of a stack of pipes into which the exhaust steam is admitted and over which a small amount of cooling water is allowed to drip. This water is evaporated by the heat which the condensing steam gives up Such a condenser is placed in the open, generally on a roof where the air has free access. The amount of water it uses need not exceed the amount of steam that is condensed, and is a small fraction of the amount that would be required in a set or surface condenser

High-speed Direct-acting Engines .- Prior to the development of the steam turbine the demand for engines suitable for driving electric generators without the intervention of a belt led to the introduction of various forms of direct-acting engine adapted to run at a high speed Some of these were single-acting. steam being admitted to one side of the piston only, generally the back, with the result that the rods could be kept in a state of thrust throughout the revolution, and alternations of stress in them and at the joints thereby avoided, together with the knocking and wear of the bearing brasses which it is apt to cause. To secure, however, that the connecting-rod should always push and never pull against the crank-pin there had to be much cushioning during the out stroke on account of the fact that from about the middle of that stroke to the end the reciprocating mass was being retarded. In engines of this class designed by P. W. Willans, which were at one time much used, but are now displaced by turbines, the cushioning was provided by means of a supplementary piston which compressed air during the out stroke; the energy which the reciprocating masses had to part with in losing their motion during the second half of the out stroke was stored in this air and was restored in the succeeding down stroke. The engine was entirely enclosed in a casing the bottom of which formed an oil bath in which the cranks splashed to ensure ample lubrication. This feature is retained in many modern high-speed engines.

Pumping Engines.-In engines for pumping or for blowing air it is not essential to drive a revolving shaft, and in many forms the reciprocating motion of the steam piston is applied directly to produce the reciprocating motion of the pump-piston or plunger. Often an inverted vertical triple expansion engine is used, resembling the usual marine form, with a pump-plunger under each of the three cylinders. Most of the power is directly transmitted from the piston to the pump, but there is an auxiliary crank for each cylinder, driving a shaft with a flywheel to equalize

the effort on the pump.

A familiar example of direct-acting pump is the small donkey pump used for feeding boilers, in which the steam-piston and pump-plunger are on one and the same rod. In some of these pumps a rotative element is introduced, partly to secure steadiness of running and partly for convenience in working the valves. But many pumps of this class are entirely non-rotative, and in such cases the steam is generally admitted throughout the stroke without expansion. The valve may be actuated by tappets from the piston-rod. In some cases a tappet worked by the piston as it reaches each end of its stroke throws over an auxiliary steamvalve, which admits steam to one or other side of an auxiliary piston carrying the main slide-valve.

Pulsometer .- Hall's "pulsometer" is a peculiar pumping engine without cylinder or piston, which may be regarded as the modern representative of the engine of Savery. The sectional view, fig. 11. shows its principal parts. There are two chambers, A, A', narrowing towards the top, where the steam-pipe B enters. A ballvalve C allows steam to pass into one of the chambers and closes the other. Steam entering (say) the right-hand chamber forces water out of it past the clack-valve V into a delivery passage D, which is connected with an air-vessel. When the water level in A sinks so far that steam begins to blow through the delivery passage, the water and steam are disturbed and so brought into inti-

entailed in non-compound working. There is, however, still enough mate contact, the steam in A condenses, and a partial vacuum is formed This causes the ball-valve C to rock over and close the top of A, while water rises from the suction-pipe E to fill that chamber At the same time steam begins to enter the other chamber A', discharging water from it, and the same series of actions is repeated in each chamber alternately While the water is being driven out there is comparatively little condensation of steam. partly because the shape of the vessel does not promote the formation of eddies, and partly because there is a cushion of air between the steam and the water. Near the top of each chamber is a small air-valve opening inwards, which



METER

uum is formed. When any steam is condensed, the air mixed with it remains on the cold surface and forms a non-conducting layer. The pulsometer is, of course, far from efficient as a thermodynamic engine, but its adaptability to situations where other steam-pumps cannot easily be applied, and the simplicity of its working parts, sometimes make it practically Marine Engines.-The early steamers

allows a little air to enter each time a vac-

were fitted with paddle-wheels, and the engines used to drive them were for the

most part modified beam engines. Bell's "Comet" was driven by a species of inverted beam engine, and another form of inverted beam, known as the side-lever engine, was for long a favourite with marine engineers. An old form of direct-acting paddle-engine was the steeple engine, in which the cylinder was set vertically below the crank. Two piston-rods projected through the top of the cylinder, one on each side of the shaft and of the crank. They were united by a cross-head sliding in vertical guides, and from this a return-connecting-rod led to the crank. Most modern paddle-wheel engines are direct-acting engines of the ordinary connecting-rod type, with the cylinders fixed on an inclined bed and the guides sloping up towards the shaft.

When the screw-propeller began to take the place of paddle-

wheels in ocean steamers, the increased speed which it required was at first obtained by using spur-wheel gearing in conjunction with one of the forms of engines then usual in paddle steamers. Types of engine better suited to the screw were introduced later, and were driven fast enough to be connected directly to the screwshaft. After passing through various forms, now obsolete, the marine engine settled into one which is now universal in all screw steamships that are not driven by steam turbine

This is the inverted vertical direct-acting engine, with two or more cylinders placed side by side directly over the shaft. It has the great advantage that the shaft can readily be put at the low level necessary for screw propulsion Two, three and four cranks are employed, the arrangement with four cranks being specially suitable, as has already been pointed out, when a balance of the engine at high speeds has to be secured. In vessels of high speed and power the engines are often arranged in twin sets, on two shafts with twin screw propellers.

The marine engine is always furnished with a surface condenser, consisting of a multitude of brass tubes about 4 inch in diameter cooled by sea-water which is caused to circulate through the condenser by means of a circulating pump This pump and the air pump are often driven independently of the main engine.

It is in marine practice that the most powerful reciprocating engines are still to be found, although in the largest and fastest vessels the turbine has taken their place. Another and more recent rival is the internal combustion engine, using the Diesel cycle of action, which by 1928 had found favour in many new liners. The reciprocating engine continues, however, to be much used for sea-going vessels, especially those of the "tramp" class, most commonly in the triple expansion form. Often the third stage of the expansion is performed in two cylinders, making four in all. This avoids the use of a very large cylinder, and secures an advan-tage in the better balance which can be obtained with four cranks, Locomotive Engines.—The ordinary locomotive consists of a pair of direct-acting horizontal or nearly horizontal engines, fixed in a rigid frame under the front end of the boiler, and coupled to the same shaft by cranks at right angles, each with a single slidevalve worked by a link-motion, or by a form of radial gear The engine is non-condensing, except in a very few special cases, and the exhaust steam, delivered at the base of the funnel through a blast-pipe, serves to produce a draught of air through the furnace. In some instances a portion of the exhaust steam, amounting to about one-fifth of the whole, is diverted to heat the feed-water

On the shaft are a pair of driving-wheels, whose frictional adhesion to the rails furnishes the necessary tractive force Nearly always a greater tractive force is secured by having two or more driving-wheels on each side, connected by a coupling-rod between

pins on the outside of the wheels

It is general to have under the front of the engine a group of smaller wheels which do not form part of the driving system These are carried in a bogie, that is, a small truck upon which the front end of the boiler rests by a swivel-pin or plate which allows the bogie to turn, so as to adapt itself to curves in the line, and thus obviate the grinding of tyres and danger of detailment which would be caused by using a long rigid wheel base.

In inside-cylinder engines the cylinders are placed side by side within the frame of the engine, and their connecting-rods work on cranks in the driving shaft. In outside-cylinder engines the cylinders are spread apart far enough to lie outside the frame of the engine, and work on crank-pins on the outsides of the driving wheels Many modern locomotives combine the outside and inside arrangement, in order to get greater power, placing one or in some cases two cylinders within the frame, as well as two outside

The principle of compounding has often been applied to locomotive engines, but without much advantage. (See Locomotives.)

## THEORY OF THE STEAM ENGINE AS A HEAT ENGINE

Properties of Steam.-Steam-engine theory is an application of the principles of thermodynamics (qv) to a machine using steam as its working substance. The relevant properties of the substance have been briefly described in the article STEAM. They include the pressure, temperature, and density (or volume per unit of mass), also (per unit of mass) the entropy  $\phi$  and the total heat I. For definitions of these quantities reference should be made to that article. Numerical values will be found in Callendar's or other steam tables, over a sufficiently wide range of conditions to meet the purposes of the engineer.

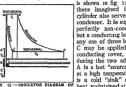
Given steam in any initial state, we have to consider what hanpens when it expands, doing work, as in the cylinder of a steam engine. It is easy to imagine steam expanding without turbulence in an ideal cylinder which is a perfect non-conductor of heat. Under these conditions no heat is being taken in, and there is no change of entropy: such expansion is said to be adiabatic. Adiabatic expansion, and adiabatic compression, although never strictly realized owing to the influence of the conducting cylinder walls, are ideal actions important in the theory of the steam engine.

During adiabatic expansion the substance is doing work at the expense of its stock of internal energy, and its temperature falls. Steam expanding adiabatically becomes partly condensed, the substance then becomes a mixture of saturated steam with water at the same temperature, and the energy or the total heat of one pound is to be found by considering what fraction is present as water and what fraction is steam. Such a mixture is often called wet steam. The degree of wetness reached at any stage of adiabatic expansion is readily calculated by taking account of the fact that the expanding mixture keeps its entropy unchanged.

From the general principles of thermodynamics it is easy to assign an upper limit to the efficiency of a steam engine, when the temperatures are known at which the working substance takes in and rejects heat. By "efficiency" is here meant the ratio of the work done to the quantity of heat supplied. Suppose, to simplify the problem, that there is no superheating, that is to say no supplementary taking in of heat after the steam has been formed at the constant temperature T, of the boiler Suppose also that the only rejection of heat is at the constant temperature Ta of the condenser. Then the principle of Carnot (see THERMODYNAMICS)

shows that under ideally favourable conditions of working the fraction of the heat supplied which is converted into work cannot exceed I-T2/T1, when the temperatures are expressed on the absolute scale

Carnot Cycle.-This result would be attained in an engine working in a strictly reversible manner, where the whole change from T, to T, occurs as a result of adiabatic expansion, and the whole change from T2 to T1 as a result of adiabatic compression The indicator diagram of an ideal engine working in this manner



CARMOT'S CYCLE

is shown in fig 12 The engine there imagined is one whose cylinder also serves as boiler and condenser. It is supposed to have perfectly non-conducting sides, but a conducting bottom to which any one of three bodies A. B. or C may be applied B is a nonconducting cover, to be applied during the two adiabatic stages A is a hot "source," maintained at a high temperature Ti, and C is a cold "sink" or receiver of heat, maintained at a low temperature T2. Imagine the cylinder

to contain one lb of water at T1 and A to be applied, while the piston begins to move towards the right The "isothermal" (constant temperature) line ab is traced out during the evaporation of the water. At b the substance is all steam. A is then removed, B is applied, and the adiabatic expansion be takes place, until the temperature of the working substance falls to T2 C is then applied and the piston is pressed back, giving an isothermal line cd during which most of the steam is condensed. At d there is a mixture, chiefly water, which is adiabatically compressed. If this point d has been properly chosen, the operation da completes the cycle, bringing the substance back to the condition a in which it 15 all water at temperature T1. The whole process is called Carnot's cycle.

The formula I-Ta/Ta which expresses the efficiency in this ideal operation shows the importance of making T1 high and T2 low. No real engine attains this limit of efficiency, for no engine completely expands the steam down to the condenser temperature in a strictly adiabatic manner. Further, no engine has an adiabatic compression stage corresponding to da; the use of a separate condenser makes that impracticable

The action in an engine cylinder may be more appropriately idealized as in fig. 13 where AB represents the admission of the steam at T1, BC its adiabatic and complete expansion to T2, and CD its rejection to the condenser Under these conditions it is easy to show that the work done, which corresponds to the area of this ideal diagram, is equal to

for each lb, of steam admitted to the engine, where I, is the total heat (per lb.) on admission, and Is is the total heat (per lb. of mixture) in the condition C, when expansion is complete. This applies whatever be the state of the steam on admission, whether superheated or not. The quantity I1-I2 is called the adiabatic



heat-drop, and measures the greatest amount of work theoretically obtainable from each lb. of steam. In practice about 70 per cent. of the adiabatic heat-drop may be realized in favourable cases. Tables of the adiabatic heat-drop, for steam in THE ACTION OF AN AVER. Various assumed initial states as to pres-

AGE PRGINE sure and temperature, expanding to various assumed condenser pressures, have been compiled, and are of great service in problems of engine design,

Rankine Cycle.—The process exhibited in fig. 13 becomes a complete cycle when, in addition, account is taken of the action by which the feed-pump restores the condensed steam to the boiler. Thus completed the process is called the Rankine cycle. Its efficiency is necessarily somewhat less than that of the Carnot cycle of fig. 12. Superheating, which is not in practice carried beyond a temperature of 4,00° C, and rarely so far, adds to the heat-drop by increasing I., But its chief effect on the efficiency of the process is mirrect. By tending to keep the steam in a drier state it greatly reduces the losses that arise through exchange of heat between the working substances and the cylinder walls in effect superheating makes the expansion more nearly adiabatic than it would otherwise be, and therefore gives a better approach to the ideal conditions of fig 12. In a turbine superheating is beneficial by reducing the friction of wet steam on the blades

Entropy-temperature Diagrams.—In exhibiting graphically the action of an engine under assumed conditions of working we may adopt various alternatives to the pressure-volume or "indicator" diagram. One interesting form takes for its two co-ordinates the temperature and the entropy. another (introduced by Mollier) takes the entropy and the total heat. Both of these diagrams are instructive in allowing the action to be traced through its several stages and in exhibiting the differences which result from varying the conditions of supply and of condensation. They show the direct influence of superheating, and the amount of wetness to be expected at any stage in the expansion. They allow, in some cases, measurement from a chart to take the place of numerical calculation; but their greatest merit is that they enable the operation of the working fluid to be visualized No account of such diagrams can, however, be attempted within the limits of this article

Modern High-efficiency Steam Plants.-In modern steam engines, especially of the turbine class where a very large range of expansion may be effectively carried out, efficiency is aimed at by using the best possible vacuum, to make T2 low, and by raising the pressure of supply to make T, high Pressures approaching 1000 lb. per square inch are not uncommon; occasionally that figure is exceeded, and even at the highest pressures some additional high-temperature heat is taken in by superheating Reheating at one or more stages during expansion is resorted to, in order to prevent the expanding steam from becoming unduly wet. Another device, which is also applied in the most economical large-scale turbine plants, is to remove a portion of the expanding steam at each of two or three stages, and apply it in heating the feedwater on its way back from the condenser to the boiler This progressive heating of the feedwater, by "bleeding" the turbine of steam which has already done more or less work, is called "cascade" feed-heating. Its effect is to make the whole cycle approach more nearly to the ideal cycle of Carnot, for the progressive feed-heating is nearly reversible and serves as a substitute, in this respect, for the adiabatic compression which makes

tute, in this respect, for the adiabatic compression which makes that cycle differ from the cycle of Rankine. Coes also Turberne: Stram; Locomotove; Marine Engineering, 100 Marine Engineering, 100 Marine Engineering, 100 Marine (1920); Marine Radiovers, 100 Marine, 100

STEAM-GAUGE is an instrument which by utilizing the elasticity of a metal indicates the pressure of steam in a bolter or other vessel. The action is explained in the article PRESSURGAUGE. The agange must be fixed above the highest water level of the boller, and stand away from it to avoid heating. A gauge is unduly hot if it cannot be touched by the hand without discomfort, and the U-tube or syphon is therefore used for connection to the boller. In norder to avoid straining the action, a gauge is generally graduated to twice the working pressure. Then the pointer stands vertically at the normal working pressure. Then the pointer stands vertically at the normal working pressure. Then the pointer stands vertically at the normal working pressure. High-pressive steam-gauges are those graduated for pressures between 20 lb. and 1,000 lb.

STEAM GENERATION. In a modern plant the course of operation can be traced broadly as follows: The water operates in a closed system and circulates in the form of steam or vapour and returns to its original state in the form of condensation. The water is first heated in feed water heaters, then goes

through the tubes in the bollers and is changed to stam, then through a superheater that adds heat to it and from there to the utilizing equipment, a turbune for example. Finally it reaches the condenser from which it is returned to the starting point. The fuel usually starts through some preparation process such as revishing. From there it is usually conveyed to bunkers that provide a continuous feed to the stokers under the boolers. It is burnt on the stoker grates in the furnaces with natural or forced draft and the gases are used as they leave the boiler in superheaters, economizers and any preheaters. From there they finally escape through the stack. The economizers, superheaters and unrepetaters are means by which some of the waste heat in the gases is reclaimed. In steam generating plants is found all oxome of this ecupipment and much other availancy equipment.

Subjects dealing with the generation of steam and with the equipment used in that process will be found in the articles: BOILERS;
STEAM; COMBUSTION; ECONOMIZER, ELECTRICAL FOWER GENERATION; FUEL; HEAT; HEATING AND VENTILATION; PULVERIZED,
FUEL, STEAM ACCUMILATORS; STEAM CREST; STEAM ENGINE,
STEAM TURSINE, etc The present article attempts to co-ordinate above references under the following headings: Fuels; Combustion; Boilers and Steam Generators; Mechanical Stokers;
Other Equipment; and Selection of Steam Generatine Equipment.

## DEVELOPMENT OF STEAM GENERATORS

When steam units were first used industrially the boiler was purchased, a brickmason employed to set the boiler in place and a labourer indiscriminately secured to shovel fuel under the boiler to generate enough steam for the process in question. Fuel, labour and material were cheap. It was not then economical to seek refinements in equipment or labour-saving devices; steam demands and pressures were low and in many cases, return tubular boilers answered the necessary requirements. The industrial development of the 20th century caused rapidly increasing demands for power. These were first met by the improvement in the design of steam turbines, and the application of mechanical stokers to the existing boilers. This met the needs for a few years but about 1916 steam turbine units began to increase rapidly in size and in 1030 single turbines of 60,000 kw, were in operation and compound units of 200,000 kw. turbines in course of construction In 1939 power houses containing 770,000 kw. were in operation and power houses designed for 1,000,000 kw output have been projected. In 1920 there were a few stations operating above 250 lb, pressure. In 1939 there were several score of stations operating at over 1,200-1,400 lb. pressure and a few

are now in operation at higher pressures.

With these changes steam boilermakers discarded rule of thumb methods and employed research engineers, metallurgists and various specialists, installed machine tools, and adopted scientific methods of manufacture. It was found at this time that the kind of water introduced into the boiler was of considerable importance; that the superheater should be located in a position that would give a wide range of load with very little change of temperature; that an evaporation of from 13 to 21 lb of steam per square foot of heating surface per hour should be the minimum; that the use of pulverized coal to secure these high ratings was desirable. Air-cooled refractory furnaces to burn pulverized coal at high ratings were tried but it was seen that, with watercooled furnaces, a unit could be designed that would combine economy and efficiency with low maintenance cost and maximum continuous hours of service. With new and larger plants, the question of the best cycle to be used became of paramount importance affecting the boiler, superheater, feed water heater and economizer design. Means were needed to remove free oxygen from water to prevent corrosion. The water entering the economizer was of higher temperature than when exhaust steam alone was used and the temperature of the gases leaving the economizer were too high for the best efficiency. Consequently air preheaters were developed to recover heat from the escaping gases, to provide hot air for drying the coal in the course of pulverization and to preheat the air for combustion before being introduced into the furnace. This cut down the time required for complete combustion and raised the temperature of the furnace

A 4,00,000 kw plant will burn 200 tons of coal per hour and roughly one-tenth of this will be ask which must be removed Ash, in a dry state, is removed by conveyors or by shicing with water A newer development is to melt the ash and to remove as sing Safety consideration, abatement of smoke and noise, consideration of the design of the plant to fit in with surrounding buildings and landscape, were additional problems to be solved IT will be seen then that the problem of generation of steam to meet the requirements of modern industrial civilization has become extremely complex.

#### FUELS

The principal fuels for the generation of steam are coal and oil (see Fuel, Pulverized Fuel, Petroleum, Coal and Coal MINING). There are, however, many localities where there is a limited supply of certain other materials which are sometimes used for fuel Coke breeze is the small size coke and dust which is burned successfully on chain grate stokers Lignites  $(q\ v\ )$  are burned on chain grate stokers and in pulverized form Wood is usually put through a hogger to reduce it to small sizes for greater ease in handling and better burning in the furnace. The furnace must be large to provide sufficient time for complete combustion. Bagasse is the residual sugar cane, left after the juice has been extracted. The furnace is especially constructed for admitting air around its sides The silica in the bagasse runs on to the grate and prevents air coming in from underneath Bonecoal is the name given to coal taken off the top of coal seams and contains a large amount of impurities. Formerly discarded, it is now being burned on stokers and in pulverized form. Anthracite coal is used for household use in the districts adjacent to the anthracite fields. There is, however, a large amount of small sizes and dust that is now being burnt on travelling grate stokers, especially built for this purpose. Natural gas (q.v.), blast furnace gas (q v ), coke oven gas (qv) and producer gas (see GAS MANUFACTURE) are also frequent boiler fuels.

Boilers are used to generate steam from the otherwise wate heat of cement klans, metallurgical furnaces, coke ovens, gas generators and other such processes where high exit temperatures of the products of combustion prevail In the McEwen-Runge process of coal carbonization, the coke in pulverized from served as a fuel for boilers as did also the screened coke residue from the K.S.G process which was burnt on forced draft chain grate stokers.

## COMBUSTION

Combustion within the furnace of a steam generator consists in the chemical combination of the elements of the fuel with oxygen from atmospheric air supplied for that purpose Corresponding to the weights of carbon (C), hydrogen (H), oxygen (O) and sulphur (S) in the fuel fired, the weight of air theoretically required for combustion is given by

$$A = \frac{2 \cdot 67 \, C + 8 \, (H - o/8) + S}{o \cdot 23^2}$$

since atmospheric air contains 23-2% of oxygen by weight. It is necessary to supply "excess air" above this theoretical minimum, however, and "free oxygen" always occurs in the products of combustion. Even with excess air, some combustible will escape unburnt from the furnace and a small amount of carbon monoxide may simultaneously be found in the products of combustion. The unburnt combustible is generally carbon with a corresponding combustion loss of 14,600 B.T.U. per pound. The formation of carbon monoxide (CO) instead of carbon dioxide (CO,) is named "incomplete combustion." One pound of carbon burned completely to CO; liberates 14,600 B.T.U. One B.T.U. but the complete of 
content of the excess air at the temperature of the products of combustion escaping to the stack Leakage of air through the walls of the furnace and boiler setting increases the excess air loss to the stack without effecting, in general, any corresponding gain in combustion efficiency. Considerable saving in fuel may often be made simply by reducing leakage through cracks or openings in bother settings.

For each kind of fuel, type of furnace and method of firing, there is a certain percentage of excess air which results in a minimum loss. The most economical percentage of excess air is determined for any given installation from analyses of the products of combustion, and it corresponds to that percentage of carbon dioxide at which the carbon monoxide amounts to only a few tenths of 1% For hand-fired coal furnaces and older stoker installations with restricted furnace volume, the best carbon diovide percentage is around 12% which represents about 50% excess air. Larger combustion chambers were later employed because it was thereby possible to reduce the excess air below 50% without producing much carbon monoxide. At high operatmg capacities, however, furnace temperatures became so high that slagging of refractory walls and formation of clinkers in fuel beds became excessive. Water-cooled walls have eliminated refractory troubles and permitted the most economical percentage of excess air to be used without reaching excessively high temperatures, so that in some of the most modern steam generator furnaces as high as 15 to 16% of carbon dioxide is attained in daily operation.

With gases and oils, the most economical percentage of carbon dioxide will, in general, be less than mentioned above for cap, although the excess air percentage may be lower by reason of the more intunate mixture of fuel and air that can be obtained with proper burners and furnaces. This is due to the larger percentage of hydrogen in these fuels which combines with oxygen-forming water that is not ordinarily included in analyses of products of combustion.

When burning pulverized coal, thorough mixing in the furnace of the fuel particles with the air is conductive to complete combustion with low excess sir. This may be secured by means of turbulent firing where the coal and air streams impinge upon one another in the furnace, but while the volatile matter may be burnt within a small volume, a much larger furnace must be provided to give time for the fixed carbon particles to burn before they escape from the furnace. Finer pulverization will reduce the unburnt combustible loss at the expense of the use of more power for grinding the coal. For solid fuels burned on grates and stokers, the furnace shape as well as its size is important in securing thorough mixture

Smoke is often taken as an indication of poor combustion, and so it may be. However, smoke is often due to the presence of fine particles of soot resulting from breaking down volatile matter by heating with insufficient air rather than to larger particles of unburnt fixed carbon. Hence a smoking furnace may be working at fairly high efficiency, while one with a clear stack may have a large excess air loss. Smoke may be prevented by using a low volatile fuel such as anthractic coal and codes, or by mixing air with the volatile matter more thoroughly and thereby insuring its complete combustion in the furnace.

Combustion losses are reduced by preheating the air. The maximum permissible preheat temperature is determined by the durability of grates or stoker parts. In pulverized coal firing, the preheat temperature is limited only by the durability of the pre-heater elements. There is an economic relation, however, between the cost of air preheater surface, economizer surface and boiler tube surface, which results in a minimum cost for the complete steam generating unit corresponding to a moderate air preheat temperature between 400° and 500° F.

If all the heat liberated by combustion and carried into the furnace in the preheated air were imparted to the products of combustion, very high furnace temperatures would be reached. Much lower temperatures catually obtain in boiler furnaces due to radiation. Radiation from the incandescent fuel and finness varies approximately as the fourth power of their absolute tem-

perature. With water-cooled walls, over one-half the heat of combustion is absorbed in the furnace by radiation from the incandescent fuel and flames. This radiant heat will fuse any particles of ash which cannot be kept cool by adjacent watercooled surfaces. Hence refractory baffles must be protected by two or more rows of boiler tubes on the furnace side or particles of ash adhering to them will fuse and form large slag masses With pulverized coal firing, ash will melt on the furnace bottom unless cooled below its fusing temperature and protected from radiation by "screen tubes" While the melted ash may be run out of the furnace as molten slag, there is an additional furnace loss in the latent heat of fusion of this slag

Boiler test codes adopted by engineering societies in various countries, define boiler efficiency as the ratio of the heat absorbed by the steam produced per unit weight of fuel burned, to the gross, or upper, heating value of the fuel as determined in a calonmeter where the moisture present in the fuel and formed from the hydrogen therein is condensed to water. In England, efficiencies are often guaranteed as based on the lower heating value, which is equal to the upper heating value minus  $1,050 \times (M+9H)$ , where M=lb. of moisture and H=lb. of hydrogen per lb. of fuel burned and 1,050=latent heat of steam at (W L DE B) atmospheric temperatures.

### BOILERS AND STEAM GENERATORS

Boilers are of the following designs: return tubular, water tube electric steam generator.

Return Tubular boilers consist of a shell 60 in. to ro8 in. in diameter. The shells are made of several plates riveted together with the tubes acting as stay bolts for the heads The gases pass through the tubes. The boilers are limited in size to about 3,000 square feet. This type of boiler is used where small quantities of steam are required, at pressures not exceeding 250 lb. per square inch. It is also used extensively for waste heat in the manufacture of open hearth steel and other processes, in marine work and for locomotives.

Water Tube Boilers are boilers in which the water passes through the tubes and the gases are on the outside of the tubes. One of the main advantages of this type of boiler is safety. The latent heat in hot water under pressure has a particularly destructive effect in case the pressure in the vessel is suddenly released

By confining the water to tubes, the quantity of water in any particular part of the boiler is kept to a minimum and if a tube bursts, the resulting damage will be small. Another advantage is that the size of the unit is limited only by the size of plates available.

This boiler is made in several different classes; straight tubes with box headers and both longitudinal and horizontal drums. straight tubes with sectional headers, and both longitudinal and horizontal drums, bent tubes with vertical and semi-vertical tubes and drums

For box header boilers the headers are formed by riveting together two plates, spaced apart to form a boxlike structure. This construction is usually limited to 10,000 sq.ft. on account of the difficulty of shipping larger plates and to pressures of about 400 lb. per square inch

The straight tube sectional header boiler is substantially of the same general cross-section as the box header except that in some cases there is a greater inclination of the tubes. The headers are made of forged steel and contain one or more vertical rows of tubes. This type of boiler has been built in sizes up to 35,000 sq ft. and can be built larger and for pressures up to 1.800 lb. per square inch.

Electric Boilers.—The electric boiler is used to generate

steam or hot water where a small quantity of steam is required or in larger sizes where electricity can be secured at reasonable rates to improve the load factor of plants

Steam Generators.—The advent of pulverized coal (see PULVERIZED FUEL) crystallized the design of complete steam generating units giving consideration to the proper furnace volume and co-ordination of radiant and convection heating surface, super-

heater, economizer and air preheater. Such construction can be fired by oil, gas or pulverized fuel. It can readily be built for pressures up to 2,000 lb per square inch. The fuel may be introduced at several points and sometimes the burners are located at the top of the furnace with the gases passing downward. In other designs the fuel is introduced at the front wall or at the four corners with the gases passing upward through the furnace, The economizer and fan may be placed duectly back of the convection surface and the fans directly above the air preheater so that the duct work, with its chances for radiation and leakage. is reduced to a minimum. Some steam generator units give efficiencies of 80%

Drums.—When built for pressure of 100 to 350 lb, all boiler drums were constructed of rolled plates formed on bending machines and riveted together. As the pressure increases the plate is necessarily thicker, making it more difficult to form plates and drive the rivets. It is generally accepted in 1030 that riveted drums should be limited to not more than 14 inches Up to 1928 a few boiler drums less than 2 in, thick have been constructed by forge welding In Europe, but not in the United States up to 1929, drums have been constructed of drawn seamless tubes. In 1931 the A S.M E boiler code made permissible the use of autorenous or electric welding for the construction of boiler drums. Prior to 1931 it was customary to construct drums 24 in thick and over of forgings but welded drums are now made up to five inches in thickness.

The joints to be welded are carefully machined before welding and submitted to X-ray examination after welding under rigid inspection. The drums are then annealed to remove stresses.

In the United States the steel for riveted and forge-welded boiler drums must conform with the chemical and physical characteristics given in the ASME. boiler code. Alloy steels with varying percentages of chrome, titanium, molybdenum, and other elements are used to take care of the higher temperatures and to keep plate thicknesses within reasonable limits for high pressure

Large Units .-- For large capacity units, the bent tube boiler has been found to give the most economical results. At low ratings, below 300%, the straight tube boiler has been found to give lower exit temperature but above these ratings the bent tube boiler gives approximately the same and in some cases lower exit temperatures

At high ratings the draft loss of the bent tube boiler is much less. It is customary in designing large boilers to place two bent tube boilers in the same setting and facing each other. With this method of construction, firing is usually done from two sides or from the four corners. The radiation losses are low, the gases are most thoroughly mixed before entering the boiler surface, the unit is compact and the drums are practically one-half the length that would be required for a single unit with firing from one side Single units to deliver 750,000 lb, of steam per hour and double units to deliver over 1,000,000 lb of steam per hour at 1,400 lb. per square inch pressure, and over 900° F. steam temperature, were in operation in 1939.

(See Boiler-Making; Boilers) (T. B. C.)

## MECHANICAL STOKERS

A mechanical stoker is a device for stoking or firing a furnace by mechanical means In its broadest interpretation mechanical stoking would include the mechanical feeding of any kind of fuel to a furnace, but in common usage the term is limited to the firing of solid fuels such as coal and coke The earliest form of mechanical stoker was an endless conveyor with two endless chains situated near the sides of the furnace and engaging sprockets mounted on shafts situated at the front and rear. Transverse grate bars were attached to these chains to form the fuelsupporting surface, one shaft was provided with means for driving the chains and grate so that the top surface moved through the furnace from front to rear. A hopper fixed at the stoker front supplied fuel to the grate and natural or chimney draft provided air for combustion which was admitted through the grate and fuel bed. The speed of the grate was regulated so that the fuel

(C. STR)

was burnt out during its travel through the furnace and the motives and marine boilers. resultant ash and refuse was discharged into a pit as the grate made the return bend around the sprockets on the rear shaft A natural draft chain stoker is applicable to non-coking or free

burning bituminous coals

A modification of this type of stoker provides for the use of forced draft supplied by a fan or blower for admitting the air for combustion. With this provision, higher rates of combustion are made possible, and a wide variety of fuels may be burned successfully including anthracite fines, coke fines, lignite, and free burning bituminous coal

The overfeed, inclined grate natural draft stoker is used to a limited extent for burning bituminous coals at moderate ratings under small boilers The fuel is fed from the hopper usually at the front, to stepped grates which are rocked by mechanical means to impart a downward travel of the fuel during combustion and to deposit the ash and refuse at the rear, on dump trays which are lowered by hand at intervals to discharge the ash into a pit below.

In overfeed stokers of the spreader type the coal is fed from a hopper into the path of rapidly revolving paddles which throw the coal into the furnace where the fines are burnt in suspension and the coarser particles on a grate using forced draft.

Underfeed stokers, as the name suggests, introduce the fuel below the surface of the fuel bed. The volatile constituents of the coal are distilled off and pass up through the incandescent fire where they are rapidly ignited and burned without producing smoke. Forced draft is used with this type of stoker This method of firing finds its greatest field for use with those bituminous coals which during combustion tend to form coke masses that must be broken up to insure uniform fuel bed conditions. Underfeed stokers may be broadly subdivided into two general classessingle retori stokers and multiple retort stokers.

In single retort stokers the coal is commonly fed from a hopper at the stoker front into a centrally situated trough or retort by means of a pusher driven by a steam actuated piston or by an electric motor. In small underfeed stokers a slowly revolving screw or worm is commonly used to feed the coal from the hopper to the retort. Each new charge of coal introduced serves to push an equal volume of fuel out of the top of the retort and onto the grate bars which extend transversely from the sides of the retort. Alternate grate bars are movable and are connected to the stoker drive so as to impart a slight slicing motion which serves to maintain a porous fuel bed, to distribute the burning fuel across the stoker and to carry the ash and refuse to dump trays placed along each furnace side wall. Air for combustion is supplied under pressure by a fan or blower and is admitted to the fuel bed through openings along the sides of the retort and between the grate bars.

The multiple retort underfeed stoker comprises a series of retorts (usually inclined) mounted side by side across the furnace width. Coal is fed from a hopper, fixed at the stoker front, by rams connected to a crank shaft and driven through proper reducing gearing by an electric motor or other means. Secondary rams, situated in the bottom of the retorts, serve to break up the coke masses, to distribute the fuel over the stoker and to deposit the ash and refuse either on dump grates or into a pit at the rear where grinder rolls crush the refuse and discharge it into a pit below. Air for combustion is supplied under pressure by a fan, through nozzles or tuyeres arranged in longitudinal rows between adjacent retorts.

Mechanical stokers are usually controlled by regulators which are set to maintain a predetermined steam pressure and which are actuated by changes in this pressure. A drop in steam pressure causes an increase in stoker and fan speed so that more coal and air are admitted to correct the falling steam pressure. An increase in steam pressure causes a decrease in the amount of coal and air admitted. Stokers so equipped maintain constant steam pressure automatically and are called "automatic mechanical stokers." Mechanical stokers are principally used for firing stationary steam boilers and metallurgical furnaces. However, types have been developed and satisfactorily applied to loco-

## OTHER EQUIPMENT

Superheaters are used to increase the temperature of steam without increasing its pressure. The furnace gases furnish the heat, either in the furnace, among the boiler tubes or in the exhaust to the stack where some lost heat can be recovered. For a discussion of superheaters and superheat see Boilers; Steam Reheaters are used to prevent loss of superheat and the forma tion of moisture when steam is used in turbines. (See Boilers)

Air Preheaters -The exhaust gases coming directly from the furnace or from the economizers are used in air heaters or preheaters to heat the air that is to be used for combustion in the furnace, thus making use of otherwise lost heat. (See Boilers.)

Feed Water Heaters .- Before water fed to a boiler can be converted into steam it must first be heated to the temperature coiresponding to the pressure in the boiler. This feed water is heated in open heaters, closed heaters or economizers, either to that or to a lesser temperature, depending on the plant. The first two types of feed water heaters use live or exhaust steam to obtain heat, the last uses the exhaust gases from the furnaces. ECONOMIZER, BOILERS; ELECTRICAL POWER GENERATION.)

Evaporators and De-aerators are used to supply loss in feed water and to remove the air dissolved in the water in the condenser. (See Electrical Power Generation.)

## SELECTION OF STEAM GENERATING EQUIPMENT

Steam generating equipment may be considered as comprising not only the boiler and furnace but all auxiliaries necessary or desirable from the point of delivery of the coal to the stop valve on the boiler. A proper evaluation of factors which determine the correct selection of the necessary or desired equipment can only be made by an engineer thoroughly familiar with all the factors, their relations and a knowledge of costs, values and economics.

In a modern utility plant the steam end may and frequently does include in addition to the boiler a water-cooled furnacesteam superheaters and re-heaters-mechanical stokers of various types, burners for pulverized coal or oil; economizers and air preheaters; induced and forced draft fans or blowers and their necessary motor or turbine drive; ducts and flues for conducting the air and flue gas to desired points; chimney and dampers; cinder or dust catchers; boiler feed pumps and feed water regulators; soot blowers for the boilers; economizers and air-heaters; condensers; blow down valves; heat inter-changers to abstract heat from boiler blow down; open or closed feed water heaters; deaerators; a feed water treating plant or evaporators.

The complete coal and ash handling system from the railroad siding to the coal bunkers may include a car dumper, track hopper, screens, crushers, magnetic separators, conveyors, skip hoists. locomotive-crane and all equipment necessary for storing and reclaiming coal. If coal is pulverized there will be dryers, pulverizing mills with piping collectors, conveyors, feeders, burners and necessary motors. Ash may be handled by cars, conveyors or by water in sluices or grab buckets. Other auxiliary equipment may include a combustion control system with elaborate inter-locking of the electrical equipment. Pressure and draft gauges, thermometers, steam flow meters and gas analysers, all of the indicat-

ing or recording type, will also be found.

The problem of the selection of proper equipment may be very simply stated. Equipment should be selected that will produce steam at the lowest total cost for the expected life of the plant, with the required reliability. The weight given to various factors will differ in various types of plants. In public utility plants where the fuel cost is about half the total cost of operation greater weight is given to economy, this factor being modified by the cost of fuel. In some industrial plants operating only ten hours per day with cheap coal, first cost may be a major factor. There are certain processes requiring continuity of steam pressure or power in which a failure of either or both for a few minutes may ruin material valued at thousands of dollars. In such cases reliability usually secured by duplication or excess spare capacity should be one of the major factors considered. The total cost of steam generation is made up of fixed or capital costs and operating costs The fixed charges or costs are made up of interest on first cost, taxes, insurance, depreciation or obsolescence The operating costs include fuel; water, maintenance material-repairs; supplies of oil, tools and chemicals; operating labour; maintenance labour; clerical salaries and operating supervision Generally, by increasing the capital cost, the operating cost may be reduced. High efficiency can be obtained by high capital expenditure However, depending on the fuel cost and many other factors, a point is reached where the fixed charges of additional equipment equal the saving obtained by that equipment and any additions beyond that point result in fixed charges in excess of savings.

One of the important factors having a major bearing on economy and in capital costs is the plant capacity factor, sometimes named load factor The capacity factor is the total load per year expressed in any suitable units divided by the rated or normal capacity of the units times 8,760 hours per year or the relation of the actual annual load carried to the annual load if units were operated at normal capacity every hour of the year.

In view of the complexity of the many factors affecting the selection of steam generating equipment and their interrelation it is only possible to list them in their major relations and group these relations as logically as possible. The considerations listed below are the most usual. There may be others peculiar to certain specific problems.

Finel

Water

plant

Type of load

Power and Heating Utility Process Heating

Relation of-to economy

Power (Utility Industrial

Capacity factor

Effect of—on type Effect of—on first cost Effect of—on number of units Effect of-on rate of operating

Cost

Quality Variety

variety
Fusing temperature of ash
Burning quality
Reliability of supply
Possibility of change in quality or price

Quality, suitability for boilers\*
Use of feed water treating equipment

Foundations

Location of plant

Type of building Cost or value of land Type of coal handling or storage Use of cinder catchers

Accessibility Labour supply

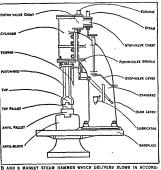
Nature of business permanency Probable growth Effect of full cost or steam cost on cost of

Probable life of product Exhaustion of natural resources

\*The size, type and operating rate of boilers may be limited by quality of water. (J. Van Br.)

STEAM-HAMMER. Steam-hammers are made in sizes ranging from ½ cwt. to about 12 tons. The size is merely a nominal rating, being the weight of the falling parts-piston, rod, tup, pallet—and takes no account of the pressure of steam which drives the piston down for the blow. As an approximate guide, however, it may be stated that the steam pressure in a 5-cwt. hammer gives a crushing effect on hot iron equal to a load of about 30 tons. Types of hammers are classified in three principal forms, the overhanging with slide, the arch and the Rigby (see drawing). In the last-named there is plenty of clearance space for the smith to manipulate work above and around the

accurately, an advantage in many cases of forging, including that done in dies The arch form has two standards between which the tup is also run in guides, and it is much used for forgework of heavy description, being a very rigid construction. The frame is often built of rolled steel plates and angles instead of cast-iron or cast-steel The operating mechanism of the B, and S Massey hammer shown comprises the stop-valve lever which regulates the quantity of steam admitted to the hammer, and the hand-level that is moved to strike light or heavy blows, or to hold work between the pallets as in a vice, for bending purposes, etc The steam is used expansively, with resulting economy, by the action of the tripper, which begins to close the piston-valve after the tup has moved a certain distance A self-acting valve-gear can be applied to any type of hammer, so as to cause the hammer to work automatically Many special shapes of hammer framings and anvils are built for specific purposes. Control is in some cases effected by a treadle, so that one man can use the hammer. Compressed air may be utilized instead of steam, should it not be convenient to furnish a supply of the latter. The lubricator attached to the side of the frame consists of a hand pump with which



NCE WITH THE MOVEMENTS OF THE HAND LEVER

the cylinder and valves can be oiled without stopping the hammer. To secure efficient results the anvil-block must be of great weight, and supported on a mass of timbering resting on deep concrete or rock. The base also rests on timbers and concrete.

(See Presses and Presswork and Drop Forging) (F. H)

STEAM PLOUGH: see AGRICULTURAL POWER AND MA-

STEAMSHIP: see Shipbuilding. STEAMSHIP LINES: See Shipping Lines and Groups.

STEAM SHOVEL or NAVVY. A form of excavator which drags a bucket or shovel, at the end of a pivoted arm, from a surface position up to the top of a cutting or other place to be excavated, filling the bucket meanwhile. The mouth has steel cutting teeth or tines for easy penetration. When the bucket is filled, discharge is made into wagons or elsewhere by opening a door at the bottom. The machine is a very powerful modified type of jib crane, specially constructed for fast and severe duty, with a great amount of steel construction, and extra hard parts of manganese steel for those subjected to excessive friction and exposure to grit. The pivoted arm either has a fixed swing from anvil-block, and the piston has a longer stroke and gives more its pivotal point about half-way up the jib, or the swing may be power than corresponding hammers of other types. The over-varied by racking the arm to or iro. As the crane stands still be hanging type hammer has sides cracking down to guide the tup in a succession of cuts the dop for pentation has to be regu-

lated to suit the capacity of the bucket. With the fixed arm design this is done by varying the radius of the 1th, and with the racking arm by the movement of the latter alone Bucket capacity varies from 1 cubic yard to about 15 cubic yards. The drive is by steam (the oldest system) but alternatively may be by petrol or paraffin motor, by electric motors, or Diesel-electric. The lastmentioned possesses the advantage of flexibility similar to the steam drive. e g, it will give a sudden access of power (not possible with a direct Diesel drive) due to the high torque characteristic of an electric motor. Shovels are either mounted on plain wheels, or on railway wheels; or caterpillar tracks are fitted, to transfer the machine as required on any ground Some of the largest shovels are built for "stripping" or removing a deep overburden of earth covering ironstone or coal The biggest machine yet built, a Marion, for this duty weighs 1,400 tons, and carries a 15 cubic yard bucket at the end of an arm 120 feet long. Eight caterpillar tracks sustain the shovel, with hydraulic devices to compensate for uneven ground The three motions, hoisting the bucket, crowding or thrusting it into the cut, and rotating, are performed by separate electric motors. This is similar to the practice in steam shovels, which carry separate engines for the three functions.

Shovels can be adapted to work grabs when this provision is necessary for handling piles of material and loose excavation The dragisne excavator is either a machine solely used for this special kind of excavating, or is a modified shovel, the change being made rapidly. Instead of thrusting a bucket, it drags it towards the machine, being suitable for reclamation, canalization, drainage, foundation work, etc The skimmer scoop acts in a horizontal direction, the jib of the navvy being set parallel with the ground, and the bucket dragged along under it, so that the surface of a road can be torn up Also the loose debris may be scooped up and loaded into a lorry. A back-acting trencher has the bucket arm pivoted at the top end of the jib, the latter being lowered to a suitable distance above the ground. As the bucket is reversed to the normal direction for a steam navvy it is dragged towards the machine excavating a trench, and the machine retreats as the work progresses Narrow and deep trenches can be cut rapidly with this adaptation of the navvy See Excavation. (F. H.)

STEAM TURBINE; see Turbine, Steam.

STEARIC ACID: SEE FATTY ACIDS

STEARIN: see CANDLE.

STEATOPYGIA, the term used of the accumulation of fat on the buttocks, thighs and knees, specially observed among Bushman, Hottentot and Pygmy women It is less common among these men but is recorded fairly often among males of the Bastaards. Statuettes found in Southern France which exhibit these features point to the former existence in Europe of such a race.

STEDMAN, EDMUND CLARENCE (1833-1908), an American poet and critic, was born of Puritan stock at Hartford (Conn ), Oct. 8, 1833. He was rusticated after two years at Yale, and was not allowed to return. In 1871, however, the college conferred on him the B.A. and M.A. degrees, and in 1895 the degree of LLD. Clarence Stedman became connected with the New York Tribune, and in 1860 went to the World as editor, later becoming its war correspondent. A clerkship in Washington formed an interlude, but much of his life was spent in trading on the New York Stock Exchange, of which he edited a history (1905). He edited a volume of Cameos from Landor (with T. B. Aldrich, 1873), A Library of American Laterature (11 vol. 1887-90), The Works of Edgar Allan Poe (with G. E. Woodberry, 10 vol. 1894-95), A Victorian Anthology (1895) and an American Anthology (1900). In addition to a large number of ephemeral reviews, he published Victorian Poets (1875), Poets of America (1885), and The Nature and Elements of Poetry (1892), books which show the poet's critical insight, technical knowledge, and high standards of workmanship. His most enduring place in literature, however, is due to his poetry-the deep serious note of his war lyrics or the whimsical fantasy of "Pan in Wall Street." The title of his rather conventional first book, Poems, Lyrical and Idyllic (1860), sounds the keynote of his work. Always a lover of beauty, he refused to be swayed from his ideals by the April 1701. Steele complained that the reception of The Christian

contemporary popularity of such jeux d'esprit as "The Diamond Wedding" As a result he has to his credit a group of fine and true lyrics such as the "Creole Lover's Song" and some longer poems-Alice of Monmouth; An Idyl of the Great War (1863). The Blameless Prince (1869), and the elaborate commemorative ode on Hawthorne (read before the Harvard Ph. Beta Kappa Society, 1877) He died in New York on Jan 18, 1908.

STEED, HENRY WICKHAM (1871- ), British jour-nalist, was born on Oct. 10, 1871, at Long Melford, Suffolk He studied economics, philosophy and history at Jena, Berlin and Paris universities, and in 1896 joined the staff of The Times as acting correspondent in Berlin, and was appointed correspondent in Rome in 1897 Transferred thence to Vienna in 1902 as correspondent for Austria-Hungary, he remained there until 1913 when he returned to London, and was appointed foreign editor of The Times, m Jan. 1914 In 1913 he published The Habsburg Monarchy. in which the internal condition of Austria-Hungary was critically examined and the possibility of a European war discussed. During World War I, Steed was mainly responsible for the foreign policy of The Times and, in 1918, was chosen to frame the policy of Lord Northcliffe's department for propaganda in enemy countries. He was sent on an official mission to the Italian front where he was authorized by the Allied governments to promise independence to the subject Habsburg peoples In Feb 1919 he was appointed editor of *The Times*, and held this post until Nov 1922. From 1923 to 1930 he was editor of The Review of Reviews. Steed was lecturer on central European history at King's college, Strand, 1925-38, and broadcaster on world affairs in the overseas Service, B B C., 1937-47 His publications include Through Thirty Years (1924), Hitler: Whence and Whither? (1934; 5th ed 1937); That Bad Man (1942), and Words on the Asr, 1938-1945, vol. i (1947).

STEEL: SEE IRON AND STEEL; WIRE ROPE; BESSEMER STEEL; STRUCTURAL ENGINEERING; OPEN-HEARTH STEEL PROCESS, HIGH SPEED STEEL; MANGANLSE STEEL; MOLYBDENUM; MUSHET STEEL; NICKEL STEEL; NICKEL-CHROMIUM STEEL, TOOL STEEL; TUNGSTEN STEEL; VANADIUM STEEL; NITROGEN HARDENING; STAINLESS STEEL, STEELS, ALLOY, ALLOYS, PRESSED METAL; SHEETS, IRON AND STEEL, and other specific headings.

STEELE, SIR RICHARD (1672-1729), Irish man of letters

in the reign of Oueen Anne, is inseparably associated in the history of literature with his personal friend Addison. The two were born in the same year Steele, the senior by less than two months, was baptized on March 12, 1672 in Dublin. His father, also Richard Steele, was an attorney He died before his son had reached his sixth year, but the boy found a protector in his maternal uncle, Henry Gascoigne, secretary and confidential agent to two successive dukes of Ormonde Through his influence he was nominated to the Charterhouse in 1684, and there first met with Addison Five years afterwards he proceeded to Christ Church, Oxford, and was a postmaster at Merton when Addison was a demy at Magdalen. Their schoolboy friendship was continued at the university, and probably helped to give a more serious turn to Steele's mind than his natural temperament would have taken under different companionship. Without waiting for a degree he volunteered into the army, and served for some time as a cadet "under the command of the unfortunate duke of Ormond" (i.e., the first duke's grandson, who was attainted in 1715). This escapade was made without his uncle's consent, and cost him, according to his own account, "the succession to a very good estate in the county of Wexford in Ireland." He found a patron in Lord Cutts, to whom he dedicated a poem on the funeral of Queen Mary (1695) Cutis took the gentleman trooper into his household as secretary, made him an officer in his own regiment, and ultimately procured for him a captaincy in Lord Lucas's regiment of foot. A duel which he fought with Captain Kelly in Hyde Park in 1700, and in which he wounded his antagonist dangerously, inspired him with the dislike of duelling that he showed to the end of his life. Steele won William III.'s favour (too late to be of practical use) by a timely reference to him in The Christian Hero, his first prose treatise, published in

trying him by his own standard, and would not pass "the least levity in his words and actions" without protest. He therefore determined to clear his character of the charge of undue solemnity by writing a comedy, The Funeral (1701). With this play he began his work of reconciling wit, good humour and good breeding with virtuous conduct which he was afterwards to accomplish in the famous essays in the Tatler and the Spectator In his next comedy, The Lying Lover; or, the Ladies' Friendship (1703), based on Corneille's Menteur, Steele's moral purpose was directly avowed, and the play, according to his own statement, was "damned for its putty." The Tender Husband, an imitation of Molière's Sicthen (in April 1705), was more successful It was seventeen years before Steele again tried his fortune on the stage with The Conscious Lovers, the best and most successful of his comedies, produced in December 1722.

The Tatler and the Spectator .- In 1707 Steele was given the office of gazetteer. The Gazette gave little opening for the play of Steele's lively pen, his main duty, as he says, having been to "keep the paper very innocent and very insipid"; but the position gave him insight into journalism. The Tatler made its first appearance on April 12, 1709. It was partly a newspaper, a journal of politics and society, published three times a week. Steele's position as gazetteer furnished him with special advantages for political news, and as a popular frequenter of coffeehouses he was at no loss for social gossip. He gradually introduced into the Tatler as a special feature essays on general ques-

tions of manners and morality.

Steele was always in want of money He had £300 a year from his gazetteeiship (paying a tax of £45), £100 as gentleman waiter to Prince George, £850 from the Barbadoes estates of his first wife, a widow named Margaret Stretch, and some fortune by his second wife-Mrs Mary Scurlock, the "dear Prue" of his charming letters. But he lived in considerable state after his second marriage, and before he started the Tatler was horrowing money The assumed name of the editor was Isaac Bickerstaff, but Addison discovered the real author in the sixth number, and began to contribute in the eighteenth. The success of the Tatler was established before Addison joined him, and Addison contributed to only forty-two of the two hundred and seventy-one numbers that had appeared when the paper was stopped, obscurely, in January 1711.

Only two months elapsed between the stoppage of the Tatler and the appearance of the Spectator, which was the organ of the two filends from March 1, 1711 to Dec. 6, 1712. Addison was the chief contributor to the new venture, and the history of it belongs more to his life. Nevertheless, it is to be remarked as characteristic of the two writers that in this as in the Tatler Addison generally follows Steele's lead in the choice of subjects. The first suggestion of Sir Roger de Coverley was Steele's although

it was Addison that filled in the outline.

Steele projected various journals in the next years, most of them, such as the Englishman (1733), and the Reader (1714), Town Talk, Tea Table and Chit Chat, very short lived; though the Guardian (1713) had 176 numbers. Steele's most famous political paper, the Plebeian (1718) embroiled him in a controversy with Addison. A pamphlet, An Apology for Himself and his

Writings (1714) is important biographically,

١

Later Life.-The fortunes of Steele as a zealous Whig varied with the fortunes of his party. Over the Dunkirk question he waxed so hot that he threw up a pension and a commissionership of stamps, and went into parliament as member for Stockbridge to attack the ministry with voice and vote as well as with pen. But he had not sat many weeks when he was expelled from the house for the language of his pamphlet on the Crisis, which was stigmatized as seditious. The Apology already mentioned was his vindication. With the accession of the House of Hanover his fortunes changed. Honours and substantial rewards were showered upon him. He was made a justice of the peace, deputy-lieutenant of Middlesex, surveyor of the royal stables, governor of the royal company of comedians—the last a lucrative post—and was also

Hero by his comrades was not so respectful; they persisted in he was appointed one of the commissioners of forfeited estates. and spent some two years in Scotland in that capacity. In 1718 he obtained a patent for a plan for bringing salmon alive from Ireland. Differing from his friends in power on the question of the Peerage Bill he was deprived of some of his offices, but when Walpole became chancellor of the exchequer in 1721 he was reinstated With all his emoluments however the imprudent, impulsive, ostentatious and generous Steele could never get clear of financial difficulties, and he was obliged to retue from London in 1724 and live in the country. He spent his last years on his wife's estate of Llangunnor in Wales, and, his health broken down by a paralytic seizure, died at Carmarthen, Sept 1, 1720

oy a paranyute senzure, due at variantanent, sept. 1, 1729
A selection from Steele's essays, with a prelationy memori, beat been direct by Austin Dobson (1888) and the sent steeled by Austin Dobson (1888) and the sent steeled by Austin Dobson (1888) and the sent steeled (1889) and the sent steeled (1889) and the sent steeled (1889) are sent so of R. B. Johnson Dobson contributed a biography to Andrew Lang's series of English Worthers, in 1886 In 1889, an exhaustre life was published by G. A. Attken, who also cited Steele's plays (1898) and

the Tatler (1898).

STEELS, ALLOY. It is almost as hard to draw a clear line of demarcation between "alloy steels" and "steels," as it is between "steel" and "non" Diverse definitions have been set up legally for customs purposes, and commercially for statistical but more especially for pricing purposes. As may be seen in the article Iron and Steel, iron is produced from its ores by commercial processes that leave a number of impurities, either alloyed with it or included as insoluble non-metallic particles (A brief definition of an alloving element or compound is one that is more or less soluble in the major metal and which participates in physical or chemical reactions with changing temperatures and thus modifies the properties ) Carbon (in the chemical compound non carbide. "cementite," Fe<sub>2</sub>C) is the principal alloying element in iron, proportionately increasing its strength and hardness, especially after a correct heat treatment Only a little iron carbide (carbon) is needed to convert iron into a hardenable steel, so a metallographer's definition of carbon steel might well be "a malleable alloy of iron and iron carbide" ("malleable" being inserted to distinguish plain carbon steel from cast iron, which is a non-malleable alloy of the same substances) The article Iron and Steel also explains the necessity for the presence of fractional percentages of the alloying metals manganese and silicon in commercial plain carbon steels, and it is difficult to say, as these incidental elements increase, just where a carbon steel stops and a manganese allow steel (or more briefly, a "manganese steel") and a silicon steel start. Likewise "alloy steel practice" consists of far more than adding alloying metals to the liquid steel. The raw material is selected for a low content of deleterious impunities, the furnace practice is extended to include a careful refining period, additions are made to control the grain size (which, in turn, controls the toughness), all surface defects are cut out of ingots or billets-to mention some of the major differences. It may be said, then, that an "alloy steel is a carefully made steel with sufficient alloying metals added to it to modify usefully the properties of a plain carbon steel" The amount of alloy added is no distinction, it may range from very low (0.10% vanadium) to very high (18% chromium or more).

The earliest alloy steels used those alloys then available; since World War I very useful steels have been developed with alloying metals that were formerly unavailable, even rarities. Chromium alloy steels were made commercially into hard grinding equipment by the American, Baur, in 1865. They made their debut into structures in the main arch members of the Eads bridge (1874) across the Mississippi river at St. Louis (USA), they now enter many steels for machine parts, and the high chromium steels are corrosion and oxidation resistant (see Stainless Steel). Nickel, now the other most common constituent of alloy steels, was first incorporated in steels by the Frenchman, Marabeau; the properties were described in 1889 by the Scot, James Riley. Nickel steel was adopted by the American Navy for armour-plate in 1801; it is said that the first application in the mass production industries was some armour-plate rolled into small bars for bicycle chains. Tungsten is the essential element in the air-hardening tool steel of knighted (1715). After the suppression of the Jacobite rebellion the Englishman, Mushet (1871), the precursor of modern high

speed tools It is also used in magnets and in steels for high temperature, high pressure service (Malybdenum, its chemical cousin, was unavailable until large American deposits began producing in Colorado about 1918. In addition to being a substitute for tungsten, it is now a most important element, in fractional percentages, in engineering alloy steels ) Manganese formed the first high alloy steel, 10% being added by the Englishman, Hadfield, in 1882 to form a very tough steel of unique properties. largely used in places like steam-shovel dipper teeth that must resist tiemendous battering Low manganese steels are the product of 1920-30, and are being substituted in many uses for the more expensive chromium and nickel steels Silscon steels, especially useful for electrical transformers and other equipment, were devised in 1880 by Hadfield. Vanaduem and chromium-vanadium steels were investigated in England by Arnold and J Kent-Smith at the turn of the century, the latter, at Canton, Ohio, U.S.A., in 1907 made the first alloy steel by the open-hearth process for the Ford Motor Co , and this company pioneered the use of alloy steels in mass production Copper, used in fractional percentage for atmospheric corrosion resistance, is a pre-World War product

These eight common elements in various percentages and combinations, to say nothing of an equal number of less commonly used alloying metals, may formulate an infinite variety of steels In the last half-century literature about them has accumulated at an accelerated rate until its mass is now formidable. A group of metallurgists led by the American, Edgar C Bain, has systematized much of the existing information Commercial requirements of both producers and consumers have also demanded a limitation of types The American Society of Automotive Engineers led the way in 1911 by adopting chemical specifications for 7 carbon and 11 alloy steels, a list extended in 1935 to 102. Many large transportation companies and Governments have their own lists, and the total (exclusive of tool steels and high alloy steels) was somewhere in the neighbourhood of 300 in 1939 The scientific classification above mentioned has given logic to the practical conclusion that many of the varieties are interchangeable. However, users are slow to discard a steel that has served well in the past, fits into an existing heat treatment schedule, and is approved by the staff, but economics slowly forces the adoption of the cheapest suitable raw material. This generally means steels of lower and lower alloy content

General Influence of Alloys.—A statement frequently heard is that alloy steels are chiefly valuable because they may be hardened and strengthened by heat treatment without incurring the brittleness associated with hardened plain carbon steel Further it is frequently said that to be economically justified, the alloy steels should be used in the quenched and tempered state. It will be shown below that the true function of alloys in the engineering or machine steels is to get high strength and toughness, or hardness and toughness, simultaneously, either more easily than they can be had in carbon steels, or in sizes and shapes in which they cannot be had in carbon steels. Certain alloys also impart unique properties to carbon steels (such as high chromium for corrosion resistance or high manganese for battering abrasion) but in defence of the plain carbon steel it may be said that high strength, hardness and toughness are not the sole property of alloys. Thus, the intensity of hardening primarily depends on carbon content, and no alloy steel has yet been discovered which can be made harder than properly quenched carbon steel containing 0.75% or more carbon (measured as C-67 by the Rockwell instrument, wherein hardness number is inversely proportional to size of indentation by a loaded diamond point). There are also very strong, tough steel wires for steel cable; these are of high carbon steels, properly cold drawn to high strength; they withstand 225,000lb. per sq.in. before fracture, at which time they have extended 4% in rom of their original length. Since steel is an alloy of iron and iron carbide, the alloys present in it can be located in one or more of three possible phases or micro-constituents: (a) in solid solution in the iron—the alpha iron or "ferrite" (b) combined with carbon, either replacing some iron in the iron with oxygen or nitrogen in non-metallic, insoluble inclusions. Rarely does one alloy act in one way alone, their partition between (a), (b), and (c) depends upon the amount of alloying element or elements, amount of carbon, and the temperature However, some alloys, such as mickel and manganese, act notably to form solid solutions and strengthen the feirite Others act notably to enter and form carbides, as vanadium and molybdenum Aluminium is the outstanding example of the elements in category (c).

Strong Structural Steels .- Alloys falling in category (a) are particularly useful in improving the mild steels used for plates and structural shapes These steels are fabricated by the user as they are delivered to him from the rolling mill, without heat treatment In fact, they must be rather insensitive to heat treatment, else bending, flanging, and especially welding will produce hard regions ruinous to the tools that punch or cut them, or regions lacking in required ductility Extra strength and correspondingly lighter sections, such as are desirable for a long-span bridge or for railway car bodies can, of course, be had by increasing the carbon content, but this aggravates the above troubles of hardness. The alternative is to add alloys that enter into solid solution with the iron and so strengthen the ferrite, which, by the way, is the bulkiest con-stituent of these low carbon steels E C Bain lists, in the order of their influence as ferrite strengtheners, from strongest to weakest, these alloying elements as phosphorus, silicon, manganese, nickel, and that portion of the chromium which is not combined with carbon. Each of them is used and in various combinations in commercial tonnage steels Nickel steel was undoubtedly the first, used for long-span bridges, 34% of that element greatly improving the tensile properties and doubling the impact strength A cheaper alloy, known as "structural silicon steel," is now favoured in America and much used by structural engineers. An early type of such steel, used by constructors of pre-World War I "Mauretania" is also shown in the table, although the British admiralty now prefers the "D-steel" These strong steels, when weldability is important, have very low carbon content. Reductions in section thickness also demand a better degree of corrosion resistance than is afforded by the normal addition of o 20% copper, and phosphorus and chromium have been added to low carbon steels (<0.10% C) for their combination strengthening and ennobling effect American steels much used for railway rolling stock and bus and truck bodies are shown in the last three lines of Table I

Hardenability of Alloy Steels.-Alloys are, of course, of most importance to heat treatable steels. To understand their action it is necessary to know that when steels are heated above their "critical points"—a characteristic range of about 725° to 825° C .- the crystal structure of alpha ferrite is transformed into a new one called "gamma iron" which has far greater solubility for carbide. This high temperature solid solution of the carbides in gamma iron is called "austenite." On slow cooling the reverse action takes place at about the same critical range, and the annealed, fairly soft and ductile steel is reconstituted, except that the process may have refued the grain On more rapid cooling the precipitation of carbide from austemite is delayed-a little time is necessary for the action to incubate and then to proceed to completion-and occurs at a somewhat lower temperature. On rapid cooling, as when quenching a small piece in cold water, austenite is trapped unchanged down to below 150° C. but then changes completely in a second or two to a very hard structure called "martensite," which seems to be alpha iron (ferrite) in which the iron carbide is dispersed in almost molecular particles. This is the essence of the hardening action. (For a fuller account of the metallographic changes see Iron and STEEL.) Plain carbon steels have a low hardenability, in the sense that if a 11in round bar is quenched in cold water only the outer layers of the steel are cooled rapidly enough to transform at low temperature into martensite, the inner core, cooling more slowly, is transformed at high temperatures near the critical into a much softer entity, a coarser mixture of laminated ferrite and carbide. The outer surface may be intensely hard, even the maximum possible for the carbon content of the steel, but the "penetration" of that hardness is low. To harden more deeply the cooling rate at the surface carbide, or forming a special carbide of its own; (c) combined must be faster, so the deeper regions of the steel may cool rapidly

TABLE I -Low Alloy, High Yield Steels for Revoted and Welded Structures

Steel			Con	nposition	Tensile	Yield	Elongation in 8 in
acei	C	Sı	Mn	Others	strength	point	
Good structural Nickel Structural silicon Mauretama D-steel "Cor-ten" "Man-ten" "Double Strength"	0 20 0 33 0 30 0 25 0 33 <0 10 <0 30 <0 12	0 15 0 00 0 25 1 10 0 12 0 75 <0 30	0 50 0 60 0 80 0 75 1 25 <0 40 1 50 0 75	3 25%Ni 0 15%P, 1 0% Cr, 0 40% Cu 1 0% Cu, 0 60% Ni, 0 20% Mo	60,000-68,000 105,000 85,000-90,000 92,000-105,000 83,000-95,000 65,000-75,000 80,000-90,000	40,000-47,500 63,000 50,000 55,000 50,000-60,000 55,000-60,000	30%-25% 20% >20% 30%-25% 17% 25% in sin 30%-20%insin 30%

enough to escape the high temperature transformation; even the metal to resist "creep" at high temperature. The American Society most drastic quenching, as in brines or water sprays, may be insufficient for complete hardening. Fortunately, the presence of all the alloying metals except cobalt slows up both the solution of carbides in the austenite on heating, and their precipitation on cooling This means that alloy steels do not need to be cooled nearly so fast in order for the austenite to be "trapped" and transformed at about 150° C into hard martensite. Alloy steels therefore have a higher hardenability. Given an equal quench and an equal sized bar, the alloy bar will harden much more deeply than the carbon steel bar of the same carbon content, or it may be satisfactorily hardened in a much milder quenching bath, as in oil or even in still air, with correspondingly less warpage and danger of cracking As an example, the presence of 11% nickel and 0 60% chromium doubles the hardenability of a 045% carbon steel Bain's list of the relative potency of alloys in this respect follows. Very strong, vanadium; strong, molybdenum and tungsten, moderate, chromium, manganese, silicon; mild, copper, nickel, phosphorus

Toughness of Alloy Steels .- Certain of the alloys have still another beneficial effect-that of refining the grain. According to the laws of crystallography, certain favoured austenite grains should grow at the expense of their neighbours, with the result that the hot steel should become coarser grained with longer and longer stay at higher and higher temperature But first a considerable time is necessary to dissolve complex and sluggish carbides in the austemite, and many seem to have a central particle that resists dissolution, and these refractory particles disseminated through the metal effectually prevent the natural grain growth of the solid solution The advantage is that a fine-grained austenite, when quenched and tempered, has a very desirable degree of toughness. Bain's list of grain refining elements, arranged according to their effectiveness is Titanium (very strong), vanadium, molybdenum, tungsten, chromium, and manganese (mild)

Aluminium, added to the metal in proper small quantity in a properly deoxidized steel, apparently reacts with traces of oxygen and nitrogen dissolved in the steel, and precipitates out as a cloud of insoluble particles in the solidifying steel. These inclusions are even more effective obstructions to austenite gram growth. Such fine-grained steels are popular in America. They are especially useful in low carbon, carburizing steels. In the carburizing operation, machined steel parts can acquire a high carbon skin or case, say o osin, deep in shr exposure to a highly carbonaceous gas at 1,700° F. Even after such a long and high heating the austenite remains so fine in grain size that the parts can be quenched direct from the carburizing heat to harden the high carbon case, secure in the fact that the inner portions remain fine grained and tough.

The toughness of alloy steels, or the ability to absorb rapid blows, is also improved by the circumstance that those containing the carbide-forming elements listed two paragraphs above may be tempered or reheated after quenching to considerably higher temperatures than carbon steels of the same carbon content and still retain the hardness of the plain carbon steel, quenched and tempered at a lower temperature. Evidently the sluggish diffusion of alloying elements, trapped in solution in the freshly quenched martensite, requires a higher temperature and a longer time before the complex-carbides can re-form, in comparison with the formation of simple iron carbide (Fe<sub>2</sub>C) by diffusion of trapped carbon. Since the toughening due to tempering is largely a matter of relieving the high internal stresses in freshly quenched steels, and since this stress-relief is greater at higher temperature, it can be seen why alloy steels may give, after proper heat treatments. metal that is strong, hard and unusually tough

These sluggish changes in the complex alloy carbides are utilized in steels for high temperature, high pressure equipment Stable carbides enable the hot

of Mechanical Engineers' Boiler Code has tentatively proposed a working stress of 5,750lb. per sq in for plain carbon steels at 900° F, and 10,000lb per sq in (nearly double) for the same steels plus o 50% molybdenum.

Interchangeability of Alloy Steels.—From what has gone before one might properly conclude that a definite combination of strength, hardness, and toughness might be secured from any one of a large number of alloy steels, provided the size was not too large and the heat treatment properly adjusted. How true this is may be proved by transmission drive shafts in six leading American automobile plants. One firm uses o 60% carbon steel, oil quenched; another 1 75% nickel, 0 25% molybdenum, 0 20% carbon steel, carburized, two others use 1% nickel, 0 60% chromium, o 75% manganese, o 40% carbon steel, oil quenched, another uses o 25% carbon, o 80% manganese, o-20% molybdenum steel, carburized, and the last one uses 1% chromium, 0.75% manganese, o 35% carbon steel, oil quenched

It will also be noted that the above alloys are all low alloys, and this represents an undoubted trend in alloy practice, both in England and America, especially in the smaller sizes of forgings or machined gears where adequate penetration of hardness may be secured by not too drastic quenches. For the massive forgings, steels with higher content of alloys, and long continued heat treatments to permit the sluggish reactions, are still necessary

Gear Steels,-As a specific application of the above general principles, the problems of gear manufacture may be considered. for the choice of steel and its treatment depends very intimately on the design of the part and its intended duty. Large gears for rough service are frequently cast direct in gray iron or low carbon steel, but the irregularities in dimensions of wheel and gear teeth are such that speed and power transmitted must be relatively small, life is short and noise is great. An improvement as to accuracy and wear resistance consists in welding together a gear "blank" of appropriate shapes, the rim into which the teeth are to be cut being of medium carbon steel; after machining, the teeth surfaces are individually hardened by passage of an enveloping flame from oxy-acetylene torches, followed closely by quenching jets. In comparison with these, the high duty herringbone gear sets used on turbine-driven propeller shafts are marvels of precision; they are of cast alloy steels heat treated to relieve internal stresses and insure dimensional stability as well as induce as much hardness for wear resistance as is consistent with machinability. This hardness limit is somewhere about C-40 (Rockwell scale). The steels contain 0-50 to 0.60% carbon, but alloys are necessary to give proper depth of hardening and fine grain size Examples are 1.25% manganese plus one or more of the elements molybdenum (0:30%), nickel (1%), chromium (0.5%) and vanadium (0.15%). In large sections a quenched and tempered chromium-nickel-molybdenum cast steel will have the following physical properties indicating medium strength and hardness with great toughness. Yield point 105,000lb. per sq.in.; tensile strength 135,000lb, per sq in.; elongation 20% in 2in.; reduction of area 64%; Rockwell hardness C-32

In the smaller gears utilized for automobile transmissions and rear axle drives the mass effect or deep hardening effect is not so necessary. Requirements are very diverse and exacting, and these, together with the desire to save weight, and therefore to have gears as small as possible, have preserved this field to alloy steels. The original conception of a gear tooth was that it should have a hard surface to resist wear and a tough centre or core to

resist impact Following this idea, gears were cut from annealed blanks, forged from low carbon alloy steels (less than o 20% carbon), the machined gears were then carburized by heating in contact with carbonaceous solids or gases until their surfaces had come up to 0 90 or 1 00% carbon for a depth of 0-030 to 0 050in (about % the thickness of the tooth at the base) The subsequent heat treatment was at times rather intricate, consisting of a high temperature quench to refine the low carbon core, a lower temperature quench to harden properly the high carbon surface, and a tempering to improve the toughness. Steels widely used in this way included those shown in Table II. Representative properties of the core after an oil quench suitable to harden the carburized case are as shown Evidently here is a variety of steels suitable for any designer's requirements, where he balances cost (alloy content, machinability, and heat treatment schedule) against strength desired to carry the loads on the gear tooth, and toughness against impact loadings Probably the ultimate in properties, disregarding cost, is a so-called "armour plate" analysis with carbon 0 10%, nickel 4%, and chromium 1 5%, used for aircraft, heavy duty truck, and bus gears Its heat treatment is quite complicated, including an oil quench from 850° C and draw at 650° to make the forgings machinable, 24hr carburizing of machined gears at 940° F, annealing at 730° F and cooling slowly (8ohr ) to soften the case so the teeth can be finish-machined a few thousandths to remove distortion. The gears are then hardened by oil quenching from 760° C and tempering at 150° C

Carburizing all these analyses gives an outer surface containing 0 90 to 1.0% carbon, and since surface hardness of the quenched gear depends on carbon, rather than alloy, content, all of these teeth can be made "file hard"—that is, too hard to be bitten by a testing file whose hardness is Rockwell C-65 Experience has also proven that maximum resistance to abrasion is secured from such high carbon cases on steel containing chromium or molybdenum carbides. One serious objection to the practice outlined above is the cost of heat treatment after carburization, and this has been attacked by the use of the fine-grained steels which may be quenched direct from the carburizing heat and still possess a fine structure and considerable toughness. This practice was fairly common with the 1% chromium, o 15% vanadium steels, which are inherently fine-grained, before the special fine-grained steels were regularly produced by the steel mills One much used type is the nickel-molybdenum steel shown in the last line of Table II

Table II — Properties of Low Corbon Cores of Gent Teeth Carburized and oil quenched from temperature shows

Steel	Quenching temperature	Tensile strength lb persq.m	Rockwell hardness	Izod impact ft-lb
o-20% carbon (no alloy) 3.5% nickel, 5% nickel, 1.25% nickel, o.35% chromium 1% chromium, o-15% vanadium 1.75% nickel, o-23% molybdenum	780° C.* 800° C 815° and 735° C 800° C. 890° C. 930° C.	80,000 150,000 110,000 155,000 125,000	C-0 C-35 O-20 C-34 C-25 C-32	70 35 75 30 80 35

<sup>\*</sup>Water quench

High speed transmission gears in automobiles must operate without much noise, and this requires a degree of accuracy of shape on the order of o-0005 inch. Warpage increases with the depth of carburization, so shallow cases were tried to give quieter gears. This was successful, but the hard case now tended to flake off, due to fatigue failure of the weaker low carbon metal at junction of case and core 'To strengthen this metal it has been necessary to increase carbon content, and the result is that in 1940 American automobiles the great majority of transmission gears are of steels that used to be called "oil quenching gear steels," high enough in carbon and alloy to quench to a file hard surface without carbunzation. An upper carbon limit is set by the demands of reasonable machinability. Whereas the old oil quenched gears were heated in molten lead for quenching (in order to avoid any trace of decarburized soft skin), the more modern practice is to hold them in a cyanide bath at 815° C. for about 25min. which is enough to induce a o co2-in case of carbides and nitrides, exceedingly hard and wear resistant, or to heat them in a controlled gas of carburizing nature A representative steel would contain 0.45% carbon, 1.25% nickel, 0.60% chromium. After the above quenching from cyanide and a 2-hr. draw at 235° C the core would have a tensile strength of 275,000lb. per sqin, and a correspondingly high fatigue strength. After such treatment the involute errors seldom would amount to 0 0004 inch It is seen that the result is a gear with high surface hardness to resist wear, high core strength just under the case to resist fatigue failure (flaking or pitting of the surface), high strength to carry the normal loads, moderate cost of the steel with its moderate alloy content, cheap heat treatment, and a quiet running gear "A soft, tough core to resist impact," once a prime requisite of a successful gear, is not contained within these specifications, as it has become amply evident that if design and shape are correct, a transmission gear set will operate normally without much impact Toughness is achieved by fine gram size rather than high tempering after quench; indeed, tempering is done at the minimum temperature to avoid letting down the hardness at the surface. Other 0.40 to 0.50% carbon fine-grained steels widely used in this improved practice con tain 1.75% nickel and 0.25% molybdenum, 1% chromium; 1% chromium with 0 18% vanadium. Here is a good example of that interchangeability of alloy steels mentioned in the preceding section, choice may depend more on personal preference than on demonstrated advantages

Austentité Steels.—Hadfield's cast 10% manganess steel, discovered in 1882, was remarkable in that it did not harden on quenching. It is, in fact, an austentic alloy, in the sense that the expected change from austenite solid solution to hard martensite does not occur at 200° C but the quenched austentie sysstable at room temperature Cobalt, but especially nickel, has similar effects One result of this is that the most useful of the stainless steels, known as 18-8 and containing 18% chromium and 8% mickel, su unhardenable by quenching

One characteristic of these commercial austenitic steels is that the austenite is not entirely stable. The small plastic movements in high manganese steel, associated with battering or attempted cutting, permit the martensitic reaction to occur in those restricted regions, causing intense hardness-hence their wear resistance in rough service. This is a favourable reaction, but many of the 18-8 steels are put into petroleum stills operating between about 450° and 850° C., and this temperature gives enough thermal agitation to the atoms so that chromium carbides form from the austenite solid solution, unfortunately not in a cloud throughout the mass to "key" and strengthen the metal, but localized at the gram boundaries, seriously depleting the surrounding matrix of its chromium necessary for corrosion resistance. This detenoration of 18-8 (even by the heat of welding) is prevented by introducing minor amounts of strong carbide-forming elements, like molybdenum, titanium or columbium. The latter two, especially, form carbides that are so insoluble in austenite that they act as mert non-metallic inclusions (See also Iron and Steel: Alloys: and the various types of steels under their own headings.)

Binitography.—Edgar C. Ban, The Alloying Elements in Steel (1939), Sir Harold Carpenter and J. M. Robertson, Metals (vol II, 1939). Comprehensive monographs critically appraising the literature on the various alloys are being issued by Alloys of Iton Research, New York.

STELION, a borough of Dauphin county, Pennsylvania, US, 3 mi. S.E. of Harrisburg, on the Susquehnan river; served by the Pennsylvania, the Reading and the Steelion and Highspire railways. Pop. was 12,654 in 1950 and 12,115 in 1940. It has vast steel works and various smaller manufacturing industries, and there is a large limestone quarry within its limits. A town called Baldwin was laid out there in 1866, and the present name was adopted for the borough in 1880.

STEEL WOOL, a mild abrasive commonly used to clean or polish metals and metallic objects. It is of great practical use in the japanning, plating and moulding rooms of factories. In rubbing down metallic articles to attain a fine finish, steel wool achieves much the same results as purnice Steel wool is also used to clean rusty and turnished hollow-ware STEELYARD, MERCHANTS OF THE, Hansa merchants who settled in London in 1250 at the steelyard on the riverside, near Cosin lane, now Ironbridge Wharf Henry III. in 1259, at the request of his brother Richard of Cornwall, king of the Romans, conferred on them important privileges, which were confirmed by Edward I. It was cheefly through their enterprise that the early trade of London was developed, and they continued to flouish till, on the complaint of the Merchant Adventurers in the reign of Edward II, they were deprived of their privileges. They succeeded in maintaining a footing in London till 1597.

See Stow, Survey of London (1598); Lappenburg, Urhundhche Geschichte des hausischen Stahlhofes zu London (Hamburg, 1851); Paul, Pretures of Old London (1851); Ehrenberg, Hamburg und England im Zeitalter der Komgin Elusabeth (Jena,-1896).

STEEN, JAN HAVICKSZ (1656-1679,) Dutch subject-painter, was born at Leyden in 1626, the son of a brewer According to Houbraken he studied under Nicolas Knupfe, a German artist, at Utrecht, and under Jan van Goyen, whose daughter he married in 1649 In November 1646 he enrolled himself as a studient of the university at Leyden and in 1648 he was one of the founders of the Guild of St. Lukie in that city. He sestited at The Hague in 1649, and at Delft in 1654. In 1657 he is said to have been a hrewer at Delft. He is repeatedly mentoned in documents in the Delft archives during 1656-57. He was a resident of Haarlem during the years 1661-69. He then moved to Leyden, where he received permission to open a tavern in 1672. In 1673 he took a second wife, Maria van Egmont, the widow of a Leyden bockseller. He died at Leyden Fe S, 1679.

The works of Jan Steen are distinguished by correctness of drawing, adminable freedom and spirit of touch, and cleamess and transparency of colouring. But their true greatness is due to their intellectual qualities. In the wide range of his subjects, and their dramatic character, he surpasses all the Durch figurepainters, with the single exception of Rembrandt. His productions range from the stately interiors of grave and wealthy critizens to tavers scenes of joility and debanch. He painted chemists in their laboratories, doctors at the bedside of their patients, cardparties, marriage feats—even religious subjects, though in these he was least successful His rendering of children is especially delightful. Portraits from his brush are comparatively yare.

The National gallery contains three pictures by Jan Steen, of which the "Music Master" is the most important, and other excellent examples of his art in England are preserved in the Royal, the Bute, and the Northbook collections, at Apaley House and Bridgewater House, and in the galleries of The Hague, Amsterdam, and the Hermitage, St. Petersburg (Leningard). A remarkably fine example of his work is the "Grace Before Meat" in the collection of Charles Morrison, London.

See Hofsteede de Groot, Catalogue of Dutch Painters (1907); F. Schmidt Degener, Jan Steen (1927) (trans. by G. Renier).

STEENKIRK or STEENKERKE, a village in Belgian province of Hamaut, on the river Senne, pop. (1939) 494; battle of Steenkirk (Steinkirk, Estinkerke) fought here July 23-Aug. 3, 1692 between Allies (see GRAND ALLIANCE, WAR OF THE) under William III of England and the French commanded by the duke of Luxemburg. Previous to the battle the French army lay facing north-west, with its right on the Senne at Steenkirk and its left towards Enghien, while the army of William III was encamped about Hal. William, seeing the opportunity of surprising a part of the enemy's forces and having forced a detected spy to give Luxemburg misleading news, set his army in motion before dawn on Aug. 3 to surprise the French right about Steenkirk. The advanced guard, mainly English and Danish infantry, under the duke of Württemberg, deployed close to the French camps ere Luxemburg became aware of the impending blow; at this moment the main body of the army farther back was forming up after the passage of some woods. When the fight opened, Luxemburg was completely surprised, and could do no more than hurry the nearest foot and dragoons into action as each regiment came on the scene. But the march of the Allies' main body had been mismanaged; while Württemberg methodically cannonaded the enemy, waiting for support and for the order to advance, the Allies' main

body, which had marched in the usual order, one wing of cavalry leading, the infantry following, and the other wing of cavalry at the tail of the column, was being hastily rearranged in rear. A few battalions only had come up to support the advanced guard when the real attack opened (1.230). The advanced guard had already been under arms for mue hours, and the march had been over bad grounder that when the real three three the second of the secon

it The English and Danes stubbornly advanced, the second and third lines of the French infantry giving ground before them, but Luxemburg was rapidly massing his whole force to crush them, and meanwhile the confusion in the allied main body had reached its height. Count Solms, who commanded it, ordered the cavalry forward, but the mounted men, scarcely able to move over the bad roads and heavy ground, only blocked the way for the infantry. Some of the English foot, with curses upon Solms and the Dutch generals, broke out to the front, and Solms, angry and excited, thereupon refused to listen to all appeals for aid from the front. No attempt was made to engage and hold the centre and left of the French army, which hurried, regiment after regiment, to take part in the fighting at Steenkirk. William's counterorder that the infantry was to go forward, the cavalry to halt, only made matters worse, and by now the advanced guard had at last been brought to a standstill At the crisis Luxemburg had not hesitated to throw the whole of the French and Swiss guards into the fight, and as, during and after this supreme effort, more and more French troops came up, the Allies were driven back, contesting every step against weight of numbers. Those troops of the main body, foot and dragoons, which succeeded in reaching the front, served only to cover and to steady the retreat of Württemberg's force, and, the coup having manifestly failed, William ordered the retreat. The Allies retired as they had come, their rear-guard-of grenadiers from the British regiments-showing too stubborn a front for the French to attack. The latter were indeed in no state to pursue. Over eight thousand men out of only about fifteen thousand engaged on the side of the Allies were killed and wounded, and the losses of the French out of a much larger force were at least equal. Contemporary soldiers affirmed that Steenkirk was the hardest battle ever fought by infantry.

STEEPLECHASING: see Honese Racing and Beedding.
STEER, PHILIP WILSON, O.M. (1860-1942). English painter, born at Birkenhead. He was trained at the Gloucester school of art and afterwards in Parns at the Académic Julan, and in the École des Beaux Arts under Cabanel. After 1836, before which date he had shown three pictures at the Royal academy, practically the whole of his work was seen in the exhibitions of the New English Art club. In his early work he appears as an adherent of the French Impressionist movement, and as a teacher at the Slade school he exercised an important influence on the development of English art. His figure subjects and landscapes show great technical skill. He ded March 27, 1942.

STEEVENS, GEORGE (1736-1800), English Shakespearian commentator, was born at Poplar on May 10, 1736, the son of an East India captain, afterwards a director of the company He was educated at Eton and at King's college, Cambridge Leaving the university (1756) without a degree, he settled in chambers in the Temple, removing later to a house on Hampstead Heath, where he collected a valuable library, rich in Elizabethan literature. He walked from Hampstead to London every morning before seven o'clock, discussed Shakespearian questions with his friend, Isaac Reed, and, after making his daily round of the booksellers' shops, returned to Hampstead. He published in 1766 reprints of the quarto editions of Shakespeare's plays, entitled Twenty of the Plays of Shakesbeare, . . Dr. Johnson suggested to him the preparation of a complete edition of Shakespeare. The result, known as Johnson's and Steevens's edition, was The Works of Shakespeare with the Corrections and Illustrations of Various Commentators (10 vols., 1773), Johnson's contributions to which were very slight. This early attempt at a variorum edition was revised and reprinted in 1778, and further edited in 1785 by Isaac Reed; but in 1793 Steevens, who had asserted that he was now a "dowager-editor," was persuaded by his jealousy of Edmund Malone to prepare an edition of 15 volumes. He made somewhat reckless emendations, but the edition showed a wide innovelage of Elizabethan Hierature. Steevens was one of the foremost in exposing the Chatterton-Rowley and the Ireland forgreiss. He wrote an entirely fictitious account of the Java supstree, derived from an imaginary Dutch traveller, which impose on Erasmus Darwin, and he hoazed the Society of Antuquises with the tombstone of Hardicanute, supposed to have been ding up in Kennington, but really engraved with an Anglo-Sxon inscription of his own invention. He died at Hampetead on Jan. 22, 1800. A monument to his memory is in Poolar chanel.

Steevens's Shakespeare was re-issued by Isaac Reed in 1803, in 21 volumes, with additional notes left by Steevens. Thu, which is known as the "first vanorum" edition, was reprinted in 1813 Steevens's notes are also incorporated in the edition of 1821, or low by Edmund Malone and completed by James Boswell the younger

STEEVENS, GEORGE WARRINGTON (1869-1902). English journals, was borm et Sydenham, near London, on Doc 10, 1869, and was educated at the City of London school and Balliol college, Cofford, of which he was a school and Balliol college, Cofford, of which he was a school. In 1839, he was elected a fellow of Pembuoke college, Cofford. In September 1899 he went to South Africa and joined Sir George White's force in Natal as war correspondent, being subsequently besiged in Ledysmith Reided during the siege, of enterie fever, on Jan. 15, 1900. The articles he had sent home from South Africa were published posthumously in a volume called Prom Capetons to Ladysmith (1900). Another of his most interesting books was With Kutchemer to Karbosom. Steewess had a remataballe gift of seizing the saltent facts and principal characteristics in anything he washed to describe and putting them na varied may supplied the saltent facts and principal characteristics in anything he washed to describe and putting them na varied whem na varied whem na version washed to describe and putting them na varied whem na varied whem na varied whem na varied whem na varied to describe the control of the control

wasset to describe and putting tnem in a vivid way.

\*\*STEFANIE, BASSO NAEBOR or CHUWAHA, a lake of East Africa, lying in 37° E, between 4° 15° and 5° N., and measuring some 40 m. by 15. It is the southermost and lowest (1,856 ft,) of a series of lakes which he in the northeasterly (1,856 ft,) of a series of lakes which he in the northeasterly (1,856 ft,) of a series of lakes which he in the northeasterly (1,856 ft,) of a series of lakes which which have the series of the lakes which have no outlet, varies greatly according to the amount of water brought down by its principal feeder, the Dules, which enters at its north end, being there a rapid stream 50 yd wide and 3½ ft. deep.

Lake Stefanie was discovered by Count Samuel Teledid in 1881.

Lake Stefanie was discovered by Count Samuel Telekt in 1881, and has since, with others of the series, been explored by Donaldson Smith, V. Bottego, M. S. Welby, Oscar Neumann, Arnold Hodson and others. An agreement of 1907 with Great Britain recognized the lake as within the Abyssinian empire.

See Geographical Journal (Sept. 1896, Sept. and Dec. 1900, Sept. 1901, Oct. 1902, July 1922), L. von Hohnel, Discovery of Lakes Rudolf and Stefanne (1894); L. Vannutelli and C. Citerni, L'Omo (Milan, 1899); British War Office map, Africa, 12,000,000 (1924).

STEFANSSON, VILHJALMUR (1879- ), Arctic explorer, was born on Nov. 3, 1879, at Arnes, Manitoba, Canada, of Icelandic parents. He graduated from the University of Iowa and later studied theology and anthropology for three years at Harvard university. After two archaeological voyages to Iceland in 1904 and 1905 he turned to arctic research and had by 1928 spent altogether 10 winters and 13 summers in scientific work north of the polar circle. In 1906-07 he was ethnologist of the Leffingwell-Mikkelsen expedition on the north coast of Alaska and at the mouth of Mackenzie river; in 1908-12 he commanded an expedition on which he discovered certain Eskimo groups and visited others who had not seen a white man for half a century. From 1913 to 1918 he commanded an arctic expedition under the auspices of the Canadian government. During more than five years continuously north of the Arctic Circle (the longest arctic expedition on record) he explored vast regions north of Canada and Alaska, sometimes sledging for months over moving ice, accompanied by two or three companions and living exclusively by hunting. He discovered between 1915 and 1917 the islands now known as Borden, Brock, Meighen and Lougheed, and several smaller islands. In 1918 his then second in command, Storker Storkerson, taking charge while Stefansson was ill with typhoid fever, explored by sledge, with four companions, the Beaufort sea north of Alaska. They were absent from shore about eight months, during six of which they were encamped, and lived by hunting, on a floe more than five miles in diameter while it drifted with them 450 mi. over a previously unexplored ocean from 1 mi. to 3 mi. deep They found an abundance of seals everywhere, had therefore plenty of food and fuel, suffered no hardships, and reported on their return that they felt sure they could have spent several years on this floe safely. This confirmed the conclusions of all the previous sledge journeys of the expedition over the moving ocean ice: that seal life, and therefore probably other water life, does not necessarily decrease, as was previously beheved, farther north in the arctic. Stefansson laid stress on the economic value of the arctic regions, chiefly as meat-supplying countries through cultivation of the domestic reindeer and domestication of the ovibos or musk ox. In 1932 he became adviser on northern operations for Pan American Airways, During World War II he served the U.S. government in an advisory capacity, surveyed defense conditions in Alaska and prepared reports and manuals for the armed forces.

His principal publications are. My Life with the Eshimo (1913); The Friendly Arctic (1921), The Northward Course of Empire (1922); Hunters of the Great North (1922), The Adventure of Wrangel Island (1926); The Standardization of Error (1927); Unicolved Mysters of the Arctic (1938); Greenland (1942); Arctic Manual (1944).

STEFFANI, AGOSTINO (1653-1728), Italian ecclesiastic, diplomatist and musical composer, was born at Castelfranco on July 25, 1653 At a very early age he was admitted as a chorister at St. Mark's, Venice. Count Tattenbach took him in 1667 to Munich, where his education was completed at the expense of Ferdinand Maria, elector of Bavaria, who gave him a court appointment. He was sent in 1673 to study in Rome, where Ercole Bernabei was his master, and among other works he composed six motets, the original manuscripts of which are now in the Fitzwilliam Museum at Cambridge. On his return to Munich in 1674. he published his first work, Psalmodia vespertina, a part of which was reprinted in Martini's Saggio di contrappunto in 1674 In 1675 he was appointed court organist. The date when he was ordained priest, with the title of Abbate of Lepsing, is not precisely known. Steffani's first opera, Marco Aurelio, which was written for the carnival and produced at Munich in 1681, was followed by other works now lost. In 1688 he became Kapellmeister at the court of Hanover, where he made many friends. He wrote for the opening of the new opera house in 1680, an opera called Enrico il Leone, which was produced with extraordinary splendour. For the same theatre he composed La Lotta d'Ercole con Achilleo in 1689, La Superbia d'Alessandro in 1690, Orlando generoso in 1691, Le Rivali concordi in 1692, La Libertà contenta in 1693, I Trionfi del fato and I Baccanali in 1695, and Briseide in 1606. Elevation of Ernest Augustus to the electorate in 1602 led to difficulties with the various German courts; Steffani was sent round as an envoy in 1696 and as a result received from Innocent XI the bishopric of Spiga for his services in securing privileges for Hanoverian Catholics. In 1698 he was sent as ambassador to Brussels, and after the death of Ernest Augustus in the same year he entered the service of the elector palatine, John William, at Dusseldorf, where he held the offices of privy councillor and protonotary of the Holy See.

Steffani did not accompany the elector George to England; but in 1724 the Academy of Ancient Musick in London elected him its honorary president for life; and in return for the compliment he sent the association a magnificent Stabat Mater, for six voices and orchestra, and three fine madrigals. The manuscripts of these are still in existence, and the British museum possesses a very fine Confitebor, for three voices and orchestra, of about the same period. All these compositions are very much in advance of the age in which they were written; and in his operas Steffani shows a remarkable appreciation of the demands of the stage. Notable too are his beautiful chamber-duets, which, like those of his contemporary Carlo Maria Clari (1669-1745), are chiefly written in the form of cantatas for two voices, accompanied by a figured bass. The British museum (Add. MSS. 5,055 seq.) possesses more than a hundred of these compositions, some of which were published at Munich in 1670. Steffani visited Italy for the last

time in 1727 He died at Frankfurt on Feb. 12, 1728.

Steffini stands somewhat apart from contemporary Italian composers (e.g., Alessandro Scarlatt) in his mastery of instrumental forms. His opera overtures show a combination of Italian suavity with a logical conciseness of construction which is due to French influence. His vocal music and his famous duelst are hefore to those of Scarlatti, but his instrumental music is historically important as a factor in the artistic development of Handel.

STEFFEN, ALBERT, Swiss novelist and dramatist, was born at Murguntal (Canton Aargan) on Dec. 10, 1884. He is an unaginative, spiritual, mystical and idealistic writer, showing little of the concrete and disciplined methods that are so characteristically Swiss. His nearest spiritual kunsman is, perhaps, Dostoievel (q.n.). His special quality reveals itself in his novels, such as (q.n.); he has also something in common with Carl Spiritual (1912). His special quality reveals itself in his novels, such as Grad, alone, und Weresheek (1907), Due Backinsmung der Rohest (1912), Due Rechte Liebhaber des Schickkals (1915), Söyligh Meriana (1917) and Die Erneuerung des Bundses (new ed. 1915); in his shorter stones, such as Die Heilige mit dem Fusche (1913) and Verhäugusse (1927); in his plays, such as Das Vergett (1924) and Due Tohef des Generalistabs (1927); and nib sessays, such as Das Versiss im Lebon des Kunstlers (1922), Der Kunstler wuischen Westen and Osten (1925) and Begegnungen mit Rudolf Steiner (1926).

STEFFENS, HENRIK (1733-1484), German philosopher, of Norwegian extraction, was born on May a, 1773, at Stavanger He studied in Germany, and began to lecture at Copenhagen in 1760. His lectures were appreciated by Grundriys and Oelhen-schläger, but the authorities regarded them with disfavour, and Steffens removed to Germany, where he fought in the Napolonici wars on the German side. He was professor of physics at Breslau (1811-22) and at Berlin (1812-43). He died in Berlin on 18-013, 1248, Steffens was the friend and adherent of Schelling and Schleemracher. He had been the start of Schelling and Schleemracher. He had been to be start of the start

See M. Tietzen, Zur Erinnerung an Steffens (1871); Petersen, Henrik Steffens (1884); W. Dilthey, Leben Schleiermachers (1870). STEFFENS, LINCOLN (1866-1936), American journalist and political philosopher. In 1901, after graduate study in Germany and newspaper experience in New York, Steffens became managing editor of McClure's Magazine Here he published the influential articles later collected as The Shame of the Cities For ten years he was the leading figure among the writers whom Theodore Roosevelt called muckrakers, but he was more concerned with the causes of corruption than with specific reforms. and he became a student of revolution, first in Mexico and then in Russia, Barred from many American magazines by his unorthodoxy during and after World War I, he lived quietly and obscurely in Europe during the 1920s, pondering his experiences and observations. His conclusions finally found expression in his autobiography, which had a great success when it appeared in 1931. Although he supported many communist activities in the depression years of the early 1930s, he remained essentially a pragmatist, preferring to ask questions rather than to answer them. His characteristic achievement, both as muckraker and as autobiographer, was in persuading readers to examine for themselves the character of contemporary civilization.

See: The Autobiography of Lincoln Steffens (1931); The Letters of Lincoln Steffens (1933). (G. Hs.)

STEGANOPODES or PELICANTFORMES, an order of birds characterized by the fact that the hind toe is united to the second toe by a web. Most species are gregarious and live on fishes; The order includes the pelicans, commants, gannets, shake/birds, frigate birds and tropic birds (qq.w.).

STEGOCEPHALIA, a term often applied to Palaeozoic and Triassic amphibians with solidly roofed skulls, mainly members of the Labyrinthodontia, (See AMPHBIA.)

STEGOSAURUS, the name given to a type of dinosaur

١

found in the late Jurassic of North America. The name (plated haard) refers to the armament of the reptile in the shape of a paired row of bony plates extending upward along the length of the back; the tail bore two pairs of bony spakes. Stegosturus was an inoffensive, small-headed vegetarian with a maximum length of 30 ft. The hind legs are much longer than the fore, suggesting a descent from bipedial ancestors. (See ReprillES; DINOSAURIA.)

(A. S. RR.) STEIBELT, DANIEL (c. 1764-1823), German pianust and composer, was born at the earliest in 1764 or 1765 in Berlin. He was indebted to the crown prince Frederick William for his musical education. Very little is known of his artistic life before 1700 when he settled in Paris and attained great popularity as a virtuoso by means of a pianoforte sonata called La Coquette, which he composed for Queen Marie Antoinette; his dramatic opera entitled Roméo et Juliette, produced at the Théâtre Feydeau in 1793, was equally successful. In 1796 Steibelt moved to London, where his pianoforte playing attracted great attention. In 1798 he produced his concerto (No. 3, in E flat) containing the famous "Storm Rondo"—a work that ensured his popularity In the following year Steibelt started on a professional tour in Germany; and, after playing in Hamburg, Dresden, Prague and Berlin, he arrived in May 1800 in Vienna, where he challenged Beethoven to a trial of skill. His discomfiture was complete and he retired to Paris, living alternately in that city and London during the next eight years. In 1808 he was invited by the emperor Alexander to St. Petersburg, succeeding Boseldieu as director of the royal opera. in 1811. Here he resided in the enjoyment of a lucrative appointment until his death on Sept. 20, 1823.

Besides his dramatic music, Steibelt left behind him an enormous number of compositions for the pianoforte. His playing, though brilliant, was wanting in the higher qualities which characterized that of his contemporaries, John Cramer and Music Clementi: but he was gifted with talents of a high order, and the

reputation he enjoyed was fully deserved.

STEIN, SIR AUREL (1862-1943), British archaeologist, was born at Budapest on Nov 26, 1862. Educated at Budapest and Dresden and at the Universities of Vienna and Tubingen. he went to England for further study and then to India, where he became principal of the Oriental college, Lahore, and registrar of the Puniab university in 1888. He was appointed in 1800 to the Indian Education service, and for the next two years carried out archaeological explorations for the Indian government in Chinese Turkestan. In 1906-08 he made further explorations in central Asia and western China. From 1910 he was superintendent of the Indian Archaeological survey, and in 1913-16 carried out explorations in Iran and central Asia, described by him in The Geographical Journal (1916), He was created K.C.I.E in 1912. In 1926 he continued his explorations on the northwest frontier and identified the site of Aornus, thus correcting Abbott's view, and between 1926 and his death explored Iran, Iraq and Trans-Jordan. He died in Kabul, Afghanistan, Oct. 28, 1043

All The Territors of the Control of

Tran (1930). "HARLOTTE VON (1742-1837), the friend of Goethe, was born at Weimar on Dec. 25, 1745, the deletst dungiture of the Hofmanschall (master of the cenenoies) von Schardt. She of the Hofmanschall (master of the cenenoies) von Schardt. She can be supported to the decrease Anna Annalia, the accomplished mother of Duck. Or the duckets Anna Annalia, the accomplished mother of Duck. Or the duckets and samila, the accomplished mother of Duck. Or the support of the horse to the duck, and seven children were the issue of the noise to the duck, and seven children were the issue of the noise. Or the duck, and seven children were the issue of the noise. Or the duck, and seven children were the issue of the noise. One captivated by the charm of this lady, his senior by seven years, and the noise. Or the duck of the

STEIN 373

in 1788 the previous close relationship between them came to an end although their friendship was later renewed. Goethe's letters to Frau von Stein form one of the most interesting volumes of the poet's correspondence. She was also a close friend of Schiller and his wife, and numerous interesting letters from her are to be found in Charlotte von Schiller und shre Freunde (vol ii, 1862). She became a widow in 1793 and continued to live at Weimar until her death there on Jan 6, 1827

Gethe's Brief an Fron von Stem aus den Jahren 1776-1820 was clited by A. Scholl (3 vols), 1848-1851, and ed by W. Fabitt, 1883-1885, 3rd ed by J. Wallet, 1900. Set H. Duntter, Charloise von Stem (2 vols), 1874); al. Charloite von Stein und Corona Schroter (1879), ed. H. Ostert, Charloite von Stein (1800. and New York, 1877), and A. Saure, Framenbider aus den Blutesti der deutschen Literatur (1889). W. Bods, Charlotte von Stein (1900.)

STEIN, GERTRUDE (1874-1946), expatriate U S author, was born in Allegheny, Pa, Feb 3, 1874, spent her infancy in Vienna and Paris, her girlhood in Oakland, Calif. She read Shakespeare at eight years. At Radchffe college, 1893-97, she specialized in psychology. William James is said to have considered her the most brilliant woman pupil he ever had She studied at Johns Hopkins Medical school, 1897-1902. Of independent means, she went abroad to live in 1903. Her home in Paris, 27 rue de Fleinus, was a centre for artists and writers for more than a generation After 31 years, she returned to the U.S for a lecture tour in 1934 Notwithstanding her German-Jewish origin, she continued living in Paris under nazi occupation

A literary "cubist," Gertrude Stein carried to extremes her weird, repetitious, and seemingly nonsensical manipulation of words and of words and of words. "Widely ridiculed and seldom enjoyed," comments Edmund Wilson in a chapter about her in Axel's Castle, "she has yet played an important role in connection with other writers who have become popular" Sherwood Anderson and Ernest Hemingway were two such. In The Autobiography of Alsce B. Toklas (1933), simply written and easily readable, Miss Stein, while ostensibly writing the life of her secretary and close companion since 1907, actually wrote her own In this book she appeared as one of her protégés, Bravig Ihms, called her in his Confessions of Another Young Man, a "vital, headstrong and cordial personality," with "an insatiable appetite for people' They came and went in an unending procession, year after year, some famous, some unknown, some to become famous later. Matisse, Cézanne, Pablo Picasso, Juan Gris, Mildred Aldrich, Clive Bell, Wyndham Lewis, Carl Van Vechten, Avery Hopwood, Ezra Pound, Ford Madox Ford, Bernard Faÿ, André Gide, John Reed, Elhot Paul, Jo Davidson, Paul Robeson, and scores of others.

"Flowing," said Carl Van Vechten, "is the one word that best describes Gertrude Stem." Sherwood Anderson likened her to "an American woman of the old school," plain and strong, who worked hard in her "kitchen" to make good things-out of words She was a substantial person, with a striking head and close-cropped hair. She dressed plainly. She laughed infectiously. When angry, she swore Her favourite song was On the Trail of the Lonesome Pine. Alice Toklas, so the Autobiography recounts, knew personally three geniuses in her lifetime: Picasso, Alired North Whitehead and Gertrude Stein. She died on July 27, 1946, in Paris.

The principal works of Gertrude Stein are Three Lives (1908); Tender Buttons (1915); Geography and Plays (1923); The Mak-Tender Dittons (1915); Geography and ruys (1923); He making of Americans (1925); Useful Knowledge (1928); Acquaintance with Description (1920); Ten Portraits (1930); Lucy Church Amably (1930); Before the Flowers of Friendship Faded Friendship Faded (1931); How to Write (1931); Operas and Plays (1932); Matisse, Picasso and Gertrude Stein (1932); The Autobiography of Alice B. Toklas (1933), Four Saints in Three Acts; an opera (1934); Portraits and Prayers (1934); Lectures in America (1935); Narration (1936); Everybody's Autobiography (1937), Picasso (1938); The World is Round (1939); Paris France (1940); Ida (1941); Wars I Have Seen (1945); Yes Is for a Very Young Man; a play (1946); Brewsie and Willie

STEIN, HEINRICH FRIEDRICH KARL, BARON VOM UND ZUM (1757-1831), German statesman, was born at the family

estate near Nassau, on Oct. 26, 1757 He studied law at Gottingen, Wetzlar, Regensburg and Vienna, and settled in Berlin in 1780. There he entered the Prussian service.

After holding various diplomatic and other appointments he became (1787) Kammerdirektor, ie, director of the board of war and domains for the king's possessions west of the river Weser; and in 1796 he was appointed supreme president of all the Westphalian chambers dealing with the commerce and mines of those Prussian lands Among the benefits of his administration was the canalization of the river Ruhr, which became an important outlet for the coal of that region. He also improved the navigation of the Weser, and kept up well the main roads committed to his care On June 8, 1793 he married the countess Wilhelmine von Wallmoden-Gimborn, daughter of a natural son of King George II of Great Britain

Stein's early training, together with the sternly practical bent of his own nature, made him completely impervious to the enthusiasm which the French Revolution had aroused in many minds in Germany He disliked its methods as an interruption to the orderly development of peoples. Nevertheless he carefully noted the new sources of national strength which its reforms called forth in France Under the untoward circumstances which followed the Peace of Basel Stein in 1804 took office at Berlin as minister of state for trade. He protested against the effects of the Gallophil policy of the chief minister, Haugwitz, and the evil influences which clogged the administration. Little, however, came of Stem's protests, though they were urged with his usual incisiveness and energy Prussian policy continued to progress on the path which led to the disaster at Jena (Oct 14, 1806).

The king then offered to Stein the portfolio for foreign affairs, which he declined, because he desired to see Hardenberg take that office and effect, with his own help, the necessary administrative changes. The king refused to accept Hardenberg, and, greatly irritated by Stein's unusually outspoken letters, dismissed him altogether, adding that he was "a refractory, insolent, obstinate and disobedient official." Stem now spent in retirement the months during which Napoleon completed the ruin of Prussia; but he saw Hardenberg called to office in April 1807 and important reforms effected in the cabinet system. During the negotiations at Tilsit, Napoleon refused to act with Hardenberg, who thereupon retired Strange to say, the French emperor at that time suggested Stein as a possible successor, and on Oct. 4, 1807, Frederick William

called Stein to office with very wide powers

Stein's strong convictions led him to press on drastic reforms in a way which could not otherwise have been followed. First came the Edict of Emancipation, issued at Memel on Oct 9, 1807, which abolished the institution of serfdom throughout Prussia from Oct 8, 1810. All distinctions affecting the tenure of land (noble land, peasants' land, etc.) were also swept away, and the principle of free trade in land was established forthwith. The same famous edict also abrogated all class distinctions respecting occupations and callings of any and every kind, thus striking another blow at the caste system which had been so rigorous in Prussia. Stein's next step was to strengthen the cabinet by wise changes and he also furthered the progress of the military reorganization which is connected more especially with the name of Schamhorst (q,v). Stein's efforts were directed more towards civil affairs; and in this sphere he was able to issue a measure of municipal reform (Nov. 19, 1808) which granted local self-government on enlightened and practical lines to all Prussian towns

In August 1808 the French agents, who swarmed throughout the land, had seized one of his letters, in which he spoke of his hope that Germany would soon be ready for a national rising like that of Spain. On Sept. 10 Napoleon gave orders that Stein's property in the new kingdom of Westphalia should be confiscated, and he likewise put pressure on Frederick William to dismiss him. The king evaded compliance; but the French emperor, on entering Madrid in triumph, declared (December 16) le nommé Stein to be an enemy of France and the Confederation of the Rhine, and ordered the confiscation of all his property in the Confederation. Stein saw that his life was in danger and fled from Berlin (Jan. 5, 1809) to Bohemia.

For three years he lived in the Austrian empire, generally at Brunn, but in May 18:1 be received an nuvitation from the emperor Alexander I to visit St. Petersburg, seeing that Austrian was certain to range herself on the side of France in the forthcoming France-Russian War. At the crisis of that struggle Stein may have been one of the influences which kept the tast determined never to treat with Napoleon. When the miserable remains of the Grand Army reclied back into Piussia at the close of the year, Stein urged the Russian emperor to liberate Europe.

Events now brought Stein iapidly to the front On Dec. 30, 1812, the Prussian general Yorck signed at Tauroggen a convention with the Russian general Diebitsch for neutralization of the Prussian corps at and near Tilsit, and for the free passage of the Russians through that part of the king's dominions The tsar thereupon requested Stein to act as provisional administrator of the provinces of East and West Prussia. In that capacity he convened an assembly of representatives of the local estates, which Feb 5, 1813, ordered the establishment of a militia (Landwehr). a militia reserve and a final levy (Landsturm). He took part in the drafting of a Russo-Prussian convention (March 19, 1813) respecting the administration of the districts which should be delivered from French occupation. During the varying phases of the campaign of 1813 Stein continued to urge the need of war à outrance against Napoleon. The Allies conferred on Stein the important duties of superintending the administration of the liberated territories After the battle of Leipzig (Oct. 16-19, 1813) Stem entered the city

He now desired to see Germany reconstituted as a nation, in a union which should be at once strong for purposes of defense and founded on constitutional principles. His statesmanlike projects were foliale, partly by the short-sightedness of German rulers and statesmen, but also by the craft with which Metternich guined the allance of the rulers of south and central Germany for the Austrian empire. During the Congress of Vienna Stein pressed in van for an effective union of the German people. Austra and the secondary German states resisted all proposals in this direction, and Stein blanded the Prussian chancellor Hardenberg for an indefiniteness of purpose which probably resulted from the decisie of all Presson statemens at that time to have Saxony wholly absorbed in their kingdom. In that, as in other matters, he was disappointed.

Stem passed into retirement after the Congress of Vienna, and as we that and disgust the postponement of the representative system of government which Prederick William had promised to Prussa in May 1812. His chief interest was in the sixed of listory, and in 1818-1820 he worked hard to establish the society for the encouragement of historical research and the publication of the Monumenta Germaniae Instorica, of which his biggrapher, Perts, became director. Stein died on June 29, 1831.

Possibly there has been a tendency to magnify the achievements of Stein. Research has shown that the credit for originating his reforms must be shared with Heinrich Theodor von Schon and many others. The king hmself rendered large services to this manual than the stein should be supported to the control of the stein should be supported to the stein should be supported by the stein should be su

human energy ensured the triumph of these principles.

Bianzonature.—Tere biographus of Stein, set G. H. Pertz (6 vols., 1849-53); Sr. J. Seeley (3 vols., 1878), M. Lehmann (Leiplei, 1902-1903); Cr. T. Eveley (3 vols., 1878), M. Lehmann (Leiplei, 1902-1902); Cr. T. Evelens, Publicate Mattheward Persones in Dustichland are Zeit der fransösischen Herrachalt (4 vols., Gotha, 1835); Denkaurdigkleiten des Stanzischensier Briries von Hardneberg, ed. by L. von averdigkleiten des Stanzischensier Briries von Hardneberg, ed. by L. von Article (6 vols., Mannheim, 1837-42); English ed., London (1847); Asten, Abbandiungen und Aktoniuche aus der preusischen Referensier Stanzischen (1948); M. Philippon, Geschichte als preusischen Referensier 1962-24; G. vols., Leipung, 2880); M. Lehmann, 2003-240; M. Philippon, Geschichte als preusischen Referensier 1962-24; G. vols., Leipung, 2880); M. Elminant, 2004-240; M. Philippon, Geschichte als preusischen Referensier 1962-24; G. vols., Leipung, 2880); M. Elminant, 2004-240; M. Philippon, Geschichte als preusischen Referensier 1962-24; G. vols., Leipung, 2880); M. Elminant, 2004-240; M. Philippon, Geschichte als preusischen Referensier 1962-24; G. vols., Leipung, 2880); M. Elminant, 2004-240; M. Philippon, Geschichte als preusischen Referensier 1962-24; G. vols., Leipung, 2880); M. Elminant, 2004-240; M. Philippon, Geschichte als preusischen Referensier 1962-24; G. vols., Leipung, 2880); M. Elminant, 2004-240; M. Philippon, Geschichte als preusischen Referensier 1962-24; G. vols., Leipung, 2880); M. Elminant, 2004-240; M. Philippon, Geschichte als preusischen Referensier 1962-24; G. vols., Leipung, 2880); M. Philippon, Geschichte als preusischen Referensier 1962-24; G. vols., Leipung, 2880); M. Elminant, 2004-240; M. Philippon, Geschichte als preusischen Referensier 1962-24; G. vols., Leipung, 2880; M. Philippon, Geschichte als preusischen Referensier 1962-24; M. Philippon, Geschichte als preusischen Referensier 1962-24; M. Philippon, Geschichte als preusischen Referensier 1962-24; M.

Knesthock und Schon (Laping, 1872). J P. Hastel, Geschichte der prevasischen Politik, 1807-1815. (Laping, 1883). Jen d'Ussel, Études sur l'année 1813, la déjection de la Praise (Paris, 1907). A D. White, Seven Grarts Stalement (1907). G Hasse, Phoedor von Schon und de Stemuche Westschafterform (Loppic, 1915). G S Förd, Stêin and the Stemuche Westschafterform (Loppic, 1915). G S Förd, Stêin and the Stemuche Westschafterform (Loppic, 1915). G S Förd, Stêin and the Stemuche Westschafterform (Loppic, 1915). G Förd, Stêin (Leppic, 1925). R Huch, Stein (Vienna, 1925). H M Elster, Frenkerr vom Stem (1927).

STEINER, JAKOB (1796–1863), Swiss mathematician, was born on March 13, 1796, at the village of Ulcendorf (Berne). At egipteen he became a pupil of Helmich Pestalozar, and afterwards studied at Heidelberg Thence he went to Berlin and became one of the chief contributors to Crelle's Journal founded in 1846 in 1844 a new chair of geometry was founded for him This he occupied till his death on April 1, 1863.

Steiner was one of the great developers of synthetic geometry. In his Systematische Entwickelung der Abhangigkeit geometrischer Gestalden von emmander he introduces the geometrical forms (the row, flat pencil, etc.), and establishes between their elements a one-one correspondence, or, as he calls it, makes them projective Sec C. F. Geiser's pamphlet, Zur Ernnerung an J. Steiner (Zurich, 1874).

STEINER, RUDOLF (1861-1925), German philosopher, was born on Feb. 27, 1861, at Kraljevic, Austria, the son of a minor railway employee, From 1890 to 1897 he worked in Weimar at the "Goethe-Schiller Archive," editing Goethe's works on natural history. In 1902 the German section of the theosophic association was founded and Stemer was called upon to become its spiritual leader. As such he developed for some years an astonishing activity as regards lectures and writings, but then became opposed to theosophy altogether, and was therefore excluded from the theosophical centre under English leadership. Steiner now developed his own teaching in a series of writings He called this "anthroposophy," : e , wisdom of humanity mankind is regarded as the centre of all perceptions of this "spiritual science," and an attempt is made to deduce the nature of the world from the nature of humanity. In 1913 the Anthroposophical society was formed to further spiritual research on Steiner's principles. In order to try his educational and political views in practice, Steiner founded the Waldorf school, near Stuttgart, and the "free high school for spiritual science" known as the "Goetheanum" at Dornach near Basle, which was burned a few years later All Steiner's works are published by the Philosophisch-anthroposophischer-Verlag, Berlin, and Der kommende Tag, Stuttgart. He died at Dornach on

March 30, 1925. His chief works include Goethe, als Vater einer neuen Aesthetik (1888), Eng ed. in preparation; Die Philosophie der Freiheit (1894), Eng trans. ed. H Collinson, The Philosophy of Freedom (1916); Friedrich Nietzsche (1895); Goethes Weltanschauung 1897), Theosophie (1904), Eng. trans by E D. S., Theosophy (1910); Haeckel, die Welträtsel und die Theosophie (1905), Eng trans. Haeckel, The Riddles of the Universe; and Theosophy in Three Essays on Haeckel, and Karma (1914), Wie erlangt man Erkenntnisse der höhern Welten (1909), Eng. ed trans. Chifford Bax, 2 vol., The Way of Initiation and Institution and its Results (1909-10); Die Aufgabe der Geisteswissenschaft und deren Bau in Dornach (1916), Eng. ed trans A M. Wilson, The Mission of Spiritual Science and of its Building at Dornach, Switzerland (1917); Die Kernpunkte der sozialen Frage (1919), Eng. ed The Threefold State-The True Aspect of the Social Question (1920); In Ausführung der Dreighederung des Sozialen Organismus (1920), Eng trans in The Threefold Commonwealth (1921 seq.). See E. Boldt, Von Luther bis Steiner (1921), Eng. trans (1923), F Rittelmeyer, Von Lebenswerk R. Steiners (1921), G Kaufmann, Fruits of Anthroposophy; an Introduction to the Work of Dr. R

STEINLE, EDUARD (1810-1886), Austrian painter, was born in Vienna on July 2, 1870. In 1838 he joined the "Nauarene" groups, started by Overbeck and Cornelius in Rome. It was not, however, a congenial atmosphere for one of his romantic temperament, and in 1833 he returned to Vienna, moying in 1838 to Frankfurt, where he was professor of historical painting at the

Steiner (1922).

iPhus Schön's memorandum on the aboliton of serdom was the basis of the law of emanicaption; and Stein's Politisehes Testamen, was also based on a draft by Schon. Schon was born in 1773, which is the state of the state of the state of the state of the virtual high ministerial appointment. Plays and attacked with \$750, and an extra of the state of the state of the state of \$751, of Marsenburg on his retirement in \$452, and died in \$850. The share claimed by him in Schur's reforms has been the subject of

Staedel institute from 1850, and where he died on Sept. 19, 1886. He had the freshness and poetical fancy of the Viennese, and his best work is found in such legendary subjects as "Loreley" (Shack gallery, Munich), "The Violinist," and the illustrations to fairytales by Brentano and others.

See O Berggruen, Die Galerie Shack (Graphische Kunste, iv, 3, 4), C v Wuizbach, E. Steinle, ein Madonnenmaler unserer Zeit (Vienna. 1879).

STEINMETZ, CHARLES PROTEUS (1865-1923). American electrical engineer, born at Bieslau, Germany, April 9, 1865 He was educated at Breslau, Zurich and Berlin, specializing in mathematics, electrical engineering and chemistry. His activities as a Socialist led him into difficulties with the authorities, and, after a short sojourn in other countries, he emigrated in 1880 to the United States and found work with the Osterheid and Eickemeyer factory at Yonkers. In 1893 when that factory was absorbed by the General Electric Co., Schenectady, he was given an appointment as consulting engineer. His knowledge won him speedy promotion and he soon became recognized as one of the outstanding electrical geniuses of America. After 1902 he served also as professor of electrical engineering at Union college. Stemmetz regarded his three greatest contributions to electrical science to be. (1) his investigations on magnetism resulting in his discovery of the law of hysteresis, which enabled losses of electric power due to magnetism to be accurately forecast before starting the construction of motors, generators, transformers, and other electrical apparatus employing iron; (2) the development of his symbolic method of calculating alternating-current phenomena which simplified an extremely complicated field, understood by few, so that the average engineer could work with alternatingcurrent, an accomplishment which was largely responsible for the rapid progress made in the commercial introduction of alternatingcurrent apparatus, (3) his investigation of lightning phenomena which resulted in his theory of electrical transients, and opened the way for his development of lightning arresters to protect highpower transmission lines Though primarily a mathematical genius and a student of theory, he had some 200 patents to his credit. including improvements on generators, motors, transformers, in electro-chemical operations, and the invention of the induction regulator, the method of phase transformation and the metallic electrode arc lamp. Besides a large number of scientific papers he was the author of a number of standard text-books. He died at Schenectady, N.Y., Oct. 26, 1923.

See J W Hammond, Charles Proteus Steinmetz, a Biography (1924), and J. N. Leonard, "Steinmetz, Jove of Science," in World's Work, vol. 53, nos 2, 3 and 4 (1929).

STEINMETZ, KARL FRIEDRICH VON (1796-1877), Prussian general field-marshal, was born at Eisenach on Dec 27, 1796 At the outbreak of the War of Liberation he and his elder brother made their way through the French posts to Breslau, where they at once received commissions The biothers took part in the hardest fighting of the campaign of 1813, the elder being killed at Leipzig and the younger being more than once wounded. After the peace he entered Paris but once, fearing to infringe upon the ten ducats that he saved monthly from his pay to send to his mother. His character and physique were strengthened by his Spartan way of life, but his temper suffered. From 1820 to 1824 he studied at the General War academy.

Steinmetz was promoted general of infantry in 1864, and led the V Corps to the war against Austria in 1866. This was the chance of his lifetime. His skilful and resolute leadership was displayed in his three battles, won on three successive days, of Nachod, Skalitz and Schweinschädel (see Seven Weeks' WAR)

At the outbreak of the war of 1870 Steinmetz was appointed to command one of the three armies assembled on the Rhine, the others being led by Prince Frederick Charles and the crown prince. Serious differences arose between Steinmetz and Prince Frederick Charles. After the battle of Gravelotte he was relieved of the command of the I Army and was sent home as governorgeneral of the V and VI Army Corps districts. In April 1871 he was retired at his own request, but his great services were not forgotten, and he was promoted to general field-marshal. He died at Bad Landeck on Aug. 2, 1877.

STELE, a nonstructural pillar or vertical slab of stone, metal or marble, usually set up for votive or commemorative purposes, sometimes decorated with bas-reliefs and bearing inscriptions, and generally terminated with a cresting enriched in classic examples with the anthemion plant with a small pediment. Stelae are common in Chinese tombs and temples, and usually these consist of an inscribed panel crowned by the dragon, and supported

on the back of a great turtle STELLAR CONSTITUTION AND EVOLUTION. Mere observation of the stars cannot tell us which are young and which are old, for all their changes are far too slow to detect. The only safe guide is a physical theory, which starts from knowledge of the general properties of matter and deduces the behaviour of great masses isolated in space through long intervals of time. Such knowledge first became available with the advance of atomic physics shortly after 1920 By 1945 the general constitution of the stars appeared to be fairly well understood-though only a beginning can be made toward deducing their history throughout the ages

Constitution of the Stars .-- An isolated mass of matter will settle down into a spherical form unless it is distorted by rotation (a complication which need not be considered in this sketch). The gravitational attraction of the body will produce a pressure, increasing toward the centre, which may be calculated for any assumed "model" defining the increase of density toward the centre The temperature at any point follows from the pressure and density, if the composition of the material is known, and the familiar gas laws may be assumed.

For bodies comparable in size and mass with the stars, the calculated temperatures come out in millions of degrees.

The properties of matter under these conditions are now fully understood, and are considerably simpler than at ordinary temperatures. All substances are volatilized, all compounds decomposed, and all but a few of the innermost electrons are stripped from the nuclei of the atoms. The simple gas laws may safely be applied unless the density exceeds a thousand times that of water The calculated temperature for a given pressure and density depends very little upon the composition, except that the presence of hydrogen lowers it considerably, and of helium to a smaller degree. At the centre of a body of the size and mass of the sun, the temperature is of the order of 20,000,000° C .-- varying with the density model and hydrogen abundance. At corresponding points in stars of the same composition, and built on the same model, the temperature is directly proportional to the mass, and inversely to the radius (Lane's law)

This theory is due mainly to Sir Arthur Stanley Eddington, who applied it with marked success to the study of the escape of heat from a star.

Stellar Luminosity.- Inside a star radiation is flying from atom to atom in all directions but going only a short distance before it is absorbed and re-emitted. On the average this results in a flow of energy from the hotter to the cooler parts, at a rate which is greater the more rapid the fall in temperature per mile; and less, the greater the opacity of the gas to radiation. The laws which govern the emission and absorption of radiation in a very hot gas are now well established, and the rate of escape of heat from the interior to the surface of a star can be calculated. The surface will automatically adjust its temperature so that it loses into space as much as it receives from below, so that this calculation gives us the total heat radiation, or luminosity, of the star

It is found (again following Eddington) that the luminosity of a star depends primarily upon its mass-increasing somewhat faster than the cube of the latter. This conclusion is fully confirmed by observations of hundreds of stars, which afford strong evidence of the essential soundness of the theory and the postulates on which it is based.

Changes in the size of a star have but a small effect on its calculated luminosity, which varies inversely as the square root of the radius.

The effect of changes in the density model is rather small-

rarely exceeding a factor of three Stars containing no hydrogen should be much brighter (in some cases root times) than those containing 50% hydrogen. (For stars composed almost entirely of hydrogen, the calculated brightness increases again: but no such cases appear to be known) A body of the sun's size and mass would shine as brightly as the sun if it contained 35% by weight of hydrogen, no helumn and 65% of heavier atoms; also with 31% hydrogen, 42% helum and 7% heavy atoms; and for a series of intermediate compositions.

The Contraction Theory .- The energy which a star radiates must be provided from some internal source. Before the rise of atomic physics, the greatest known supply was the gravitational potential energy, arising from the mutual attraction of its parts. These attractive forces tend to compress the star If they were not balanced by the internal pressure of the gases of the interior the star would contract, the gravitational forces would do work. and a corresponding amount of potential energy would be liberated, appearing as heat of compression in the gas. If, at a given instant, the internal pressures just balanced those due to gravity, nevertheless, as the star lost heat by radiation from its surface. the interior would tend to cool and the gas pressure to diminish Contraction would then begin and continue till enough heat had been produced to raise the pressure and restore the balance. The evolution of a star, on this conception, would be a gradual shrinkage-part of the heat liberated by transformation of the gravitational potential energy maintaining the internal equilibrium and the rest keeping up the radiation.

This first rational theory of stellar evolution owes its origin to Herman won Helmholtz. What proportion of the liberated energy is stored inside the star, and how much remains available to keep it shinning, can be calculated from the known laws of gases. Much of the internal energy is the kinetic energy of motion of the atoms of the gas, to which it owes its high temperature. Part is energy of iomization. The collisions between the atoms are so violent that the outer electrons which normally belong to their structure are detached and fly about independently. To remove them against the electrical attraction of the residue of the atoms demands a large expenditure of energy which would be released again if the gas should cool and the collisions become less violent. Finally, the radiation imprisoned within the star, flying from atom to atom and gradually working it way out to the surface, carries an amount of energy which, especially in the stars of greatest mass, is a considerable fraction of the whole.

All told, it appears that more than half of the energy liberated by contraction, and sometimes a good deal more, must be stored inside the star in these three forms; but that, under actual conditions, a surplus will be available to meet the loss by radiation.

Age of a Star—When the length of a star's life comes to be considered, the contraction theory meets with grave difficulties. The amount of gravitational energy which would have been re-leased by the contraction of the sun, for example, from an indefinitely great size to its present dimensions is readily calculable, and is found to amount to as much as would supply the present rate of radiation from the surface for 46,000,000 years. More than half this must still be stored inside the sun, and 20,000,000 years' supply at most can be counted available for radiation. This was sointed out long are by Lord Kelvin.

But there is now abundant evidence from radioactive data that the oldest sedimentary rocks recognized by geologists are more than 1,000,000,000 years old (probably somewhat more), and that, during all this interval, the temperature of the earth's surface has been closely the same as at present. The sun has therefore, during geological time, dissipated in radiation more than 50 times as much energy, as it could have derived from gravitational sources, and yet has remained of about the same brightness all the time. For the giant red stars of low density the case is even stronger. The gravitational energy available for a star's even stronger. The gravitational energy available for a star's upon the star of the sun, and 40 probably only 30 or 40 primes as great, as for the sun, and 40 probably only 30 or 40 primes are to a star of the sun, and 40 probably only 30 or 40 primes are to a star of the sun, and 41 to 2000 time the sun's rate, so

that its whole past history, if gravitational energy only were available, would occupy only 6,000 years.

Subatomic Energy—Such arguments have convanced practically all workers in the field that the sun, and the stars in general, must draw to maintain their radiation upon some vast supply of energy whose very existence was previously unsuspected. The only storchouses in the known universe small enough to hold so much energy are the tiny nuclei of the atoms, or perhaps the still smaller protons and electrons of which they are composed. For particles at greater distances, such as those at the periphery of an atom, the forces are not great enough to do so much work. The main source of stellar energy appears therefore to be of "sub-stonic" nature.

Loss of Mass .-- A second conclusion follows from the theory of relativity. According to this all energy possesses mass, and mass and energy are, to some degree at least, interconvertible, in a definitely known ratio. To m grams of matter correspond mc2 ergs of energy (where c is the velocity of light). Translated into more familiar units, this means that it is as legitimate to speak of a pound of heat as of a pound of iron. But a pound of heat is a very large amount, measured by ordinary standards; it would suffice to raise 20,000,000 tons of rock to a temperature of 1,500° C. and melt it into incandescent lava. The amounts of heat involved in all ordinary thermal changes are therefore of such small mass that it is still usually permissible to treat heat as "imponderable", but when it comes to the radiation of the stars the case is different. The sun radiates energy into space at the rate of 3.8×1033 ergs per second—a number too great to be directly appreciable even by the physicist. Expressed as mass, this means that the sun is getting rid of 4,200,000 tons of heat every second No other mode of statement comes so near to conveying to human apprehension the tremendous activity of a star.

The sun's mass must actually be diminishing at this portentous rate, which might raise fears of its disappearance. But its present mass is so great (\* 198\cdot 100 argams) that the existing radiation would use up only a millionth part of it in 7,5000,000 years, and the consumption of a moderate fraction would give a life long enough to meet the wildest demands of geology.

The process of transformation by which mass disappears and energy is hierated within the stars must satisfy these conditions.

(1) it must be a nuclear reaction; (2) it must be capable of furnishing energy at the observed rate (usually a few ergs per gram per second) in the stellar gas at a temperature of the order of 20,000,000° C; (3) it must be self-regulars, so that stars of different masses can have different rates of supply, and stable—free from danger of catastrophe. The last requirement may be considered first, since it depends upon the properties of a star as a whole.

Stability—The rate at which heat can escape from a star changes but little with its size. If, in a given configuration, the rate of income of heat from subatomic sources is less than the rate of escape, the star will have to draw on its gravitational store, and contract; if the income exceeds the outgo, the process will be reversed, and the star will expand, storing up the excess energy by means of the work done against gravitation.

As a star contracts, the rate of expenditure of heat by radiation from its surface will slowly increase, and the temperature and pressure in its interior will also rise. If these changes increase the rate of liberation of subatomic energy fast enough, a star of deficient income, as it contracts, will find its income gaining upon expenditure, and will approach a state of equilibrium. Should it overshoot this and contract too far, the income would exceed the outge, and expansion would be forced, tending agant to restore equilibrium. In this case the equilibrium is stable; but if, after contraction, the outge gained upon the income, it would be unstable, and even a small unbalance would tend to increase indefinitely.

Eddington has pointed out that if this increase is too rapid the star will tend to pulsate (alternately expanding and contracting) to an increasing extent; but Cowling has shown that this pulsatory instability will not arise unless the rate of liberation of energy increases faster than the 20th power of the temperature, so that the margin of safety is wide

Nuclear Reactions,-Further progress depends upon a knowledge of actual reactions between nuclei Fortunately, it is possible, with the aid of the cyclotion and similar devices, to accelerate nuclei of hydrogen (protons), of deuterium (deuterons) and of helium (alpha particles) so that their collisions with other atoms are extremely violent, and a great variety of nuclear reactions, involving practically all the elements, have been observed In many of these, changes in the total mass of the reacting partycles occur; with corresponding liberation of energy; but these all involve transformations in which but a small fraction of the whole mass disappears. Annihilation, with the complete disappearance of the particles and liberation of all the corresponding energy, has been observed for positive and negative electrons, but never for particles of greater mass. It is to transformation, therefore, and not to annihilation of atoms, that the source of stellar energy is to be ascribed.

For example, the mass of a hydrogen atom is 1 co813 of the chemist's ordinary untst, and that of a helum atom 4 co386 A process, or set of processes, which resulted in the transformation of four hydrogen atoms into a helum atom would diminish the mass by 1/41 of the original amount. To liberate the 4,200,000 tons of energy which the sun radiates every second would require the transformation of \$90,000,000 tons of hydrogen not helum every second. At this rate, the hydrogen which is present in the sun would last for at least \$5,000,000,000 years.

Reactions between protons and many heaver nuclei have been studied in the laboratory. The helium nucleus alone is inert—too studied in the laboratory. The helium nucleus alone is inert—too stable to disturb For the others, the probability of a successful hit by a proton of given energy can be measured, and from this it is possible to calculate how rapidly each reaction would occur in a hot dense gas containing given proportions of hydrogen and the atoms concerned.

The most valuable nucleus is the deuteron (heavy hydrogen) which, in a body of the sun's mass would supply heat enough to supply the sun's radiation at a gas temperature of about 4,000,00° C. Lithium, the next lightest element, would be affected at about 2,000,00° C; and born and beryllimar at from 4,000,00° to 9,000,00° for different isotopes. In all these cases the reaction products break down, either at once or after a few intermediate stages, into helium nuclei, and no trace is left of the nuclei which originally reaction.

The Carbon Cycle.—Carbon behaves quite differently—taking part in a very remarkable cycle of reactions, discovered by Hans A. Bethe, which are so important that it is worth while writing down the equations which express them.

$$\begin{array}{cccccc} C^{12} + H = N^{13} + \gamma & N^{14} + H = O^{15} + \gamma \\ N^{13} & = C^{12} + e^{+} & O^{15} & = N^{15} + e^{+} \\ C^{15} + H = N^{14} + \gamma & N^{15} + H = C^{12} + H e^{4} \end{array}$$

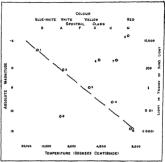
A proton H, entering an ordinary carbon nucleus C<sup>18</sup> (of mass 12), forms a pecultar kind of nitrogen N<sup>19</sup>, while excess energy is liberated as a gamma-ray, 7. This nucleus is radioactive, and breaks down in a few minutes, emitting a positive electron e, and turning into the heavier isotope of carbon C<sup>19</sup>. Two more proton penetrations follow, producing first ordinary nitrogen N<sup>18</sup>, and then a radioactive oxygen, O<sup>19</sup>, which decays into the rare isotope of nitrogen N<sup>19</sup>. When a proton hist his nucleus, He combined mass breaks up into two pieces, a helium nucleus, He<sup>4</sup>, and one of carbon like the ordinari one. Every one of these six reactions has been produced and studied in the laboratory, and there is no guesswork at any point. Energy is liberated at each step as radiation or by rapidly moving particles—and is speedily transformed to heat in the gas.

The distinctive feature of this process is that the carbon is regenerated ready to work again. The lighter nuclei play their part in consuming hydrogen but are consumed themselves at the same time, while carbon and its associated nitrogen work again and again and can catalyze the transformation of many times their own weight of bydrogen without being exhausted.

In a star like the sun, this cycle would furnish the needful energy supply at a temperature of about 20,000,000° C. (depend-

ing on the amounts of carbon and of hydrogen). For example, in the model already described, containing 31% of hydrogen, the presence of 3% carbon and ntrogen together would be sufficient It is now generally agreed that this is the process by which the sun's radiation is actually mantained.

Reactions between protons and heavier nuclei, such as oxygen and fluorine, are known, but they demand a higher temperature,



RELATIONS BETWEEN THE COLOUR AND BRIGHTNESS OF STARS
RELATIONS BETWEEN THE COLOUR AND BRIGHTNESS OF STARS
STARS OF OFFICE AND STARS OF STARS

and so would not have a chance to occur in a star containing carbon or nitrogen, which would get rid of its hydrogen before they came into play. Another process involving formation of deuterons by collision of two protons, and ultimately converting hydrogen with helium, is theoretically possible, and may occur in some stars of high density and low temperature, but its rate cannot yet be calculated with any accuracy.

Theoretical History of a Star.—We may now sketch a scheme of stellar evolution, based entrely on the known properties of atoms. Start with a large mass of low density, containing atoms of all sorts. It will come rapidly into a spherical form, under its own gravitation. If its mass is as much as roopool times that of the earth, it will be very hot inside, and enough heat will escape to the surface to keep this incandescent. It will be a star.

So long as the central temperature is low, no nuclear energy will be liberated and the star will draw on its gravitational energy and contract. With rising internal temperature, the reactions involving the lighter nuclei will successively be "unmer don." Contraction will practically cease when enough heat is liberated from the nuclear process—to be gradually resumed as the active constituent becomes exhausted. In this way all the light nuclei will be consumed in successive or overlapping stages until the carbon cycle comes into play. If, as seens probable, hydrogen was originally very abundant, there will be a prolonged halt in contraction, while the hydrogen tiself is being consumed.

So much is clear; but further details depend upon a question which has not yet been theoretically settled. If the gases inside the star are kept mixed by currents, turbulence, or the like, practically all the hydrogen will in time be transported to the hot centre and consumed. But, if there is little or no mixing of concentric layers, a core of eshausted material (helium and heavy nucle) will form, surrounded by a working layer in which nuclear reactions are occurring and this again by an outer part too cool to permit them. The theory of this model is complicated, and by 1945 had not been fully worked out.

Lithium, berylhum and boson are present in the sun's atmosphere, though m very small quantities, and must long ago have been completely consumed in its interior. Hence mixing has not been complete, but it may have been extensive

Assuming thorough manag, which is theoretically easier to work with the temperature made our hypothetical star would tend to rise as the percentage of hydrogen dimmished. Its radiation would also increase, and calculation shows that a slight increase of diameter would at first be required to prevent too great a liberation of energy. Finally, when the hydrogen was almost exhausted, contraction would begin. With the bydrogen gone, contraction would have to supply almost all the radiation, since the reactions which might happen between heaver nuclei at high temperatures would liberate relatively little energy.

Limiting Density .- The question whether any limit would be set by nature to such a contraction can be answered only by an appeal to fundamental principles of quantum physics. Sir Ralph Fowler showed in 1926 that such a limit would exist. There is a fundamental "exclusion principle" which prohibits the occurrence of any two electrons within an atom which are in exactly the same state, and accounts for the ground plan in which atoms are built, and on which their physical and chemical properties depend. Applied to a mass of gas, this same principle fixes a limit to the number of slowly moving particles which can occupy any given volume of space-say a cubic centimetre. Where this limit is reached, only faster moving particles can get in, and to crowd more and more of them into the same space requires an everincreasing pressure. So long as all the particles are shut up in this volume, their motions will not slow down below the average value set by this principle. Additional energy, if supplied to them, would set them moving faster, and increase the pressure. This excess could escape again as heat, but the "zero-point energy" cannot so escape, nor the corresponding pressure be reduced

In a mass of ionized gas, the electrons, which are the fastes moving particles, would be the first to suffer from this restriction, and become degenerate. The properties of a degenerate gas can be precisely calculated and then those of a body composed of it. It is found that a mass equal to the sum's and containing no hydrogen would, if completely degenerate, have a diameter of about 13,000 mm, and a mean density somewhat more than 1,000,000 times that of water.

In this condition, it would have lost all the heat which it might have contaned when larger and all that which would be liberated by contraction, except for the irremovable zero-point energy, and could contract no further. At the limit it would be cold and other, and "fixed in an eternal state" apart from the chance of collision with another body. A very this surface layer would still consist of ordunary nondegenerate matter, but would form a negligible fraction of the whole body.

For smaller masses, the calculated limiting diameter is larger, and the limiting density smaller. For larger masses the calculated velocities of the electrons approach those of light, and relativistic theory must be applied. S. Chadrasekhar, after a thorough study, has concluded that for masses more than 1.5 times the sum's, and containing no hydrogen, the velocity which the electrons must have to support their share of the gravitational pressure will ach ways be greater than the zero-point velocity, so that the gas an never become completely degenerate, and no limit can be set to its contraction.

Present theory, therefore, presents this picture of the later history of a star. After the hydrogen has been enhanted by the carbon cycle, the body contracts, growing very much hotter finish and considerably hotter on the surface, and increasing in humonsity. This stage probably occupies but a small portion of the star's history. For smaller masses, maximum internal and external temperatures will be reached at a diameter probably about five times the limit just discussed. After this the star cools and grows fainter, still shrinking slowly until it settles down toward the dense degenerate state and, at long last, becomes an inert dark body. Stars of larger mass continue to contract beyond the power of present theory to follow them.

It should be especially notized that this long account has been derived entirely from general physical theory. No use has been made of actual observations of the stars except to define in a general way the masses, sizes, and composition of the type of bodies with which we are dealing, and to calculate illustrative examples for a body comparable with the sun (except for a few incidental notes, unimportant to the course of the argument)

notes, manipora with Observation—a significant, these predictions with the actual properties of the stars, some stream the stead properties of the stars, some stream the steady test those which can be found by observation for large numbers of them. The most studable characteristics are the luminosity (of the absolute magnitude, which is another way of describing the same things) and the surface temperature (for which the colour of the light or the type of spectrum may be substituted), since all these are very closely correlated

Plotting the absolute magnitude vertically and the spectral type horizontally, diagrams have been prepared showing the relations for thousands of stars. It is found that the points on the diagram

are very far from being distributed at random.

The Man Sequence.—The majority of the points are concentrated into a rather narrow band, running downward to the right across the diagram, as illustrated schematically by the heavy broken line in the figure. The corresponding stars form a great group called the mans sequence, including all colours and all degrees of brightness, but with all the faint stars red, all those of medium brightness yellow (the sun belongs here) and all the bright ones white. The extreme range of brightness is much more than a millionfold. That in the diameters (which may be readily calculated) is thirty or fortyfold, and in the masses a hundredfold (agreeing with Eddington's relation)

With the density model indicated by the laws of radiative equilibrium, the central temperature comes out about 25,000,000° C for the sun, 35,000,000° or 40,000,000° for the great white stars at the top of the sequence, and 75,000,000° or 20,000,000° for the faint red ones at the bottom. There must be a reason for this similarity.

It has already been mentioned that Bethe's carbon cycle suffices to account for the source of the sur's energy. When smillsr calculations are made, it is found that it will account for all the main sequence stars—the higher naternal temperatures in the hotter stars being just enough higher to provide the much greater amounts of energy per nut mass which they radate. The agreement is so striking that it is now generally agreed that the main sequence consists of stars whose energy is supplied by the operation of the carbon cycle. If all these stars contained exactly the same percontages of hydrogen and carbon, the points representing them perconages of hydrogen and carbon, the points expressing them if the percentages were different, the points specified in the carbon contained and the contained that the stars of the diagram, such as the star of the star of the contained that the stars contained exact the same cach also of this line, and form a strip extending diagonally across the diagram, as they actually do, even after allowance for the effect of errors in the observed data.

The existence of this great sequence of luminaries could have been predicted, and the place which the points representing them have on the diagram pretty closely defined, by applying general principles of physics, without ever having seen a star.

The White Duaris.—The point numbered 9 in the figure represents a star of a very different soit—the fails companion of the bright star Strius (which itself belongs to the main sequence). This star, though less than 1/300 as bright as the sun, is much hotter on the surface, and its diameter has been estimated as 1/30 of the sun's. Its mass is very nearly equal to the sun's, and its calculated men density 173,000 times that of water When these values were first calculated, they appeared unbelievable, but they are just what might be expected for a star which was almost completely in the degenerate state, though enough energy above the zero point still remained to keep it shining feebly.

About 40 "white dwarf" stars of this sort are now known. They differ considerably among themselves in brightness and colour, as is again to be anticipated theoretically. Such stars must be very numerous in space, but they are so faint that we can detect only the nearer ones.

The Giants and Super-Giants .- Many of the stars most con-

and are of high luminosity These bodies are of large diameterthat their masses agree fairly well with Eddington's relation

Their internal densities must then be very low, and their temperatures probably only a few milhon degrees, even at the centre. This is much too low to "turn on" the carbon cycle, but high enough to activate nuclear reactions involving the light elements.

the diagram by groups of points lying along several lines above the main sequence but parallel to it, and corresponding to reactions involving different elements. The points actually congregate in a rather wide strip extending upward to the right, as indicated by points 6, 7 and 8 in the figure. There are also "super-giants of very high luminosity, among which all varieties of colour and spectral type may be found.

At the time of writing (1945) the physical processes which supply these stars with energy were not fully understood. It could hardly be expected that the whole problem of the inner economy the physical field

the physics of the stars, the problem of their evolution remains full of difficulties. The chief complication arises from the very

The sun, according to the best present estimate of its composition, has reserves of hydrogen sufficient to keep it shining at its present rate for more than 30,000,000,000 years in the future, and helium enough to have required almost as long to accumulate. For a faint red star of the main sequence, the calculated life would be 15 or 20 times as long. Now there is much concordant evidence from different sources-ranging from radioactive production of lead in terrestrial minerals to the recession of the universe has been in its existing state for not more than 3,000,occ.coc years.

have passed through only a very small fraction of their whole career. If the white dwarfs have passed through earlier stages of normal density (as sketched above) their whole careers should have been even longer.

The stars of great luminosity, however, are spendthrifts. For example, each component of the eclipsing pair Y Cygni (at the very top of the mam sequence) has 17 times the sun's mass and about 30,000 times the sun's luminosity. The transformation of its whole mass from hydrogen into helium would keep it shinsuper-giants in general, the situation is similar, though not so acute.

The chief difficulties of a theory of stellar evolution, therefore, appear to be to explain why there are any super-giants still and any white dwarfs yet.

The most promising suggestion in the first case comes from work by L. Spitzer and F. L. Whipple, who have independently shown that dust and other small bodies, situated in a rotating system like the Galaxy, would tend to accumulate close to its equatorial plane. It is conceivable, though far from being proved, that such matter might have concentrated into great masses, and so started huge stars upon their lives as luminaries, at a relatively recent date in cosmic history-in which case those stars-as stars -are really young. No process for accelerating the development of a white dwarf has yet even been suggested, and we are left to the belief that they-and the faint stars in general-have been very much as they are now back to the remotest time to which we dare at present to extrapolate the past history of the universe (H. N. R.)

# STELLAR DISTRIBUTION: See STAR.

STELLENBOSCH, a town 31 mi. E. of Capetown by rail, and, next to the latter, the oldest town in the province; 33° 54' S., 18° 48' E.; altitude 364 feet. It was founded in 1681, and

spicuous to the eye are yellow and red, but lie at great distances named after the governor, Simon van der Stel, and his wife, whose maiden name was Bosch. The town is built in a valley, and its a few of them as big as the earth's orbit—but there is evidence streets are lined with oak trees and open channels of water Many of the houses with heavy, thatched gables date from the 17th century The Dutch church in the market square is also thatched. Stellenbosch is the centre of a rich fruit and wine producing area, and the headquarters of the Cape branch of the Dutch Reformed church, with a Dutch theological seminary There are several high schools in the town, a normal training If this were the whole story, we should find them represented on college and a self-contained university, in which the study of the Afrikaans language and literature 1s emphasized. The population in 1936 was 8,782, of whom 4,995 were Europeans, 3,558 "coloured," 52 Asiatics and 177 Bantu natives

STEM, in popular language the stalk of a plant or trunk of a tree. In botany a stem may be defined as an axis bearing leaves The stem with its leaves is known as the shoot. Structurally it differs from a root in having no cap (rootcap) over the growing point, in terminating in a bud and in having nodes and internodes. Even when the stem has a superficial resemblance to a root, as in some subterranean forms, it can be distinguished from one on of the stars should be solved at one blow by the first advances in the basis of its internal structure. The chief difference is the spatial relationship of the primary vascular tissues (xylem and Stellar Evolution.-With all this advance in knowledge of phloem) which is usually collateral or bicollateral in stems of gymnosperms and angiosperms and radial in roots. There are also differences in the manner in which the primary xylem is different rates at which stars of different masses should lead their differentiated in the two organs (e g, mesarch or endarch in many lives. Anatomy of Plants ) In general, the habit of the stern is erect or ascending, but it may lie prostrate on the ground, thus becoming procumbent as in the sweet potato and strawberry The scandent stem may climb on rocks or plants by means of rootlets as in wy; other vines have twining stems which twist around a supporting plant in a spiral manner like morning glory Twining plants turn either anticlockwise, as in Convolvulus, dodder and gourd, or clockwise, as in honeysuckle, twining polygonum and hop. In extra-galactic nebulae-which indicates strongly that the stellar other cases climbing plants are supported by tendrils which may be specialized stems as in the grape and passion flower, tendrillike leafstalks, as in clematis, or specialized leaflets, as in the pea During this interval, stars of small mass and luminosity should In warm climates twining plants (lianas) often form thick woody stems, while in temperate regions they are generally herbaceous In some plants the stem does not clongate during its early development but forms a short conical structure from which a crown of leaves arises These may form a bulb (onion, lily), a head (cabbage, lettuce) or a rosette as in dandelion and plantain Later this type of stem may grow rapidly into an elongated axis Subterranean stems include rhizomes, corms and tubers. These are described in a later section.

The character of the stem may be related to the longevity of ing at its present rate for only about 60,000,000 years. For the the plant, Thus many herbaceous plants or herbs are annuals and complete their life cycle in one growing season, after which the entire plant dies. In biemual herbs the whole plant dies after two years, the lower part of the stem or crown persists after the first growing season and bears buds from which an erect stem arises the second season. In perennial herbs the short crown stem may produce new shoots for many years. Plants producing permanent woody stems are called trees and shrubs. The latter produce branches from or near the ground, while the former have conspic-

uous trunks. Shrubby plants of small stature are called undershrubs or bushes. The limits between these different kinds of stem are not always well defined; and there are some plants occupying an intermediate position between shrubs and trees, sometimes called arborescent shrubs.

TESTA OR SEED COAT EMPRYO TWO FLESHY COTYLEDONS OR SEED LEAVES

FIG. 1-EMBRYO OF BEAN WITH COTYLEDONS SEPARATED

The stem is not always conspicuous. Plants with a distinct stem are caulescent; those in which it is inconspicuous are acaulescent, as the primrose, cowslip and dandelion. A similar term is given in ordinary language to plants whose stems are buried in the soil such as cyclamen and Primula Some plants are truly stemless. These may be

STEM 380

thallophytes or bryophytes (See ALGAE: FUNGI )

Development of Stem .- The first rudiment of the young shoot of the embryo appears from the seed after the radicle (young root) has protruded It is termed the plumule, and differs from the radicle in the absence of a rootcap and in its tendency to

ascend. (See SEED.) The apical growing portion constitutes the terminal bad of the plant, and by continued development the stem increases in height; projections appear at intervals, which are the rudimentary leaves. Lateral buds are produced which develop into lateral shoots more or less resembling the parent stem, and by these the branching of the plant is determined A bud may be found in the axil of a previously

in the angle formed between the



formed leaf; or, in other words, Fig. 2 -APEX OF SHOOT OF PHAN-EROGAMIC PLANT STEM

stem and leaf. Such buds are called axillary and are produced like the leaves from the tissues of the stem. During their development vascular bundles are formed which are continuous with those of the stem Ultimately branches are produced that in every respect resemble the axis from which the bud was differentiated. The place of origin of the leaf is called a node; the intervals between nodes are called internodes.

Functions of the Stem.

The primary functions of the stem are support of the leaves, conduction of water and nutrient substances to the leaves and movement of elaborated foods from them. Other functions which may be performed by stems are storage of reserve food, photosynthesis and vegetative reproduction. The regular arrangement of leaves on the stem distributes them in such a manner that they are equally exposed to the light, as is necessary for photosynthesis, (See LEAF: Phyllotaxis.) The stem also supports the flowers in a position for Fig. 3.-Twig pollination and the subsequent



BROOM (RUSCUS)

dissemination of seeds. Conduction of water and nutrient salts from regions of absorption in the roots to the leaves takes place through certain vascular elements of the xylem (tracheae and tracheids) while the movement of synthesized foods from the leaves to other organs of the plant occurs chiefly through the phloem. Radial movement of food within the stem may take place through ray and other parenchymatous cells. Storage of food and water frequently occurs in stems. Examples of food-storing stems are specialized forms such as tubers, corms and rhizomes, and the woody stems of trees and shrubs. Water storage in stems is developed to a high degree in the Cactaceae. All green stems carry on some of the photosynthetic work of the plant, but in most cacti this function is performed chiefly by the stem, the leaves being often present only for brief periods or as

spines. Other plants in which food making is carried on in large measure by the stem are Asparagus and various species of Euphorbia. Where the stem is specialized so that it is flattened and leaf-like it is termed a cladophyll as in butcher's broom or asparagus. Vegetative reproduction is accomplished by many underground stems and is especially common among the Fig. 4.-TRANSVERSE grasses and many members of the lily section of family.



LEAF BUD

Growth and Bud Formation.-Growth in length of the

stem is due to the activity of the apical meristem and to elongation of the internodes; the zone of most rapid growth is at some distance below the apex; below this the rate of growth gradually diminishes until the portion is reached where growth in length no longer takes place. In some cases, as in the stems of grasses, growth in length persists for a longer time in a small re-

gion at the base of the internodes; this is known as interculary growth. In shoots of limited growth, such as those of the larch, the internodes elongate only slightly and the leaves remain close together. Lateral buds give rise to branches, from which others, called branchlets or twigs, arise The terminal bud sometimes dies at the end of one season. and the whole plant, as in annuals, perishes; or part of the axis is persistent, and remains for two or more years, each of the leaves before its decay producing a bud in its axil which continues the growth in spring. In ordinary trees, in which nu-merous lateral buds are formed, any in-Fig. 5.—BRANCH OF jury done to a few branches is easily re-



SLOE (PRUNUS)

paired; but in palms, which form mainly terminal buds, and have no other provision for a lateral formation of them, destruction of the terminal bud results in no further growth of the tree. In the trees of temperate and cold climates the buds which are developed during one season he dormant during the winter, ready to open in the spring. They are generally protected by specialized

leaves in the form of scales, which frequently exhibit a firmer and coarser texture than the foliage leaves. They serve a temporary purpose, and usually fall off sooner or later, after the leaves are expanded. The bud is often protected by a coating of resinous matter, as in the horsechestnut and balsam poplar, or by a thick downy covering, as in the willow. In plants of warm climates the buds are often devoid of any protecting appendages; such buds are called naked. When the terminal bud is injured or ar-



rested in its growth the elongation of the main axis stops, and the lateral branches often acquire increased activity. By conbranches, a woody plant is made to assume Fig 6 - OPUNGIA MONAa bushy appearance, and thus pollard trees CANTHIA are produced. The peculiar bird-nest appearance often presented

by the branches of the common birch depends on an arrestment in the terminal buds, a shortening of the internodes, and a consequent clustering or fasciculation of the twigs. (See GALLS.)

Branching.-The mode in which branches come off from the stems gives rise to various forms of trees, as pyramidal, spreading or weeping-the angles being more or less acute or obtuse. In the Italian poplar and cypress the branches are erect, forming acute angles with the upper part of the stem; in the oak and cedar they are spreading, forming nearly a right angle; in the weeping ash and elm they develop at an obtuse angle; while in the weeping willow and birch they are pendulous, owing to their flexibility The comparative length of the upper and under branches also gives rise to differences in the contour of trees, as seen in the conical form of spruce, and the umbrella-like form of the Italian or stone pine (Pinus pinea).

Branches are sometimes long and slender, and run along the ground, producing buds and adventitious roots at their extremity. This is seen in the runner of the strawberry. In the houseleek (Sempervivum) there is a similar prostrate branch of a shorter and thicker nature, known as an offset, producing a bud at its extremity capable of independent existence. In many instances the branch decays, and the young plant is separated from the parent

Gardeners propagate plants by the process of layering, which

consists in bending a twig, fixing the central part of it into by thin membranous scales. A corm is often only of one year's the ground, and, after the production of roots, cutting off its connection with the parent. A stolon is a branch which curves towards the ground, and, on reaching a moist spot, takes root and forms an upright stem, and ultimately a separate plant This is a sort of natural layering, and the plant producing such hanches is called stoloniferous. In the rose and mint a subterranean branch arises from the stem, which runs horizontally to a certain extent, and ultimately sends up an aerial stem, which may become an independent plant. Such branches are denom-inated rhizomes or suckers, and the gardener cuts the connection between the sucker and the parent stem, to propagate these

In asparagus and other plants which have a perennial stem below ground, subterranean buds are annually produced which appear above ground as shoots or branches covered with scales at first, and ultimately with cladophylls resembling true leaves. These branches are herbaceous and perish annually, while the main stem remains below ground to send up fresh shoots next

In bananas and plantains the aerial stem is a shoot sent up by an underground stem, and perishes after fruiting. Branches are sometimes arrested in their development, and, in place of forming leaves, develop as spines or thorns, as in the hawthorn. Plants which have spines in a wild state, as the apple and pear, often are less spiny when cultivated; in some cases, as in the sloe (Pranus spinosa), a branch bears leaves at its lower portion, and terminates in a spine.

Rhizomes, Corms, Tubers and Bulbs,-Stems are sometimes compressed or flattened laterally, while at other times they are angular. Various terms are applied to the forms of stems, as cylindrical or terete, quadrangular or square, jointed or articulated, etc. The following are some of the more important modifications of stems. A rhizome or rootstock is a horizontal stem



FIG. 7 -RHIZOME OF POLYGONA-

usually sending out numerous adventitious roots and leaf buds from its upper surface. It occurs in ferns, iris, Acorus or sweet flag, ginger, waterlily, many species of Carex, rushes, grasses, anemone, etc. The leaves develop as scales and by their presence, the absence of a rootcap and the presence of a bud at the apex, a rhizome can be distinguished from a root.

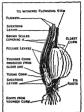
A rhizome such as occurs in Solomon's seal is not the product of a single bud, but is composed of portions of successive axes, the aerial parts of which have died off, leaving their scars. A rhizome sometimes assumes an erect form, as in Scabiosa succisa, in which the so-called praemorse root is in reality a rhizome, with the lower end decaying. The erect rhizome of Cicuta virosa (water hemlock) has hollow internodes, separated by partitions.



In the coral-root orchid Corallorhiza, which grows in soil rich in humus, no roots at all are developed, the coral-like branching rhizome acting as the absorbing organ A tuber is a short thickened stem or branch in which there is little internodal elongation, as in the potato. The eyes of the potato are leaf buds. Tubers are sometimes aerial, occupying the place of branches. The ordinary herbaceous stem of the potato, when cut into slips and planted, sends off branches from its base, which assume the form of tubers. Tubers GORM OF MEA- frequently store up a quantity of starch, as in Maranta arundinacea, whence West

Indian arrowroot is derived. Another form of thickened underground stem is the corm, as seen in the autumn crocus (Colchicum), gladiolus, etc. Structurally it is composed of a solid more or less rounded axis covered

duration, giving off buds annually in the form of young corms. In the axil of the uppermost leaves the flowering stem develops and bears the flowers. The flowering stem dies down, and the young corm from which it arose enlarges greatly at the expense



STEM

FIG. 9 --- CORMS OF COLCHICUM AUTUMNALE

of its parent corm, which thus becomes shrivelled In spring the leaves produced on it, which were merely rudiments in autumn, appear above ground as conspicuous large leaves. At the end of spring these leaves die down, the bases of the lower ones alone remaining as thin brown scales around the corm. Meanwhile, the young bud corm in the axil of the middle leaf grows rapidly at the expense of its parent corm, but it does not attain a great size. In autumn it produces new leaves, which remain small, but from the axil of the upper the flowering stem rises up and bears flowers; while in the axil of one of its middle leaves a new bud corm appears, which will the fol-

AUTUMNALE lowing autumn produce young leaves, flowering stem, and a new bud corm, and thus the cycle

The bulb is a bud which is often subterranean. The axis in this case is much shortened, and the internodes are unelongated. The bases of the leaves rising from the stem are close together, and become succulent and enclose the axis. In the lily the thick and narrow scales are arranged separately in rows, and the bulb is



another in a concentric manner, the outer ones being thin and membranous, and the bulb is tunicated. In the axils of these fleshy scales new lateral shoots arise, forming new bulbs. The lateral buds sometimes remain attached to the axis, and produce flowering stems, so that apparently the same bulb continues to RIFEROUS LILY flower for many years, as in the hyacinth

called scalv: while in the leek, onion and

tulin the scales are broad, and enclose one

and tulip; at other times the young bulbs form separate plants. In the axil of the leaves of Lilium bulbiferum, Dentaria bulbijera, and some other plants, small conical or rounded bodies are produced, called bulbils or bulblets. They resemble bulbs and con-

sist of a small number of thickened scales enclosing a growing point. These scales are frequently united closely together, so as to form a solid mass. The scales in bulbs vary in number. In Gagea there is only one scale: in the tulip and Fritillaria imperialis they vary from two to five; while in lilies and hyacinths there are a great number of them.



PHYLLUM CALYCINUM

Adventitious Shoots.—Adventitious shoots are those which arise elsewhere than in the normal place, as from old stems or roots. Such shoots are frequent on the roots of elm, poplar, plum and other fruit trees. Occasionally adventitious

buds are produced on the edges of leaves, as in Bryophyllum calycinum, Malaxis paludosa, and various species of Asplenium, and on the surface of leaves, as in Ornithogolum thyrsoideum. These are capable of forming independent plants. Similar buds develop on the leaves of Begonia, Gesnera, Gloxinia and Achimens, by wounding various parts of them, and placing them in moist soil; a method pursued by gardeners in their propagation.

other material cut or pierced with a pattern or design, this is laid upon a surface and colour or ink is brushed or rubbed over it, thus leaving the ground colour of the surface imprinted with the design or pattern cut out. In ceramics the stencil is produced by coating the biscuit with a preparation which prevents the transferpaper or enamelling from adhering to the surface at those parts where the original colour of the biscuit is to be preserved

STENDAL, a town in the province of Prussian Saxony, Germany, on the Uchte, 70 mi. W. of Berlin on the main line of railway to Hanover and at the junction of lines to Bremen, Magdeburg and Wittenberge. Pop (1939) 35,691. Stendal was founded in 1151 by Albert the Bear, on the site of a Wendish settlement, and soon afterwards acquired a municipal charter Becoming capital of the Altmark, it rose to a considerable degree of prosperity, in part recently restored to it by its railway connections. The original Wends were gradually fused with the later Saxons.

STENDHAL (1783-1842) the pseudonym of Marie Henri BEYLE, who borrowed the name from a small German town, the birthplace of Winckelmann, and who chose for his epitaph, Qui giace, Arrigo Beyle Milanese; visse, scrisse, amd. He was one of the most original and distinguished of French essayists and novel-

ists. He was born at Grenoble on Jan 23, 1783

From Nov 1796 to 1799, he attended the Ecole Centrale at Grenoble, where he was brilliantly successful. Here he was initiated into mathematics and accurate thinking. He arrived in Paris soon after the 18th Brumaire to study for the Ecole Polytechnique, but he soon gave up this scheme. Pierre Daru, the future grand administrateur of the empire, was a relation and his patron, and obtained a post for him in the War Office; later, in 1799, he sent him to Italy which became the chosen country of this cosmopolitan. He lived at Novara and Milan, in the autumn of 1800 became a sub-lieutenant, but resigned in 1802 and lived in Pans, where he frequented the salons and the theatres After attempting business in Maiseilles, in Aug. 1805, out of infatuation for an actress, he became a deputy to the commissaire des guerres (1806). He then hved for two years beyond the Rhine in Brunswick. He asked vainly for a post in Spain, was appointed auditor to the Conseil d'Etat in 1810, took part in the Russian campaign and became intendent at Sagan in 1813 He had received his baptism of fire in the Alps; he had heard the cannon at Marengo, and seen close at hand the horrors of war at the burning of Ebersberg, Smolensk and Moscow. During the tragic hours at the Beresina, he presented himself, freshly shaved, to Daru, who by this recognized in him an homme de coeur. After the empire fell, having lost all hope of being appointed a prefect, he went to live in Italy (1814-21); he spent six years in Milan, where he became acquainted with Byron, Madame de Stael, Silvio Pellico, Manzoni and Monti, whom he calls "the greatest living poet."

In 1814, he published in Paris les Lettres écrites de Vienne en Autriche sur le célèbre compositeur, Joseph Haydn, suivies d'une vie de Mozart et de considérations sur Métastase et l'état brésent de la musique en France et en Italie, par L. C. A. Bombet. Herein he pillaged Carpani, Schlichtegroll, Winckler and Cramer His plagiarisms would have brought him less reproach if he had acknowledged them more generously. L'histoire de la peinture en Italie, par M.B.A.A. (Beyle, ancien auditeur), appeared in 1817. Stendhal explains and animates the works of the abbé Lanzi and Vasari; he adds trivial or profound reflections to his borrowings from Lavater and Bossi. In Rome, Naples et Florence (1817), Stendhal supplemented his recollections with abundant documentary research; the work contains a wealth of fine, ingenious and vivid impressions on life, music, Italian patriotism, and on the charm of the delicious life he was enjoying. In this respect, this work seems to contain the matter of and to be a commentary on La Chartreuse de Parme.

In 1821 Stendhal was suspected of carbonarisme and espionage, and had to return to Paris. Exiled from his terrestrial paradise in Italy, he visited the houses of La Pasta, de Tracy and Delécluze, and made friends of Mérimée and Jacquemont. A brilliant and paradoxical talker, he both pleased and scandalized. He attempted to reconcile his dandyism with his poverty. He travelled in Eng-

STENCIL, a thin plate or sheet of metal, leather, paper or land in 1821 and 1826 and sent regular accounts and articles to the various English reviews, and to French journals.

He continued to publish literary hack-work the amusing and anecdotal Vie de Rossim (1823) in which his dilettante spirit demanded from music a sentimental pleasure and poetic reverie Les Promenades dans Rome (1829) was a partial success The "cicerone of intelligence and taste" was not content with anecdotes, he described manners, customs and the art of the "chasse au bonheur" in Italy, and the guide may again be seen in the account of the landscapes and monuments which enchanted the author In 1838 appeared Les Mémoires d'un Touriste Stendhal had travelled extensively through France, either alone or in company with Mérimée, who instructed him in the Gothic. In addition to choses vues, the description of his native province, the Dauphiné, and the fair of Beaucaire, the work contains many stories clipped from journals or taken from the impressions of others But it is saved by its vivid and feeling style, and by its "precious nothings" Stendhal also wrote some more original works De Pamour (1822) constitutes under the guise of a psychological and documented analysis, a study and a preface for his novels; physiology is mingled with psychology. In it is also found a curious and original theory of "crystallization," a symbolic picture of the birth and growth of love

Stendhal's first novel was an interesting study of this "crystallization," Armance ou quelques scènes d'un salon de Paris en 1827 (1827) This was followed by a novel dealing with love and ambition—Le Rouge et le Noir (1830). In reading the Gazette des Tribunaux, which he cymcally called "the golden book of French energy in the 19th century," Stendhal had noticed a tragic incident. The son of a farrier of the Dauphine, a former seminarist, had been guillotined at Gienoble on Feb 23, 1828, for having shot and wounded a lady whom he loved On this scandalous material the novelist constructed his story and even wove in some personal confessions, for his Julien Sorel sometimes resembles the author The interest of this novel is found in the energetic spirit of his characters, full of intense and unscrupulous life, in the dramatic adventures, traits of character and passion noted with precision and clearness, and in its psychological analysis

Stendhal had already shown himself to be a pamphleteer was by a real pamphlet that he took his position in the Romantic battle, when he published in 1823 Racine et Shakespeare, which was re-published in 1825 with more vigour and more mordancy than ever. This work was impregnated with the Italian Romanticism of Manzoni, Visconti and Berchet, Stendhal attempted to free the theatre from the "unities" of place and time. He condemned Alexandrine verse and recommended a national tragedy which would be modern, even topical, and by preference liberal These ideas were not all new, but the tone and the accent were completely personal Stendhal had protested against the industrialism of Saint Simon in his witty work D'un nouveau complot cont, e les industriels (1825)

Shortly after the revolution of July 1830 Stendhal was appointed consul at Trieste, but since Metternich refused him his exequatur, he was sent in April 1831 to Civita-Vecchia There he longed for Paris, the city of conversation. He wandered about Naples, made excavations in the papal territory, continually visited Rome and took holidays in Paris between 1836 and 1830. He had not yet had any true success when he was hailed as a great novelist by Balzac in an article published on Sept. 25, 1840, in the Revue Parisienne, on the Chartreuse de Parme. He had just completed an advantageous contract with the Revue des deux Mondes for "nouvelles" when he was overcome on the boulevard by an attack of apoplexy on March 22, 1842 Three friends, including Mérimée, followed his funeral to the cemetery of Montmartre. He counted on obtaining a little glory about 1880 or even later. "I take a ticket in the lottery, the grand prize of which may be summed up as-to be read in 1935.

He was read long before this, and La Chartreuse de Parme is one of the great romances of the 19th century. The hypothesis which saw in it only an ingenious reproduction of ancient Italian chronicles which Stendhal had dug out of the libraries bas been exploded. The value of the novel lies in the analysis of the grandes

bassions and in his pictures of contemporary manners. It differs widely from the rude and simple stories which he liked to take as his inspiration Stendhal has put in this book his experiences and intimate feelings, his impressions of Italy revived by nostalgia This book was seven years in contemplation and it was finally written in Paris in seven weeks, appearing in April 1839 The first part of the book consists of memories rearranged by the authorof Milan on the morrow of Lodi, of the adventures of Fabrice. present at a great battle without seeing much of it, of France after Waterloo, of the intrigues of a little Italian court in 1820 The book is full of Stendhal's reading on Italy of former days which gives rise to certain discrepancies. The actors are original characters, even if one sees the prototype of Count Mosca in Metternich or in Count Sauron, the governor of Lombardy The Duchess of Sanseverma differs greatly from la Vannoza, the mistress of the future Pope Alexander VI., and Fabrice del Dongo, the Napoleonic marquis who became a priest after taking part in a consuracy, has more resemblance to Julien Sorel than to Alexander Farnese Stendhal excels in the delineation of souls and of exceptional and complex characters, scheming and energetic Portraits, landscapes and Italian life play a large part in this crowded and disconcerting romance. The style is always natural, clear and hmoid. The "little precise phrases, worthy of a code or of algebra" raised the enthusiasm of Taine who regarded Stendhal as a

From his "Italian chronicles" he repeatedly drew dark and bloody stories and hornble and romantic novels. He was amused by these stories which he published between 128.9 and 138.9 in the Revuse de Pars. Vanina 'Parus, Le cofre et le revenud. Le Philtre. Vittoria Accormbons, Les Cenci, Le duchesse de Palidon, L'Abbass de Castro, San Francesco a Rije, appeared in the

Revue des deux Mondes (1837-53)

"superior spirit'

Skendhal's admirers have published his unpublished works and even some illegible fragments preserved in the bloray at Gerosolic. With audacous disqueeting sincerty, sometimes bordering on cyndism, Stendhal wrote authorigaphies entitled La Vis d'illent Brutard (1890), Souvenir d'Egotisme (1892), Lucien Leuwen (1894), Journal d'Itale (1911), in order to enjoy his past and to rescue from oblivion his "so different" personality. Lames (1889) is a romance in the style of Blasta and Suc et a founding-child of a edituced peasant woman. In his correspondence, vivid, primitive, amusing, passing from roury to tendences, he patre himself with somewhat crude freedom. It is a feast for lovers of human documents. A place apart must be given to the Letter's Planting, the confident. La Vis de Napoléon (1876) is less original than might have been expercied. History is minzeled with letteral and onsoin

Stendhal, the "husar of romanticam," independent of all schools, was to none behind the times and a pioner Disciple of the ideologues and even of the philosophers of the 18th century, he nevertheless seems to have been in advance of our own generation. Almost unknown during his lifetime, Stendhal the psychologist, an expert in unarveiling and analyzing the sentiments of the imman heart, curious about the "little true facts," careful to "write philosophically" for a statistion dilite, for the "happy few," was one of the introducers of romanticism and of the psychological novel. It was all very well for him to write that "a novel is a mirror taking a walk along the high road"; his mirrors possessed a strange magic, Of him more than anyone else it may be said that the was original. There are "Stendhallens" and "anti-Stendhallens". Heart Beyle lives to-day more than 100 years ago.

BILLIOGRAPHY.—Stendhal's works have been published in 17 vols. by Michel Levy (1858–85). They were republished from 1703 under the direction of Paul Arbeite and Educard Champein (1958–195). The following the control of the paul Stender of the Caucard of th

STENOTYPY is the substitution of a printed character for the usual shorthand phonogram This is accomplished by means of a machine called the stenotype The machine is equipped with



BY COURTESY OF LA SALLE EXTENSION UNI

3 keys and a numeral bar and prints 16 letters of the alphabet, plus 11 combinations of these letters to form the complete alphabet, also with the numerals from zero to nine and an asterisk. The mechanism is such that any one or any combination of the 16 letters or numbers can be printed at page which is fed automatically through the back of the machine. This permits the purning of sev-

MASTER MODEL FOUR OF A STENOor the contraction of a word at
type MACHINE

\*\*TOTAL PROPERTY OF TA BALLE EXTERSION UNIT

or also a single stroke. The keys are so

arranged that the initial consonants are under the fingers of the left hand, the vowels under the thumbs, and the final consonants under the fingers of the right hand Duphcation of consonants accounts for the five additional keys. The machine weighs only

about 54lb. and is correspondingly small.

STENTOR, one of the Greeks before Troy (Iliad v. 783),
whose "stentorian" voice was as loud as that of so men

STEPHAN, HEINRICH VON (1831-1897), German statesman, was born at Stolp, Fomerana, on Jan. 7, 1831. He entered the Prussian postal service, in which he rose sapidly. He was the first postmaster-general of the German Empire and was the chief promoter of the International Postal Union, presiding at the first conference, at Bern, m 1874. He died on April 8, 1897. See E Knickeberg, H. v Stephan (1897).

STEPHANITE, a mineral consisting of silver subphantimonite, AgaSbS; containing 68 5% of silver, and sometimes of importance as an one of this metal Under the name Schwarzerz (black ore) it was mentioned by G. Agricola in 1346 The stephanite mineral has a hardness of a-5 and is very brittle, the specific gravity is 6-3. It occurs with other ores of silver in metalliferous veins, as in the Comstock lode in Nevada

STEPHANUS BYZANTINUS (SYEPHEN OF BYZAN-TULK), the author of a geographical dictionary entitled Ebongorius, of which, apart from some fragments, we possess only the meagre entitome of one Hermolaus, dedicated to Justinian; whether to the first or second emperor of that name is disputed. Stephanus probably flourished in the earlier part of the 6th century, under Justinian I The chief fragments remaining of the original work (which contained quotations from classical authors and topographical and historical details) are preserved by Constantine Porphyrogenetics, De administration imperior, ch. 23 (the article 'Tāpilau bio) and De thematibus, ii to (an account of Sicily); the latter includes a passage from the comic poet Alexis on the Seven Largest Islands, Another fragment, from the article Δiphy to the end of A, exists in a mos of the Sequerian library.

See E. H. Bunbury History of Ancient Geography, 1, 102, 135, 169; ii. 669-671 (1883), Riese, De Slephani Byzant. auctoribus (Kiel, 1873); J. Gefficken, De Stephano Byzantio (Göttingen, 1886).

STEPHEN, in some senses the greatest figure in primitive Christianity prior to Faul's conversion, was one of "the Seven" (Acts xxi. 8, nowhere called "deacons") set over the "daily miniration" towards the needy members of the Jerusalom community. Like Philip and perhaps others of his colleagues (vi. 3), he had higher gifts than his office would suggest He was "full of faith and of holy Spirit"; and as his spiritual power showed itself in mighty deeds as well as words (vi. 5, 8), he became a harked man in Jerusalem Himself a Jew of Greek culture, he naturally tried to win over his fellow Hellenists (vi. 9).

It is here that Stephen's advance upon prior Apostolic teaching becomes apparent. His special "wisdom" lay in greater insight into the merely relative nature and value of the externals of Israel's religion, particularly those connected with the Temple. His fellow Hellenists, as a body, were eager to disprove the feel-

ing of the native "Hebrews" that they were only half Jews Hence teaching which minimized the value of the sacred "customs which Moses had delivered" (vi. 14), by making "salvation" depend simply on faith in Jesus as Messiah, would cause deep resentment in such circles, in spite of their more liberal attitude to things non-Jewish. For in Jerusalem the Temple overshadowed men's thoughts touching the Divine presence To this he would reply in the spirit of the prophets, that the heart is the true seat of the Shekmah; and that if they refused God manifest in His Messiah, no holy "customs"-no, not the Temple itself-could save from the displeasure of the living God Nay, he argued, quoting words of Jesus (Matt xxvi 61, Mk xiv 58, Jo ii. 10) which were easy to misquote (Acts vi 14), that the Temple might even be destroyed, as it had been in the past, without loss to true religion. But they could not rise to this conception and treated his words as "blasphemous," and roused "the people and the

384

elders and the scribes" against him He was seized and brought before the Sanhedrin on the charge of speaking "against the Temple and the Law" (vi II-I4). His defence took the form of a survey of Israel's religious past, with a view to show: (1) that "the God of Glory" had covenant rela-tions with their forefathers before they had either Holy Place (Land or Temple) or Law (vii. 1-17); (2) that the first visible meeting place between God and His people was far other than that for which absolute sanctity was now claimed. Indeed, the form of "the tabernacle of testimony in the wilderness" (no Holy Land) had more divine sanction than any later Temple (44-47); (3) that, after all, the presence of "the Most High" was not bound up with any structure of human hands, as Isaiah witnessed (48-50). The moral of all this was plain: Israel's forms of fellowship with the Most High had all along been relative and subject to change. Hence there was no "blasphemy" in suggesting that in the Messianic age yet another change might come about, and that observance of Temple services could prove little as to acceptance with God. But there is another and more urgent line of pleading. This is found in the elaborate section dealing with the person and work of Moses, the great lawgiver (17-38)-a section full of extra-biblical touches-followed by one on Israel's hardness of heart towards him, together with its result, the Exile (39-43). Pure and original Mosaism is represented as something which in its full spiritual intention had been frustrated by Israel's stiffneckedness (39, 42 seq.). The figure of Moses is made to stand forth in ideal outlines, the thinly-veiled Christian application shining through. "This is that Moses who said unto the children of Israel, 'A prophet shall God raise up unto you . . . like unto me.' who received living oracles to give unto us: to whom our fathers would not be obedient, but thrust him from them, and turned back in their hearts. . . . " (38 seq.). Here we have the very situation as between Stephen and his hearers, and it is made unmistakable by the speaker's closing words (51-53). Had they kept the Law dutifully, they would have believed on Him in whom true Mosaism was fulfilled and transcended. The author of Acts probably owed his report of Stephen's speech (as of his whole story) to Philip the "evangelist," who had been one of the Seven (xxi 8). Possibly also Paul had spoken in Luke's hearing of Stephen's death and his own part in it (vii. 58, 60, cf. vi. 9).

Stephen's martyrdom is described as tumultuary in character, though the legal forms of stoning for blasphemy were observed (via. 58); nor is it inconceivable that an act exceeding Jewish rights under the Romans should have taken place at the sudden impulse of religious fanaticism.

See articles in the Ency. Bib. vol. iv., and Hauck's Realencykl. f protestant. Theol. u. Kirche, vol. xix. (J. V. B.)

STEPHEN, the name of nine popes.

STEPHEN I., bishop of Rome from about 254 to 257, followed Lucius I. He withdrew from church fellowship with Cyprian and certain Asiatic hishops on account of their views as to the necessity of rebaptizing heretics (Euseb. H. E. vii. 5; Cypr. Epp. 75). He is also mentioned as having insisted on the restoration of the bishops of Merida and Astorga, who had been deposed for un-faithfulness during persecution but afterwards had repented. He is commemorated on August 2. His successor was Sixtus II

STEPHEN III (II), pope from March 752 to April 757, was in deacon's orders when chosen to the vacant see within 12 days after the death of Zacharias 1 The main difficulty of his pontificate was in connection with the aggressive attitude of Aistulf, king of the Lombards The death of Stephen took place not long after that of Aistulf He was succeeded by Paul I

STEPHEN IV (III), pope from Aug. 7, 768, to Feb 3, 772, was a native of Sicily, and, having come to Rome during the pontificate of Gregory III, gradually rose to high office in the service of suc-

cessive popes He was succeeded by Adrian I.

STEPHEN V (IV), pope from June 816 to Jan. 817, succeeded Leo III He did not continue Leo's policy, which was more favourable to the clergy than to the lay aristocracy. Immediately after his consecration he ordered the Roman people to swear fidelity to Louis the Pious, to whom he found it prudent to betake himself personally in the following August After the coronation of Louis at Reims in October he returned to Rome, where he died in the beginning of the following year. His successor was Paschal I.

STEPHEN VI (V), pope from 885 to 891, succeeded Adrian III, and was in turn succeeded by Formosus In his dealings with Constantinople in the matter of Photius, as also in his relations with the young Slavonic Church, he pursued the policy of Nicholas I.

STEPHEN VII (VI), pope from May 896 to July-August 897, succeeded Boniface VI, and was in turn followed by Romanus. His conduct toward the remains of Formosus, his last predecessor but one (see Formosus) excited a tumult, which ended in his imprisonment and death by strangling.

STEPHEN VIII (VII) (Jan 929 to Feb. 931) and STEPHEN IX (VIII) (July 939 to October 949) were virtually nonentities, who held the pontificate while the real direction of the pontifical state was in the hands of Marozia and, afterward, of her son Alberic,

senator of the Romans

STEPHEN X (IX), pope from August 1057 to March 1058, succeeded Victor II (Gebhard of Eichstädt) His baptismal name was Frederick, and he was a younger brother of Godfrey, duke of Upper Lorraine, marquis of Tuscany (by his marriage with Beatrice, widow of Boniface, marquis of Tuscany) Frederick, who had been raised to the cardinalate by Leo IX., acted for some time as papal legate at Constantinople, and was with Leo in his unlucky expedition against the Normans He shared his brother's fortunes, and at one time had to take refuge from Henry III. in Monte Cassino Five days after the death of Victor II he was chosen to succeed him He showed great zeal in enforcing the Hildebrandine policy as to clerical celibacy. He died at Florence on March 29, 1058.

STEPHEN (1097?-1154), king of England, was the third son of Stephen Henry, count of Blois and Chartres, and, through his mother Adela, a grandson of William the Conqueror. Born some time before 1101, he was still a boy when he was taken into favour by his uncle, Henry I. of England, and received the honour of knighthood and the county of Mortam. In 1118 he severed his connection with Blois and Chartres, renouncing his hereditary claims in favour of his elder brother Theobald But he acquired the county of Boulogne by marrying Matilda (c. 1103-1152), the heiress of Count Eustace III and a niece of Henry's first wife. The old king arranged this match after the untimely loss of his son, William Atheling, in the tragedy of the White Ship; until 1125 Stephen was regarded as the probable heir to the English throne. But on the return of the widowed empress Matilda (q.v.) to her father's court, Henry compelled Stephen and the rest of his barons to acknowledge her as their future ruler (1126). Seven years later these oaths were renewed; and in addition the ultimate claims of Matilda's infant son, Henry of Anjou, were recognized (1133). But the death of Henry I. found the empress absent from England Stephen hurried across the Channel and began to canvass for supporters, arguing that his oaths to Matilda were taken under coercion, and that she, as the daughter of a professed nun, was illegitimate

He was raised to the throne by the Londoners, the official <sup>1</sup>A priest named Stephen, elected before him, died three days after, without having received the episcopal consecration. haronage and the clergy, his most influential supporters were the old justiciar, Robert, bishop of Salisbury, and his own brother Henry, bishop of Winchester Innocent II, was induced by Bishop Henry to ratify the election, and Stephen thus cleared himself from the stain of perjury. Two charters of liberties, issued in rapid succession, confirmed the King's alliance with the Church and earned the good will of the nation. But his supporters traded upon his notorious facility and the unstable nature of his power. Extortionate concessions were demanded by the great barons, and particularly by Earl Robert of Gloucester, the half-brother of the empress The clergy insisted that neither their goods nor their persons should be subject to secular jurisdiction. Stephen's attempt to create a mercenary army and a royalist party led at once to a rupture between himself and Earl Robert (1138), which was the signal for sporadic rebellions Soon afterwards the king attacked the bishops of Salisbury, Ely and Lincoln-a powerful family clique who stood at the head of the official baronageand, not content with seizing their castles, subjected them to personal outrage and detention The result was that the clergy, headed by his brother, the bishop of Winchester, declared against him (1139).

Stephen was thoroughly discredited when the empress at length appeared in England (Sept. 30, 1139) Through a misplaced sense of chivalry he declined to take an opportunity of seizing her person. She was therefore able to join her half-brother at Gloucester, to obtain recognition in the western and south-western shires, and to contest the royal title for eight years Stephen's mitial errors were aggravated by bad generalship. He showed remarkable energy in hurrying from one centre of rebellion to another, but he never ventured to attack the headquarters of the empress In 1141 he was surprised and captured while besieging Lincoln castle. The empress in consequence reigned for six months as "Lady (Domina) of the English"; save for her faults of temper, the cause of Stephen would never have been retrieved. But, later in the year, his supporters were able to procure his release in exchange for the earl of Gloucester. After an obstinate siege he expelled Matilda from Oxford (Dec. 1142) and compelled her to fall back upon the west.

The next five years witnessed anarchy such as England had never before experienced England north of the Ribble and the Tyne had passed into the hands of David of Scotland and his son, Prince Henry; Ramilf eral of Chester was constructing an independent principality; on the west the rauds of the Angevin party, in the east and midlands the excesses of such rebels as Geoffrey de Mandeville, earl of Essex, turned considerable districts into widelensesses. Meanwhile Geoffrey of Anjou, the bushand of the empress, completed the conquest of Normandy (r144). In 1747 the situation improved for Stephen; Robert of Gloucester, the ablest of the Angevin partisans, died, and the empress left England in despair. But her son soon appeared in England to renew the struggle (1749) and conciliate new supporters. Soon after his return to Normandy Henry was invested by his father with the duchy (1750). He succeeded to Anjou in 1751; next year he acquired Aquitaine by marrage.

Skephen struggled hard to secure the succession for Eustace, his elder son. But he had quarrelled with Rome respecting a vacancy in the see of York; the pope forbade the English bishops to consecrate Eustace (1751), and there was a general unwillingness to prolong the civil war. Worn out by incessant conflicts, the bowed to the inevitable when Henry next uppeared in England (1753). Negotiations were opened; and Stephen's last hesitations disappeared when Eustace was carried off by a sudden illness. Late in 1133 he king acknowledged Zurud and the superior of the superior of the superior of the property of the superior of the superior of the property of the superior of the superi

manthy; but Stephen died soon thereafter (Oct. 175).
On his great seal Stephen is represented as sall and robust, bearded, and of en open countenance. He was frank and generous; his occasional arts of duplicity were planned reluctantly and newer carried to their logical conclusion. In warfare he showed courage, but little generability; as a stateman he falled in his

dealings with the Church, which he alternately humoured and thwarted. He was a generous patron of religious foundations; and some pleasing anecdotes suggest that his personal character deserves more commendation than his record as a king

deserves more commendation than his record as a king See the Grist Stepham, Richard of Heicham, Aefred of Riewaux' Ratati de Standardo, aid the chronicle of Robert de Torigni, all London, 1884-99.) Ordies Villatis Historia ecclematica, ed. Le Prévost (s vols, Pans, 1838-55), William of Malmesburry's Historia novella, ed. W. Stubbs, (London, 1889), john of Worster's Continuamorella, ed. W. Stubbs, (London, 1889), john of Worster's Continuanosigate's England under the Angeism Kungi, vol. 1 (London, 1887), O Rosalter's Karrein Hathilde (Bellin, 1897), 14 Round's Corpete de Mandeville (London, 1892), H. W. C. Daves's The Amerchy of STEPPHEN II. IST STEPHEN (079-7038). Ring of Hungary.

STEPHEN I. [ST STEPHEN] (977-1038), king of Hungary, was the son of Geas, duke of Hungary, and of Sarolta, one of the few Magyar Christian ladies. His tutiors included the German priest Bruno, the Cach priest Radia, and an Italian knight, Theodate of San Severino, who taught him arms and letters. In 96 Stephen married Gisela, the daughter of Duke Henry II of Bavaria. In the following year his father died and the young prince was confronted by a formidable pagar reaction between the Drave and Lake Balaton. Stephen hastened against the rebots bearing before him the banner of St. Martin of Tours, whom how chose to be his patron sant, and routed the rebels at Veszerre (998), assuming the royal title immediately afterwards.

The rest of Stephen's life was spent largely in a struggle against the pagan nobles, which engrosed his energies, and compelled him to adopt a pacific policy towards the emperors of the East and West, but when attacked by the emperor Conrad in 103 Stephen repelled the invasion successfully. He died at Exstergom in 1038 and was canonized in 1083. For an account of his reforms see Huxnaxy: History.

See Mild Por, Life of St. Stephen (Hung; Pest, 2871) I also See Antal Por, Life of St. Stephen (Hung; Pest, 2871) I also Billion, History of the Economic Catholic Church in Hung; vol. 1 (Hung; Pest, 2871), Henry of the Hung; Pest, 2871, Henry of the Hung; Pest, 2887, Henry of Hung; Pest, 28

STEPHEN V. (1239-1272), king of Hungary, was the eldest son of Bela IV, whom he succeeded in 1270. In 1261, as crown prince, he had compelled his father, whom he had assisted in the Bohemian War, to surrender 92 counties to him, virtually dividing Hungary into two kingdoms; while afterwards he sexued the southern banate of Macso, which led to a fresh war between father and son in which the latter triumphed. In 1268 he invaded Bilgaria and assumed the title of king of Bulgaria. During his father's lifetime Stephen had a double matrimonial alliance with the Netpolitian princes of the House of Anjou, the chief partisans of the pope. He certainly needed exterior support; for on his accession to the Hungarian throne he encountered almost universal hostility owing to his alleged pagan leanings, due largely to the influence of his Cuman wite Elizabeth, to whom his father had married him for political reasons in 1255. The malcontents combined with Citakar II. of Bohemia, and invagded western Hungary; but Stephen routed Ottakur at Mosony (1271) and was preparing to recover his minat son Laddislaus whom the rebels

had kidnapped, when he died suddenly on Aug 6, 127; STEPHEN, SIR JAMES FITZJAMES, Boxr. (1829— 1894), English lawyer, judge and publicist, was born in London on March 3, 1829, the third child and second son of Sir James Stephen. He was educated at Elon, London university, and Trinity, Cambridge. He was already acquainted with Sir Henry Maine (zv.), six years his senior, and then newly appointed to the chair of civil law. This acquaintance now ripened into a perfect friendship, which ended only with Maine's death in, 1838.

Stephen was called to the bar in 1854, and in 1859 he was appointed recorder of Newark. In 1856 he published his General View of the Criminal Law of England (and recast ed. 1850). This was the first attempt that had been made since Blackstone to explain the principles of English law and justice in a literary form, and it had a thoroughly deserved success 'all this time Stephen kept up a great deal of miscellaneous writing, and the Goundation of the Pall-Madl Gasatte in 1865 gave him a new

field The decisive point of his work was in the summer of 1869, when he accepted the post of legal member of council in India. Fitzjames Stephen's friend Mame was his immediate predecessor in this office Guided by Maine's comprehensive genius, the government of India had entered on a period of systematic legislation which was to last about twenty years The materials for considerable narts of this india had been left by Maine

Stephen had the task of working them into their definite shape and conducting the bulls through the Legislative Council. This did with wonderful energy, with efficiency and workmanship adequate to the purpose, if sometimes rough according to English notions, and so as to leave his own individual mark in many places. The Native Marriages Act of 1892 was the result of deep consideration on both Maine's and Stephen's part. The draft of the Contract Act was materially altered in Stephen's shands begin also in 1872, it became law. The Evidence Act of the same year was entirely Stephen's part. The Contract also in 1872, it became law. The Evidence Act of the same year was entirely Stephen's part. The Contract also in 1872 in the came home in 1872.

Indua experience had supplied Stephen with the motive for his next piece of work, which historians of the common law may well regard as his greatest tutle to remembrance. The materials which Stephen had long been collecting took permanent shape in the History of the Criminal Law of England (1832), which, though not free from inequalities and traces of haste, must long remain the standard work on the subject. The Bills of Exchange Act (1832), the State of Goods Act (1832) and the Manne Insurance Act (passed 1906) are indirectly due to his efforts in 1879 Stephen became judge of the queen's bench division. He respired that office in April 1891, after a long life with a surprising amount of work, of which a large proportion was of permanent value. He married Mary Cunningham in 1855.

"See Ser Lesko Stephen, Life of Sr James Patiziones Stephen (London, 1855), with bibbegraphical appendix, a model biography; same author's article in the Dict. Not. Blog; Letter with biographical Notes, by his daughter, Canoline Emelas Stephen (1907). See also Sir C. P. Ilbert, "Sir James Stephen as a Legislator," Law Quert. Rev. X. 222.

STEPHEN, SIR LESLIE (1832-1904), English philosopher and man of letters, son of Sir James Stephen, was born in London on Nov. 28, 1832. He was educated at Eton, at King's college, London, and Trinity Hall. Cambridge. In 1854 Stephen obtained a Goodbehere fellowship, and was ordained deacon on Dec. 27, 1855, becoming a priest in 1859 In 1856 he was admitted to a junior tutorship at Trinity Hall. He was a good athlete and a mountaineer His first ascent was in 1857 (Col du Géant), and he made many others in the following years, until his first marriage in 1867. He was president of the Alpine club from 1865 to 1868, and editor of the Albine Journal from 1868 to 1871 His accounts of his mountaineering feats were published in various journals, and collected in The Playground of Europe (1871). In the meantime, during his residence at Trinity Hall, his philosophical studies led him to abandon the orthodox theological position, and in 1875 he relinquished his orders. He interested himself in university politics, and advocated the need for examination reforms. During the American Civil War he was greatly in sympathy with the North, and in 1863 visited America to investigate the situation On his return he published *The Times* and the American War by L. S. (1865), in answer to English arguments in support of the South. Stephen came to London in 1864, with useful recommendations from his brother Sir J. Fitzjames Stephen. He contributed for many years to the Saturday Review, and from 1865 co-operated with George Smith in the foundation of the Pall Mall Gazette. From Oct 1866 to Aug 1873 he contributed political articles to the Nation. His literary criticisms for the Cornlill Magazine (from 1866) were collected from time to time in separate volumes, as Hours in a Library (1874, 1876 and 1879). In 1871 he became editor of the Cornhill, and during the II years of his editorship the magazine made a reputation by its literary excellence. R. L Stevenson; Thomas Hardy, Henry James and Edmund Gosse were among his contributors. In his Essays on Free Thinking and Plain Speaking (1873) Stephen challenged the dogmas of popular religion His

Hastory of English Thought in the Eighteenth Century (2 vols., 1850), later extended unto The English Utilitations (1900), remains a standard work on the subject He married in 1857 the younger daughter of W. M. Thackersy, and in 1868 visited America with her, where he met Emerson and Oliver Wendell Holmes, the voumer

In Nov 1882 George Smith made Stephen editor of the Dictionary of National Biography, which he conducted until April 1801, continuing to contribute until 1901. His first wife died in 1875, and in 1878 he mairied again. In his later years he was greatly affected by the death first of his brother James (1894), and shortly afterwards (1895) of his wife. One of his daughters, Mrs Virginia Woolf, is separately noticed in this book. Stephen received many marks of distinction, and in 1902 was made K C B. He continued his literary work almost to the end of his life, and his last books were a monograph on Hobbes (1904), and his Ford lectures, English Literature and Society in the Eighteenth Century, published on the day of his death, Feb 22, 1004 His work, both philosophical and literary, is remarkable for the sincerity of the author's outlook, and for his unprejudiced Judgments He wrote also Social Rights and Duties (1896); Science and Ethics (1882): An Agnostic's Apology (1893); Studies of a Biographer (2 vols, two series, 1899 and 1902), and monographs for the "English Men of Letters" series.

See F W Maitland, Life and Letters of Leshe Stephen (1906), Sir Sidney Lee, Principles of Biography (the Leshe Stephen lecture, 1911).

STEPHEN (ISTVÁN) BÁTHORY (1533-1586), king of Poland and prince of Transvlvania Bathory spent his early years at the court of the emperor Ferdmand, subsequently attached himself to Janos Zapolya, and won equal renown as a soldier and diplomatist Zapolya rewarded him with the voivodeship of Transvlvania, where his defence of the rights of his patron's son, John Sigismund, incurred the animosity of the emperor Maximilian, who kept him in prison for two years On May 25, 1571, on the death of John Sigismund, Bathory was elected prince of Transvivania by the Hungarian estates, in spite of the opposition of Vienna He expelled the rival candidate, Gaspar Békesy, from Transylvania (1572) In 1579 the Polish nobility, at the instigation of Zamoyski (q.v.) elected Bathory king of Poland, in opposition to the emperor Maximilian, the candidate of the senate Báthory persuaded the Transylvanian estates to elect his brother Christopher in his stead, hurried to Cracow, espoused the princess Anne, the sister of the last Jamello, and was crowned on May 1.

The leading events of Stephen Báthory's reign can here only be briefly indicated All armed opposition colleged with the surrender of Danzig, after a six months' siege, on Dec. 16, 1577. Stephen was now able to devote himself to foreign affairs. The difficulties with the sultan were temporarily adjusted by a truce signed on Nov 5, 1577; and the Diet of Warsaw having voted supplies, Stephen embarked on war with Muscovy. Penetrating to the heart of the country, be besseged Pskov (Aug.—Dec. 1581), and forced Ivan the Terrible to cede him Polotsk and Livonia (peace of Zapoli, Jan. 15, 1582). The chief domestic event of Stephen's reign was the establishment in Poland of the Jesuits, in furtherance of his designs of uniting Poland, Muscovy and Transylvania into one great state The project was dissipated by his sudden death, of apoplexy, Dec. 12, 1586.

Hausyvania into the gical scale. The project was dissipated by his sudden death, of apoplexy, Dec. 12, 1586

See I. Polkowski, The Martial Exploits of Stephen Bdishory (Pol., Cracow, 1837); Paul Pletling, Un Arbitrage pontifical an xome siècle (Brussels, 1890); Lajos Saddorky, Stephen Bdishory's Election to the Crown of Poland (Hung; Budapest, 1887)

STEPHENS, ALEXANDER HAMIL TON (1812-1882). American statesman, were president of the Confederate States during the Civil War, was born in Wilkes (now Talanferro) country, Georgia, on Feb. 11, 132. He was a weak and sickly child of poor parents, and from his sixth to his 15th year, when he was left an orphan, he worked on a farm. After his father's death he went to live with an uncle in Warren country. The superintendent of the local Sunday school sent him to an academy at Washington, Wilkes country, for one year and in the following year (1848) he was sent by the Georgia Educational society to Franklin college (University of Georgia), where he graduated in 1832. Deciding

not to enter the ministry, he paid back the money advanced by view to discovering and examining the antiquities said to exist was admitted to the bar in 1834.

In 1836 he was elected to the Georgia house of representatives after a campaign in which he was vigorously opposed because he had attacked the doctrine of nullification, and because he had opposed all extra-legal steps against the abolitionists. He was annually re-elected until 1841; in 1842 he was elected to the State senate, and in the following year, on the Whig ticket, to the national House of Representatives In this last body he urged the annexation of Texas, chiefly as a means of achieving more power for the South in Congress He was denounced as a traitor to his party because of his support of annexation, but he later became the leader of the Whig opposition to the war with Mexico. He vigorously supported the Compromise Measures in 1850, and continued to act with the Whigs of the North until they, in 1852, nominated Gen Winfield Scott for the presidency without Scott's endorsement of the Compromise Stephens and other Whigs of the South then chose Daniel Webster, but a little later they joined the Democrats In 1854 Stephens helped to secure the passage of the Kansas-Nebraska Bill Before the Georgia legislature in Nov 1860, and again in that State's secession convention in Jan. "1861, he strongly opposed secession, but when Georgia seceded he "followed his state," assisted in forming the new government, and was elected vice president of the Confederacy Throughout the war, he was so concerned about States' rights and civil liberty that he opposed the exercise of extra-constitutional war powers by President Jefferson Davis lest the freedom for which the South was fighting should be destroyed. His policy was to preserve constitutional government in the South and strengthen the antiwar party in the North by convincing it that the Lincoln administration had abandoned such government; to the same end he urged, in 1864, the unconditional discharge of Federal prisoners in the South. Stephens headed the Confederate commission to the peace conference at Hampton Roads in Feb. 1865 In the following May, after the fall of the Confederacy, he was arrested at his home and taken to Fort Warren, in Boston harbour, where he was confined until Oct. 12 In 1866 he was elected to the United States Senate, but was not permitted to take his seat. He was a representative in Congress, however, from 1873 to 1882, and was governor of Georgia in 1882-83, dying in office, at Atlanta, on March 4, 1883.

From 1871 to 1873 he edited the Atlanta Daily Sun, and he published A Constitutional View of the Late War between the States (1868-70), perhaps the best statement of the Southern position with reference to state sovereignty and secession, The Reviewers Reviewed (1872), a supplement to the preceding work; and A Compendium of the History of the United States (1875; new ed., 1883)

new ed., 1883)
See Louis Pennison, Meronder H. Siephers (Philadolphin, 1985):
See Louis Pennison and W. H. Browne, Life of Measurder H. Stephers
(Philadolphin, 1878); new ed., 1882). Henry Cleveland, Measurder M. Stephers
(Philadolphin, 1878); new ed., 1882). Henry Cleveland, Measurder H.
Stephers in Public and Praviate, suit Letters and Speeches (Philadolphin, 1856); M. L. Avary (ed.), Resolications of A. H. Siephers,
spondence of Robert Tombia, Alexander H. Stephers and Howell
Cobb," in American History Association, Annual Report, vol. is.
(1921); and Gannalle Bradford, Confederate Porturis (1924).

STEPHENS, JAMES (1882-1950), Irish poet, was born in Dublin. He was earning his living as a clerk in Dublin when he made his name by the exquisite prose of the delightful fairy stories published as The Crock of Gold (1912). He shows a sense of fantasy and a delicate poetic talent in all his works. The later ones include Reincarnation (1918); Deirdre (1923); In the Land of Youth (1924); Collected Poems (1926) and Etched in Moonlight (1928). Stephens was an ardent Nationalist and supported the Irish Free State. He died in London on Dec. 26, 1950.

STEPHENS, JOHN LLOYD (1805-1852), American traveller, was born Nov. 28, 1805, at Shrewsbury, N.J. Having been admitted to the bar, he practised for about eight years in New York city. In 1834-36 he made extensive travels in Europe, STEPHENSON, ROBERT (1803-1859), English engineer, Egypt and Syria. In 1839 Stephens arranged with Frederick only son of George Stephenson (q.v.), was born at Willington

the society He was a schoolmaster for about two years, and then there. Supplies, meantime, was appointed to a mission to central America. Stephens published in 1841 Incidents of Travels in Central America, Chiapas and Yucatan. A second visit (1841) to Yucatan is described in Incidents of Travel in Yucatan (1843) Stephens died at New York on Oct 10, 1852

STEPHENSON, GEORGE (1781-1848), English engineer, was the second son of Robert Stephenson, fireman of a colliery engine at Wylam, near Newcastle, where he was born on June 9, 1781 In boyhood he was employed as a cowherd, and afterwards he drove the "gin-horse" at a colliery. At 14 he became assistant fireman to his father at a shilling a day, and at 17 he was appointed plugman, his duty being to attend to the pumping-engine. As yet he was unable to read, but stimulated by a desire to study the inventions of Boulton and Watt, he attended a night school and made rapid progress. In 1801 he became brakesman, in 1802 engineman at Willington Quay, where he took up watch and clock cleaning in his spare time. In 1804 he moved to Killingworth, where in 1812 he was appointed engine-wright of the High Pit at a salary of £100 a year. It was here in 1815 that he devised his miner's safety lamp, at the time when Sir Humphry Davy was also producing his lamp, a coincidence which led to much controversy.

In 1813 Stephenson was authorised to build a "travelling engine" for the tramroads between the Killingworth colliery and the port 9 mi away on the plan of one already running at Wylam The engine, which was named "Blucher," ran a successful trial on July 25, 1814, and in 1822 he persuaded the directors of the Stockton and Darlington railway (then in construction) to use steam instead of animal traction At the opening of this railway on Sept. 27, 1825, therefore, the first public passenger train in the world was drawn by Stephenson's locomotive "Active," which was subsequently renamed "Locomotion" His connection with the Stockton and Darlington led to his employment on the Liverpool and Manchester railway, whose track he carried successfully over Chat Moss When the line was nearing completion he persuaded the directors, who favoured haulage by fixed engines, to give the locomotive a trial They offered a prize of £500 for a suitable machine, and in the Rainhill trials in October, 1829, Stephenson's engine, "The Rocket," was chosen. (For a description see Steam Engine) On September 15, 1830, the railway was formally opened, the eight engines employed having been built at the works started at Newcastle in 1823 by Stephenson, his cousin Thomas Richardson, and Edward Pease Stephenson was engineer of the Grand Junction, London & Birmingham (with his son Robert), Manchester to Leeds, Derby to Leeds, Derby to Birmingham, and Birmingham to York railways; but he strongly disapproved of the "railway mania" of 1844. He was also consulted about the construction of railways in Belgium and Spain. The last years of his life were spent in retirement at Tapton Flouse, Chesterfield, in farming and horticulture, and there he died on Aug. 12, 1848.

See Life of George Stephenson, by Samuel Smiles (1857, new ed., 1881); and Smiles's Lives of the Engineers, vol v. (1873).

STEPHENSON, GEORGE ROBERT (1819-1905), British civil engineer, was born at Newcastle-on-Tyne on Oct. 20. 1819, and was the nephew of George Stephenson (1781-1848) (q.v.). After working in colliery workshops near Manchester, he was sent to King William's School, Isle of Man. After his father's death in 1837, he worked for his uncle in the drawing-office of the Manchester and Leeds railway. In 1860, when he was consulting engineer to the provincial government of Canterbury, New Zealand, the Lyttelton-Christchurch line was built under his direction. He returned to England, and with Sir John Hawkshaw in 1864 built the East London railway. He was partly responsible for the construction of the Victoria tubular bridge across the St. Lawrence, and designed many bridges in England and abroad. In 1859 he succeeded his cousin Robert Stephenson (q.v) at the locomotive works at Newcastle-on-Tyne, and at the Snibston and Tapton collieries He died at Cheltenham on Oct. 26, 1905.

Catherwood to make an exploration in central America, with a Quay on Oct. 16, 1803. He spent four years at school in New-

castle, and was then (1819) apprenticed to Nicholas Wood, a coal-viewer at Killingworth, after which he was sent in 1822 to attend science classes at the university of Edinburgh. He assisted his father in surveying the Stockton and Darlington and Liverpool and Manchester railways, and in 1824 he took charge of the engineering operations in South America of the Colombian Mining Association of London He resigned in 1827, and returned to England via New York in company with Richard Trevithick, whom he had met in a penniless condition at Cartagena Stephenson then undertook the management of his father's factory in Newcastle, and assisted in the improvement of the locomotive. His work extended to Sweden, Denmark, Belgium, Switzerland and Egypt. He specialised in the construction of railway bridges. especially those of the tubular girder type, and among his more notable examples are the Royal Border bridge at Berwick-on-Tweed, the High Level bridge at Newcastle-on-Tyne, the Britannia tubular bridge over the Menai Straits, the Conway tubular bridge, and the Victoria tubular bridge over the St. Lawrence at Montreal. In 1847 he entered the House of Commons as member for Whitby, retaining the seat till his death in London on Oct. 12, 1859 He was buried in Westminster Abbey. London on Cet. 12, 1859. He was butten in westerniser Probest. See The Story of the Life of George Stephenson, including a Memoir of his Son Robert Stephenson, by Samuel Smiles (1857; new ed. 1881); jeaffreson, Life of Robert Stephenson (2 vols., 1864); and Smiles's Lives of the Engineers, vol. v. (1873).

STEPNEY, an eastern metropolitan borough of London, England, bounded north by Bethnal Green, east by Poplar, south by the river Thames, and west by the City of London and Shoreditch. Pop. (est. 1938) 200,500; area, 2.75 sq mi. The thoroughfares of Mile End Road and Whitechapel Road and that of Commercial Road East traverse the borough from the east and converge near the City boundary, where stood the ancient Aldgate. In the north Stepney includes the districts of Spitalfields, Whitechapel and Mile End (where William Booth commenced the work of the Salvation Army, July 1868); and in the south Wapping, Shadwell, Ratcliff and Limehouse. The name appears in Domesday and later as Stevenhethe. The suffix is thus the common form hythe, a haven: but for the prefix no certain derivation is offered. At Mile End, so called from its distance from the City (Aldgate), Wat Tyler and Richard II met in 1381. The district of Spitalfields has an old association with the silk-weaving industry; a trade in singing birds is also characteristic of this district. Wharves and factories line the river bank. In the extreme west the borough includes within its bounds the historic Tower of London  $(q,v_*)$ , the Royal Mint and the Tower Bridge over the Thames, Stepney is a bishopric suffragan in the diocese of London. The metropolitan borough of Stepney returns three members to Parliament, one each for the Limehouse, Mile End and Whitechapel and St. George's divisions.

STEPNIAK, SERGIUS (1852-1895), Russian revolutionist, whose real name was Sergius Michaelovich Kraychinski, was born in South Russia, of noble parents. He became an officer in the artillery; but his sympathy with the peasants, among whom he had lived during his boyhood in the country, developed in him at first democratic and, later, revolutionary opinions. He began secretly to sow the sentiments of democracy among the peasants His teaching did not long remain a secret, and in 1874 he was arrested. He succeeded in making his escape—possibly he was permitted to escape on account of his youth—and immediately began a more vigorous campaign against autocracy. His sympathetic nature was revolted by the brutal methods adopted towards prisoners, especially political prisoners, and by the stern measures of repression of revolutionary sentiment. For a time he supported a terrorist policy, and in 1880 he was obliged to leave the country. He settled for a short time in Switzerland, and after a few years came to London. He was already known in England by his book Underground Russia, which had been published in London in 1882. He followed it up with other works on the condition of the Russian peasantry, on Nihilism, and on the conditions of life in Russia. Stepniak was killed by a railway engine at a level crossing at Bedford Park, Chiswick, on Dec 23, 1805.

STEPPE, the level treeless Russian plains and thence sometimes extended as a type-name for similar plains elsewhere;

specifically it is usually applied to the plains in the south and south-east of European Russia and in the south-west of Asaatic Russia, and in this connection the term connotes level grassy areas on which the slight summer rainfall with a winter deficiency

produces patches with semi-desert conditions. STERCORARIDAE: see Skua.

STEREOBATE, in architecture, the rough masonry substructure, or foundation, of a Greek temple.

STEREOCHEMISTRY. The term stereochemistry (Greek STEREOCHEMISTRY). The term stereochemistry (Greek Stell, et demants) is applied in a wide sense to all thereos so that the stereochemical compounds which are believed to be due to the relative positions of the different atoms within a single molecule, or to the relative positions of different molecules in a larger aggregate of material. In this article, however, the term is used in a narrower sense. The following discussion is almost entirely limited to such aspects of the subject as are included in the field of stereochemical properties of individual molecules or ions. (For other aspects of the subject, which are largely ignored here, see X-RAY AND CRYSTAL STRUCTURE; ELECTRON DIFFRACTION; SPECTRO-SCOPY)

important goal of the structural theory of organic chemistry (knowledgy of which is here assumed, see Christian Combistry (knowledgy of which is here assumed, see Christian Combistry (knowledgy of the Christian Combistry) (knowledgy of the Christian Christ

In more mathematical language, a structural formula gives only the topological relations of the atoms within the molecule or ion to which it refers

About the middle of the 19th century, it was discovered that in certain instances the methods of structural chemistry led to the assignment of the same structural (topological) formula to more than one compound. It was, therefore, evident that the rules of structural chemistry were, in these instances, insufficient for the complete identification of the compounds in question, The theories of stereochemistry (in the narrower sense) were devised as the corrections necessary to remedy this defect. It proved possible to account for the number of distinct compounds to be associated with each structural diagram if the assumption was made that two molecules of the same substance must have not only the same structure, but also the same arrangement of their atoms in space. This geometrical interpretation has received independent support from the data derived from studies of X-ray and electron diffraction and of spectra. Consequently, although the possibility of an alternative, nongeometrical explanation of the observed numbers of isomers by 1946 seemed never to have been seriously explored, the correctness of the geometrical interpretation was generally accepted without question. In the present article, it is assumed explicitly.

For the sake of definiteness, but at the expense of anticipating and duplicating a small part of the discussion in subsequent sections, a specific example may be given here of the way in which stereoisomers are considered to differ geometrically. The two different 1, a-dichlorocthylenes, which possess the same structure CHCI=CHCI, are thought to have the different geometrical forms represented by the planar diagrams I and II.

### EARLY HISTORY OF STEREOCHEMISTRY

Optical Activity—The original approach to the subject of stereochemstry arose from a study of certain optical phenomena In 1868, E. J. Malus discovered the polarization of high by reflection (see Lioutr), and three years later D F Arago discovered the fact that crystals of quarts are optically active (i.e., that they rotate the plane of polarization of plane polarized high). That this optical activity (or rotatory power) is not restricted to crystalline solids was demonstrated by J. B Biot, who found in 1817 that of of turpentine and acqueous solutions of tartaric and or of sugar are optically active, and in 1817 that even gaseous tumpenture is also active.

Specific Rotation.—For the characterization of an optically active substance, the so-called specific rotation (introduced by Biotin 1836) has proved useful This quantity is defined by the equation

$$[\alpha]_{\lambda}^{t} = \frac{\alpha}{tJ}$$

where  $[\alpha_i]_i^k$  is the specific rotation for light of wave length  $\lambda$  at the temperature  $P^2$ ; and  $\alpha$  is the degrees of rotation produced by passage of the light through a tube l decemetres in length, which is filled with the optically active substance (either pure or in soliton) at a concentration of d grams per cubic centimetre. The rotation is taken with the positive sign if it is to the right  $(x_0, x_0)$  in the sense which is clockwase when regarded in the direction contrary to that in which the light is travelling), and with the negative sign if it is to the left (i.e., in the opposite, counter-clockwase sense.

Ideally, the specific rotation, as so defined, should be a characteristic property of the substance to which it applies, and its value should be independent of the experimental conditions. In practice, however, it varies somewhat in magnitude with the wave length of the light, with the temperature, with the solvent (if any) and with the concentration. In a few matances, even the sign of rotation is found to change with conditions. Thus, the substance of structure III (ethyl propoliturates) has a positive

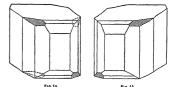
rotation if light of wave length less than about 4,909×Xr $^{\circ}$  cm. is used, but a negative rotation if light of wave length greater than about  $5,165 \times 10^{\circ}$  cm. is used material, aspartia acid, HO4C–CH<sub>T</sub>-CH(MH<sub>3</sub>)-CO<sub>5</sub>, has a positive rotation at  $20^{\circ}$  C. but a negative one at  $90^{\circ}$  C; the tartarn acid, HO4C–CHH-CHOH-CO-CO-H, which has a positive rotation in aquicous solution (see below) has a negative one in the crystalline form and also in a solution in a solution of the constant of the crystalline form and also in the control of the control of the control of the crystalline form and also as the control of the crystalline form and also are solved by the control of the crystalline form and also are appeared to the crystalline form and also are length to the crystalline fill and also are le

With colourless compounds, the variation in specific rotation with the wave length of the light used is ordinarily small, but nevertheless great enough to make necessary the precise statement of the wave length. The remaining variations are usually counteracted by standardization of the experimental procedure to as great an extent as possible. Thus, unless statements are made to the contrary, specific rotations are considered to apply to room temperature and to dilute solutions in specified solvents. Within these limitations, specific rotations may be employed for the characterization, identification and even quantitative analysis of optically active substances.

The Work of Pasteur.—After the discoveries of polarized light and of optical activity, the next important advance toward the indeed a stereochemical theories was made by Louis Pasteur

in a series of investigations on tariance and racemic acids, carried out chiefy during the years 1840-51. These two acids not only have dentical chemical compositions but also possess the same structure HO\_C-CHOH-CHOH-COH. Yet they show certain marked differences in properties. For example, racemic acid smuch less soluble in water than tariaric acid and crystallizes with water of crystallization, whereas tartaric acid separates in anhydrous crystalls, the most remarkable difference between the two substances, however, is in their effect on plane polarized plant. Tartaric acid and its salts (the tartates) are optically active; more specifically, they are dextrootatory (ie, their aqueous solutions rotate the plane of polarization to the right), on the other hand, racemic acid and its salts (the tartemates) are optically mactive.

Pasteur's discoveries arose out of a crystallographic investigation of tartaria card. He observed that there was a certain lack of symmetry in the crystalline form of this substance of such a kind that the crystal was nonsuperposable on its mirror image. The crystal and its image thus differ in the same kind of way as the right and left hands. He prepared and examined 1 yo direct salts of tartaric acid and found that each of these showed a simplar lack of symmetry in its crystalline form. Thus fig. is a repre-



FROM STEWART, "STEERS CHEMISTRY" (LONGWARD GREEN ( CO.)
FIG. 1 — (A & B) ENANTIOMORPHOUS CRYSTALS OF SODIUM AMMONIUM
TARTBATE

sents the crystalline form of one of these salts, sodium ammonium tartrate. If the crystal possessed the full symmetry of the system to which it belongs, two faces, corresponding with the two shaded areas, should be found in the positions indicated by broken lines. These faces, instead of occurring eight times in the crystal, occur only four times (there are of course two corresponding faces on the back of the crystal not shown in the figure); such faces, occurring only half as frequently as the full symmetry of the crystal demands, are termed hemihedral faces, The sodium ammonium tartrate crystal, on account of the presence of these hemshedral faces, is evidently nonsuperposable on its mirror image represented in fig 1b. In contrast to tartaric acid and the tartrates, racemic acid and such of its salts as Pasteur examined (with the exception of sodium ammonium racemate, see below) crystallize in symmetrical forms superposable on their mirror images. The optically active tartrates thus crystallize in dissymmetric forms, whereas the optically inactive racemates yield symmetrical crystals. (According to accepted terminology, an object is said to be dissymmetric if it is not superposable on its mirror image, and to be asymmetric if it possesses no element of symmetry whatever, see below. In discussions of stereochemistry, the word asymmetric is often used loosely in places where dissymmetric is intended; in the present article, however, the distinction is observed.)

Pasteur's chief discovery was made through investigating the exceptional racemate, sofium ammonum racemate, referred to above. Crystallized from water at a temperature below, 28° C., this sait yields crystals which, unlike those of the other necessate, yethic hemithedral faces; the crystals, however, are of two kinds. Some are identical in form with those of dextrootsarby sodium ammonium tartest (fg. 1a) and are in fact crystals of that sait. The other crystals differ from these only in that their hemithedrism is in the opposite sense; they are thus the

have the form represented in fig. 1b When picked out from the mixture and dissolved in water, they give a laevorotatory solution (i.e., a solution which rotates the plane of polarization to the left) The acid obtained from these crystals has a crystalline form which is the murror image of that of tartaric acid, and its solutions are laevorotatory. It is to be regarded as a second variety of tartaric acid

This new form of tartaric acid and the original one have exactly the same melting point and specific gravity, moreover, they exhibit exactly the same chemical reactivities toward all ontically inactive reagents. Two substances related in this manner are said to be enantiomorphs of each other. (The further expressions antimers and optical antipodes are also frequently used ) A more detailed discussion of the ways in which such pairs of substances resemble each other, and of those m which they differ from each other, is given below (see Enantiomorphs).

On the basis of his discoveries, Pasteur postulated that, in consequence of the arrangement of their constituent atoms in space. the individual molecules of any optically active substance must be nonsuperposable on their own mirror images (i.e., that they must be dissymmetric). Moreover, he postulated further that the molecules of any optically active substance must be superposable on the mirror images of the molecules of the enantiomorph of that substance. The situation visualized by Pasteur can be made more concrete with the aid of a rough analogy. The molecules of, say, dextrorotatory tartaric acid may be compared with righthand gloves, whereas those of its laevorotatory enantiomorph may be compared with left-hand gloves. No glove is identical with its own mirror image, but any right-hand glove is identical with the mirror image of any left-hand glove, and vice-versa. If the analogy is carried a step further, a crystal of racemic acid can be compared with a large package of pairs of gloves; since each pair consists of one right-hand and one left-hand glove, the package as a whole may be considered superposable on its mirror image These postulates of Pasteur form the basis of the following discussion; their justification lies in the fact that, as is shown below, they permit uniformly correct predictions to be made regarding the properties of, and relationships among, optically active substances.

### GENERAL DISCUSSION OF STEREOISOMERISM

The Symmetry Elements of Molecules,-It is desirable at this point to examine the characteristics of a molecule which make it dissymmetric, or prevent its being so, as the case may be.

The symmetry of any rigid body can be described with the aid of its so-called symmetry elements. These elements are of several different kinds, of which only the following need be mentioned here (1) An object is said to possess a plane of symmetry if a plane mirror can be imagined passing through it so that one-half of the object coincides with the reflection in the mirror of the other half. The plane of the mirror is then the plane of symmetry. (2) An object is said to possess an n-fold axis (or an axis of order n) if it possesses an axis, about which rotation by 360°/n brings the object into a position indistinguishable from its original one. The order n can take on any positive integral value, or it may be infinite if the object has, for example, the symmetry of a right circular cylinder. In general, n rotations by 360°/n bring the object into a position identical with, and not merely indistinguishable from, the original one. Any straight line passing through any object is clearly a one-fold axis; such one-fold axes may usually be ignored, however, in discussions of symmetry since an infinite number of them are always present. (3) An object is said to possess a centre of inversion (or of symmetry, or of reflection) if it contains a point within it, such that any straight line through that point encounters exactly the same environment in each of its two directions. Further discussion, with examples, of each of these types of symmetry element is given in the article CRYSTALLOGRAPHY. A number of additional examples are also mentioned below.

The above-mentioned plane and centre of symmetry are examples of elements with what may be termed reflection sym-

realization of the mirror image of sodium ammonium tartrate and metry. The most general type of element possessing this kind of symmetry is the so-called alternating (or mirror) axis, of which the plane and centre of symmetry are only special cases. Although no detailed description of alternating axes need be given here, mention should be made of the fact that an object may possess such an axis without having either plane or centre of symmetry.

Mathematical analysis has shown that an object is superposable on its mirror image if, and only if, it possesses reflection symmetry of some sort. In stereochemistry, this rule finds its only important applications in those instances in which the molecules have either planes or centres of symmetry, or both. No example had by 1946 been reported of an optically mactive substance, the molecules of which possess neither of these two symmetry elements. There is no theoretical reason why such a substance could not be prepared; it just happens that no chemist had by 1046 taken the trouble to do so. For this reason, the statement is often made that a compound must be optically active unless it is a mixture of enantiomorphs (like racemic acid) or else its molecules possess either planes or centres of symmetry. In practice, this simpler but incomplete form of the rule is adequate for most purposes. It is especially to be noted that the presence of simple (not alternating) axes of symmetry is not sufficient to ensure optical mactivity, or, in other words, that a molecule may possess an axis of symmetry and still be dissymmetric (For an example of a dissymmetric molecule with both twofold and threefold simple axes, see the cobalt compound XXXIX in the section below. Elements of Co-Ordination Number 6.

Enantiomorphs.—Since enantiomorphs have not only identical structures but also very similar configurations (s.e., atomic arrangements in space), the conclusion can be drawn that such pairs of substances should possess extremely similar properties. Indeed, in consequence of the mirror-mage relationship assumed to exit between enantiomorphs, the more precise conclusion can be drawn that each property of either enantiomorph must be (in the sense discussed below) the mirror image of the corresponding property of the other enantiomorph; or, in other words, that two enantiomorphs must be identical with respect to all those properties which are themselves (in this same sense) identical with their own mirror images, and can differ with respect to only those other properties which are different from their mirror images. For example, the melting point of any substance may be considered identical with its own mirror image, since the temperature at which solid and pure liquid are in equilibrium must be the same whether the experiment is viewed directly or by reflection in a mirror. Consequently, two enantiomorphs must have identical melting points. In a similar way, it can be shown that two enantiomorphs must have also identical vapour tensions at any specified temperature, identical boiling points at any specified pressure, identical densities under the same conditions, identical solubilities in any specified optically inactive solvent, identical rates of reaction with any specified optically mactive reagent (or reagents), identical equilibria in their reactions with any specified optically inactive reagent (or reagents), and so on. On the other hand, the mirror image of a rotation of the plane of polarization by a specified number of degrees to the right (or left) may be considered to be a rotation by exactly the same number of degrees to the left (or right), respectively. Consequently, two enantiomorphs, under identical conditions, must rotate the plane of polarization by equal amounts but in opposite directions. Similarly, the mirror image of right (or left) circularly polarized light is identical not with itself but instead with left (or right) circularly polarized light. Consequently, two enantiomorphs may be expected to possess different optical properties (e.g., absorption spectra, indexes of refraction, etc) when examined with circularly polarized light, but not when examined with ordinary light or even (except for the optical rotation) when examined with plane polarized light; conversely, the optical properties of a single optically active substance may be expected to be different with right and left circularly polarized light. The expected differences in spectrum have been observed experimentally (circular dichroism, Cotton effect); and the differences in index of re-fraction, although so small that their direct observation is diffi-

cult, are known always to exist since the observed angle of rota- pens that a set of stereoisomers contains both optically active and tion by an optically active substance can be shown to be proportional to the difference in the indexes of refraction for right and left circularly polarized light Moreover, since an optically active solvent is not identical with its mirror image, the solubilities of two enantiomorphs in such a solvent need not be the same, differences of this sort are found in practice, however, to be too small to be observed. On the other hand, measurable differences have been found in the rates and extents of adsorption (q,v) of enantiomorphs upon optically active solid adsorbents, and in the rates and equilibria of their reactions with optically active reagents (see Asymmetric Syntheses and Decompositions, below) Finally, the crystals of two enantiomorphs may be nonsuperposable mirror images of each other (cf. the enantiomorphic tartaric acids and tartrates, above); in many instances, however, the forms of the crystals of enantiomorphs are symmetrical and ıdentıcal

Diastereomers.-Examples of stereoisomers which are not enantiomorphs of each other are well known. In 1853 Pasteur discovered that the cinchonine (see Cinchona Bark, Alkaloms or) salt of either tartaric or racemic acid, when heated for sevor) sait of entire catalities account and matter as a certain out at 170° C, is transformed into the sait of still a different stereoisomeric acid. This acid, known as meso tartaic acid, resembles racemic acid in being optically inactive, but it differs from racemic acid in having a different melting point, different solubilities, etc., and also in not being separable into two enantio-morphic forms. The individual molecules of meso tartaric acid, therefore, must be symmetrical (se., superposable on their mirror images) The substance, although a stereoisomer, is not an enantiomorph, of either of the active tartaric acids.

In subsequent years, a large number of nonenantiomorphic stereoisomers have been discovered. An extreme example of this is provided by the aldohexoses (see Carbonydrates), of which the pyranose structure permits no less than 32 stereoisomeric forms, divisible into 16 pairs of enantiomorphs, all are known.

No general term had by 1946 been universally adopted for the description of the relationship between two stereoisomers which are not enantiomorphs of each other. The word "diastereomer" (or diastereoisomer, or diamer) is often applied to certain, but usually not to all, such pairs of substances. Thus, dextrorotatory tartaric acid and meso tartaric acid are considered diastereomers of each other, as are also any nonenantiomorphic 2 of the 32 aldohexoses; but fumaric and maleic acids are not usually considered diastereomeric. The reason for this distinction is that the isomerism of the tartaric acids and of the aldohexoses is of the type known as optical, whereas that of fumaric and maleic acids is of the type known as geometrical; most commonly, two nonenantiomorphic stereoisomers are said to be diastereomers of each other only if they are optical isomers, and not if they are geo-metrical isomers. The distinction between these two kinds of stereoisomerism is discussed briefly below in the section Optical and Geometrical Isomerism; here, it may be mentioned only that this distinction is not at all sharp since many pairs of substances are both optical and geometrical isomers at the same time. For this reason, and also for purposes of brevity and convenience, the word "diastereomer" is used throughout the remainder of this article to designate any nonenantiomorphic stereoisomer. Thus, even fumaric and maleic acids are said to be diastereomers of each other. It is to be noted, however, that, in this respect, the present article departs somewhat from the most customary terminology.

Unlike enantiomorphs, diastereomers (in the broad sense just defined) need not have closely similar physical and chemical properties. Indeed, they may differ as greatly as do structural isomers. For example, either of the optically active tartaric acids melts at 187° C., whereas meso tartaric acid melts at 143° C.; maleic acid melts at 130.5° C. and loses water at 160° C. to form an anhydride, whereas fumaric acid melts at 287° C and forms no anhydride (under sufficiently vigorous conditions, however, fumaric acid is transformed into the anhydride of maleic acid);

Meso Forms. As with the tartaric acids, it frequently hap-

optically mactive members. The mactive members of such sets are frequently distinguished from their active isomers by being called meso forms (This is, of course, the significance of the name "meso tartatic acid.") Meso forms are often referred to as internally compensated, since their individual molecules can be divided (in thought) into two halves, each of which is dissymmetric and the mirror image of the other half, the rotatory powers of these two halves exactly cancel each other, so that the entire molecule is inactive

Racemic Modifications.-- A mixture of equal quantities of two enantiomorphs, which is of course optically inactive, is known as a racemic modification. The name is derived from racemic acid, the first example of such a mixture to be carefully studied (This double use of the word "racemic" is found in practice to lead to httle if any confusion ) A racemic modification is sometimes said to be externally compensated (cf. the internally compensated meso forms). Any process by which an optically active substance is transformed into the corresponding racemic modification is known as a racemization, conversely, any process by which a racemic modification is separated into the two enantiomorphs is known as a resolution. (See Racemization and Resolution, below.)

In the liquid and gaseous states, a racemic modification seems always to be merely a mechanical mixture of its two components. In the solid state, however, three different situations have been encountered (1) Sometimes, as with sodium ammonium racemate crystallized from water at a temperature below 28° C. (see above), the solid is a conglomerate (or racemic mixture) consisting of separate crystals of the two enantiomorphic forms (2) Sometimes, as with the dimethyl ester (see ESTERS) of racemic acid, the two enantiomorphs form a 1.1 compound (or racemate) with each other. Such compounds, however, decompose into their constituents at temperatures above their melting points. (3) Sometimes, as with camphor oxime (see CAMPHORS; OXIMES), the enantiomorphs form a solid solution (q v.) (or pseudoracemic mixed crystal).

Occasionally the racemic modification is spoken of as a definite substance, as if it were distinguishable from the enantiomorphs of which it is composed Thus, the statement is sometimes encountered that there are altogether four stereoisomeric tartaric acids, viz., the dextro- and laevorotatory forms, the meso form and racemic acid. Such a mode of description is, however, not really correct. If the racemic modification is a compound, it has a greater molecular weight than the pure enantiomorphs, and so it is not strictly an isomer of them at all; on the other hand, if it is not a compound, then it is not a pure substance but a mixture of two substances, and so again it is not strictly an isomer of the enantiomorphs. In this article, the racemic modification is treated as a mixture and not as an additional stereoisomeric

A Word About Nomenclature.-Dextrorotatory and laevorotatory enantiomorphs were originally designated by the prefixes d and l, respectively, so that the dextrorotatory and laevorotatory tartaric acids, for example, were called d-tartaric acid and Ltartaric acid, respectively. Somewhat later, however, these prefixes were made to refer also to the so-called optically active series to which the substances belonged, as well as to the directions of rotation. (For the significance of these series, see Optically Active Series, below.) As a result of this ambiguity in nomenclature, many substances were found which had to be assigned the prefix d because they were dextrorotatory, and, at the same time, the prefix I because they belonged to the I-series (or vice versa). The confusion which was thus caused has been alleviated to some extent by the adoption of the convention that the prefixes d and l (or frequently D and L) refer only to the optically active series, and that the further prefixes (+) and (-) be employed to represent dextrorotation and laevorotation, respectively. Thus, the complete names of the two optically active tartaric acids are d(+)-tartaric acid and l(-)-tartaric acid, since the dextrorotatory and laevorotatory forms have been found to belong to the d- and l-series respectively. In this instance, the direction of rotation and the series coincide, in other instances, however, they do not do so, as with d(-)-lactic acid and its enantiomorph 1(+)-lactic acid, of structure CH3-CHOH-CO2H

Unfortunately, the convention just discussed is not always followed consistently by all chemists. If a substance does not belong to any of the accepted optically active series, the prefixes d and I are often used, as originally, to indicate the direction of rotation Thus, the naturally occurring laevorotatory quinine (q v.) is often referred to as l-quinine rather than as (-)-quinine. No confusion can arise in such instances since no d- and l-series have been defined for alkaloids like quinine However, an expression like "d-lactic acid" may refer either to the dextrorotatory form, which belongs to the l-series (see above), or to its enantiomorph in the d-series. Consequently, such an expression is configurationally meaningless, unless accompanied by a statement as to which convention is being employed. In this article, the prefixes d and l are used to represent only the optically active series, and the prefixes (+) and (-) are used always to represent the direction of rotation (even for substances like quinine, for which no series have been defined).

Optically inactive meso forms are frequently designated by the prefix i (for inactive) or m (for meso) Thus mesotartaric acid may be called either i-tartaric acid or m-tartaric acid Racemic modifications are similarly designated by the prefix r (for racemic) or dl (to indicate that the compound is a mixture of the two enantiomorphs). Thus, racemic acid may be called either r-tartaric acid or di-tartaric acid.

Racemization.-The ease with which an optically active substance can be transformed into the racemic modification varies within wide limits. On the one hand, the racemization of certain compounds (for example, an optically active paraffin hydrocarbon) is so difficult that no method is known by which it can be achieved at all; but, on the other hand, the racemization of certain other compounds (for example, a tertiary amine, see Stereochemistry of Nitrogen, below) is so easily accomplished that the optically active forms cannot even be obtained. Innumerable further compounds exist, however, with which the ease of racemization lies between these two extremes.

Such compounds can be separated (see Resolution) into the active enantiomorphs, which can then be racemized more or less readily.

The experimental conditions under which the racemization of racemizable substances can be effected also vary widely. In all instances, however, the racemization is presumed to occur as a result of a reversible transformation into an unstable substance of such nature that it is necessarily symmetric and so incapable of optical activity; the reverse transformation back from this hypothetical inactive intermediate then leads to the inactive (i.e., racemic) modification of the original substance.

The transformations which thus lead to racemization are considered most commonly to involve chemical reactions of familiar type, but occasionally to involve merely geometrical deformations.

The interconversion of diastereomers is closely analogous to the racemization of optically active substances; accordingly, the ways in which such transformations can be brought about, and the mechanisms by which they are presumed to occur, require no further discussion here.

Resolution .- Whenever a substance capable of optical activity is prepared under the usual experimental conditions from exclusively inactive reagents, the product obtained is always the inactive racemic modification. This is because, in view of the complete symmetry of the experimental situation, the probability that a molecule of the dextrorotatory enantiomorph will be formed is exactly the same as the probability that one of the laevorota-tory enantiomorph will be formed. Consequently, equal numbers of molecules of the enantiomorphs must be formed, so that the product must be recent. It an optically active product is desired instead, therefore, a recently english performed, so that the product must be recent. It an optically active product is desired instead, therefore, a recently englished be performed.

\*\*All a separation of a racemic modification into its two optically educated as in a particular product in the control of anatomorphis in apartic all their properties. A separation by grantiomorphis in apartic all their properties.

crystallization, for example, is impossible, because enantiomorphs have identical solubilities in all inactive solvents and also (within the limits of measurement) in all active solvents as well. A separation by fractional distillation is likewise impossible because enantiomorphs have identical boiling points at all pressures, and identical vapour tensions at all temperatures. In a small number of cases, however, partial separations have been effected by fractional adsorption on an optically active adsorbent.

Two important methods of resolution were developed by Pasteur. The first of these, known as the method of spontaneous separation, has already been described in connection with Pasteur's work on sodium ammonium racemate. It can be employed if the solid racemic modification is a conglomerate composed of observably different crystals. Only about a dozen instances in which this condition is satisfied have been reported in the organic chemical literature. Consequently, this method, although of great

historical and theoretical interest, is seldom applicable Pasteur's second method of resolution is of much greater generality than his first, and it is the only one commonly used. It is based upon the transformation of the mixture of enantiomorphs into a mixture of diastereomers, which, since they differ in physical properties, can be separated relatively easily This transformation requires the use of some previously obtained optically active substance. For example, Pasteur showed in 1853 that when racemic acid is treated with a naturally occurring optically active base, such as cinchonine, strychnine, brucine or quinine (see ALKALOIDS), the resulting salt is a mixture of diastereomers and no longer one of enantiomorphs. This is because (if, for definiteness, the base is assumed to be dextrorotatory) the salt formed from the (+)-acid and (+)-base is not the mirror image of the one formed from the (-)-acid and the same (+)-base. (The mirror image would instead be the salt formed from the (-)-acid and (-)-base.) The two salts present in the mixture may, therefore, be expected to have different solubilities and so to be separable by crystallization. After the separation has been carried out, the salt from the (+)-acid and (+)-base gives the pure (+)-acid when treated with a strong mineral acid, and the other salt gives the pure (-)-acid when treated similarly.

In the form just outlined, Pasteur's second method can be applied to the resolution of only racemic acids. Various modifications have been developed, however, which permit it to be greatly extended. Thus, a racemic base can be resolved by means of salt formation with an optically active acid, a racemic aldehyde or ketone can be resolved by means of hydrazone formation with an optically active hydrazine, and so on. Moreover, a racemic alcohol can be resolved if it is first transformed into the acid ester of a dibasic acid (such as phthalic acid, q.v), which is neutralized as before with an optically active base; the resulting ester salt can then be separated into the diastereomeric forms and finally hydrolyzed back to the alcohol.

Similar schemes of greater or less complexity can be devised for most remaining types of substance.

Asymmetric Syntheses and Decompositions.-If a compound capable of optical activity is prepared in a dissymmetric environment, the product obtained need not be completely racemic since factors are present which may favour the formation of one enantiomorph over that of the other. Such reactions are known as asymmetric syntheses (although dissymmetric syntheses might seem a more appropriate expression). For example, although the reduction of inactive phenylglyoxylic acid C<sub>6</sub>H<sub>3</sub>-CO-CO<sub>2</sub>H leads to completely racemic mandelic acid CoHo-CHOH-COoH, the reduction of the (-)-menthyl ester of the acid, followed by hydrolysis of the resulting menthyl mandelate gives a mandelic acid which is laevorotatory although it contains a considerable amount of the (+)-enantiomorph. This slightly active acid can be separated by crystallization into the "optically pure" (-)-mandelic acid and r-mandelic acid. A different type of asymmetric synthesis is illustrated by the base-catalyzed reaction between benzaldehyde C<sub>6</sub>H<sub>5</sub>-CHO and hydrogen cyanide HCN to give mandelonitrile C<sub>6</sub>H<sub>5</sub>-CHOH-CN. Since the reagents are optically inactive, the product is necessarily racemic if the basic catalyst is also inactive; however, if an optically active catalyst, such as

the alkaloid quinine, is used instead, the resulting mandelonitrile conceivably have started at such a time and place that the first is somewhat optically active

The asymmetric syntheses mentioned above are relatine, succee they require the previous existence of at least one optically active substance. A few absolute asymmetric syntheses, which are subject to this requirement, have been reported. These synthese are based upon photochemical reactions (see Photocutsateriv) initiated by circularly polarized light, since circularly polarized light is not identical with its own mirror image (see above), at the provides the necessary dissymmetric environment.

"Asymmetric" decompositions, either relative or absolute, can be performed under conditions analogous to those employed with the above asymmetric syntheses

Asymmetric syntheses and decompositions are of especially great importance in biological reactions, since the reactions which occur in living systems are so frequently brought about by optically active reagents or are catalyzed by optically active catalysts (enzymes) For example, the fact that green plants are able to transform mactive water and carbon dioxide into active carbohydrates (see Photosynthesis) is due to the occurrence of asymmetric syntheses. Similarly, the fact that the natural d(+)glucose (q v ) is easily digested by animals and is fermented by yeast, whereas its enantiomorph undergoes neither reaction, must be attributed to the occurrence of asymmetric decompositions An important application of such biological reactions was discovered by Pasteut, who found (1856-60) that the mould Pemcillum glaucum, when allowed to grow in the presence of racemic (tartaric) acid, destroys the (+)-enantiomorph preferentially, so that the acid which remains becomes laevorotatory This method of obtaining optically active substances is of considerable generality since other micro-organisms have been found to have similar effects, and since other racemic modifications have been found to be made active in similar ways; it has, however, serious limitations since many substances are not attacked by any known organisms, and since often the organism destroys just the enantiomorph which is desired. It should be noted that the method cannot be called a resolution since one of the two enantiomorphs is always destroyed. The Origin of Optically Active Substances in Nature .-

The frequent occurrence of optically active substances in animal and vegetable sources can be explained only as the result of asymmetric syntheses or decompositions. These reactions are made possible by the presence of pre-existing optically active substances, which must themselves have been made by asymmetric syntheses or decompositions; and so on. If life started on this earth many millions of years ago by the coming together of simple inorganic and optically inactive materials, there must have been a time at which the optical activity began. The question therefore arises how it came into being in the absence of any pre-existing optically active substance. (If life is assumed not to have started on this planet but to have come-from some other body, the difficulty is merely pushed back in time and not avoided!) Naturally, the answer to this question is unknown, and possibly unknowable. Scientists have nevertheless sociulated about if for many vears.

Two types of theory have been advanced to explain the origin of optical activity. The first of these is based upon the fact of spontaneous separation. It is not inconceivable that an optically active substance produced in small amount in this way may have been involved somehow in the origin of life. Thus, an early form of life may have happened to consume some d-th-y-sodium armonium tartrate, or to have lived on the surface of a crystal of (--)-quartz for this explanation is that it depends too much upon the operation of chance. There would on the average be just as much ((-)-a soft d'+)-sodium ammonium tartrate for the organism to consume, and just as many crystals of (-t)-a soft (-)-quartz for it to live on; the supposition that the universal and uniform occurrence of optical activity could have arise in such a manner seems unlikely a calcivity could have arise in such a manner seems unlikely as

The second kind of theory is based upon the existence of absolute; asymmetric syntheses and decompositions. For example, since light can be circularly polarized by reflection, life may

conceivably have started at such a time and place that the first organisms were more or less constantly subjected to the action of either right or left circularly polarized light. This theory avoids the difficulty of assigning too great a role to chance. It encounters a different one, however, in that the activities producible photochemically in the laboratory have always been extremely small, and also in that the natural circular polarization of light could at most be slight. A further theory, which assumes that the earth's magnetic held produced the necessary dissymmetric environment enjoys a similar advantage, but it suffers from similar disadvantages.

#### THE STEREOCHEMISTRY OF CARBON

The Tetrahedral Carbon Atom.—The above extremely general considerations require no assumptions in regard to the actual geometrical forms of the molecules under discussion. Such assumptions become necessary, however, if the attempt is made to account for the numbers of stereosomers corresponding to each structural formula. The first successful theory based upon explicit geometrical assumptions was brought forth simultaneously and independently in 1874 by J. H. van't Hoff and J. A. E. Bel. The ideas of van't Hoff were somewhat more definite than those of Le Bel, but they differed in no respect important to the present article. The following discussion makes no effort to follow either van't Hoff's or Le Bel's development very closely; it attempts instead to present the fundamental principles in logical rather than in historical order.

For the molecular formula CH4, only the single structure I can be drawn (if, as usual, carbon and hydrogen are considered to be quadrivalent and univalent, respectively), and only the

single substance, methane, is known. Similarly, for the formula CH<sub>2</sub>Cl, only the single structure II can be drawn, and only the single substance, methyl chloride, is known. Now, if one hydrogen atom in methane were different from any one of the others in any respect, the substance produced by the replacement of the strik hydrogen atom by a chlorne atom should be different from the one produced by the replacement of the second hydrogen atom. Consequently, at least two distinct substances, CH<sub>2</sub>Cl, should exist. The fact that only one such substance is known strongly suggests, therefore, that all four hydrogen atoms of methane are completely equivalent to each other, not only structurally (i.e., beologically, see above), but also geometrically

Alternative interpretations of the existence of only one substance with the formula CH2Cl can be imagined. Thus, several different substances with this formula might be theoretically possible, but only one of these might be stable enough to be isolated; or the various substances might be too closely similar in all their properties to be separated or distinguished from each other, or additional isomers might be obtainable if only suitable methods of preparation could be discovered; and so on At one time, chemists made serious efforts to establish beyond question the complete equivalence of the four hydrogen atoms of methane. by replacing them systematically, and one at a time In this way, they hoped to prove that, no matter which hydrogen atom is replaced by a given substituent atom or group, the same product results. It is now recognized, however, that this work was without significance since there is no assurance that, in a replacement reaction, the entering atom or group occupies the same relative position in space as did the one which it replaces (see Walden Inversion, below). The most satisfactory evidence supporting the belief that all the hydrogen atoms of methane are equivalent is therefore the fact that, in spite of the tremendously large number of known organic compounds, no example has ever been encountered of more than one substance CH3R, where R is any specified atom or group. (Here, and throughout the remaining discussion, groups designated by general symbols like R. S. or the like are considered to be not sufficiently complex to permit somersm within themselves) Thus, there is only one CH-IC, as has already been mentioned, only one CH-IC, only one CH-IB, only one CH-II, only one CH-INO<sub>2</sub>, only one CH-CO-II, only one CH-ICIs, and so on almost without limit For this reason, no chemist now seriously considers the possibility of nonequivalent hydrogen atoms in methane.

The requirement that all four hydrogen atoms of methane be geometrically equivalent restricts the atomic arrangements to the following: (1) The hydrogen atoms might lie at the corners of a rectangle, with the carbon atom at the centre, as in III The dotted lines outliming the rectangle are given only for the sake of clarity; they do not represent valence bonds of any kind This model is known as the planar model (2) The hydrogen atoms might he at the corners of the base of a square pyramid, with the carbon atom at the anex, as in IV. (It should be noted that,

if the base of the pyramid were rectangular rather than square, two enantiomorphic forms of each monosubstituted derivative CH2R would be possible. Such a configuration can, therefore, be excluded ) The dotted lines are again given only for the sake of clarity. This model is known as the pyramidal model (3) The hydrogen atoms might lie at the corners of a tetrahedron, with the carbon atom in the centre, as in V. The dotted lines which outline the imaginary tetrahedron are given, as before, only for the sake of clarity. A more convenient, but equivalent, representation of this so-called tetrahedral model, which is employed throughout the remainder of the article, is shown in the diagram VI. The two broken lines in this latter figure represent valence bonds to hydrogen atoms lying behind the plane of the paper; the two heavy lines represent bonds to hydrogen atoms lying in front of the plane of the paper. The equivalence of the hydrogen atoms does not require that the tetrahedron be a regular one, just as, in the planar model, it does not require that the rectangle be a square; only certain, rather symmetrical types of tetrahedron are satisfactory, however.

The decision among the planar, pyramidal and tetrahedral models is made possible by a consideration of the numbers of isomeric substances CE<sub>0</sub>KS, where R and S represent any two specified, but not necessarily different, atoms or groups Only one known substance, methylene chloride, exists with the formula CH<sub>1</sub>Cl-CO<sub>2</sub>H, etc. For no formula of this type is more than a single substance known. Now, the planar model would lead to the three distinct spatial arrangements or configurations VII, VIII and Xi. of which VII and VIII are identical if the rectangle

is a square. Since IX cannot be identical with VII or VIII under any circumstances, however, this model requires the existence of at least two stereoisomeric forms and so can be excluded from further consideration.

The pyramidal model might be expected, like the square planar one, to permit two stereosomeric substances. Thus, the two configurations X and XX are possible. If R and S are not idenlical, however, the configuration XX is dissymmetric, and so its fromsuperpossible mirror mage '(canationorph) XII represents

still a thud stereoisomer Since stereoisomerism has never been observed with structures of the present type and, moreover, since optical activity has never been encountered, the inference can be drawn that the pyramidal model also is incorrect.

Only the tetrahedral model remants If the tetrahedran is regular, this model permits only a single substance CHARS, whether R and S are identical or different. In particular, the configuration, as shown in XIII, is symmetrical, since it has a plane of symmetry passing through R, S and C, and so no optical activity is possible and no enantiomorphs can exist. The regular tetrahedral model, therefore, reproduces the experimentally observed numbers of isomers. The irregular tetrahedral model, on the other hand, permits to many isomers and so can be excluded.

The regular tetrahedral model is, therefore, the only one in agreement with the observed numbers of isomers; consequently, it must be assumed to be correct. Confirmation of this model is provided by the fact that it correctly predicts the occurrence of optical activity, and hence also of enantiomorphs, with substances with the formula CPRST, where no two of the atoms or groups P, R, S and T are identical. Lactic acid, CHz-CHOH-CO-H, for example, occurs in enantiomorphic dextrootatory and laevorotatory forms. For the molecules of these substances, the nonsuper-posable, mirror-mange configurations XIV and XV are possible. One of these must therefore represent the molecule of the dextrortatory lactic acid, and the other must represent that of the laevorotatory form; however, there is no way at present of deciding with complete certainty which configuration belongs to each fing with complete certainty which configuration belongs to each

Physical evidence has confirmed the conclusions reached above Studies of spectra and of X-ray and electron diffraction have shown that a saturated carbon atom is indeed tetrahedral, in the sense that the four single bonds which it forms are directed toward the corners of a tetrahedron, of which it occupies the centre. (The tetrahedron itself, of course, is only an intellectual construction without physical reality.) Moreover, the tetrahedron has been found to be regular, or very nearly regular, so that the angle between any two of the single bonds formed by the central carbon atom has the so-called tetrahedral value of 109° 28', or very nearly that value. When the four atoms or groups joined to the carbon atom are of the same kind, as in methane CH4 or carbon tetrachloride CCl., the tetrahedron seems always to be strictly regular, but, when the atoms or groups are not of the same kind, as in methylene chloride, CH<sub>2</sub>Cl<sub>2</sub>, some small distortions may occur. Thus, in methane and carbon tetrachloride, each H-C-H and Cl-C-Cl bond angle, respectively, is exactly 100° 28'; but in methylene chloride, the Cl-C-Cl angle is found instead to be about 112°. The spreading of the angle here is presumably due to a greater repulsion between the relatively large chlorine atoms than either between the chlorine atoms and the much smaller hydrogen atoms or between the two hydrogen

As mentioned above, an irregular tetrahedral model would apparently allow the existence of a greater number of stereoisomers than is observed; nevertheless, it may be presumed that no small distortions of the type found in methylene chloride can

for by the perfectly regular model This is because the configurations belonging to any further stereoisomers would doubtless be unstable, so that the corresponding molecules would revert spontaneously and immediately to the stable configuration

Asymmetric Carbon Atoms,-A carbon atom is said to be asymmetric if it is joined to four different atoms or groups Thus, of the three carbon atoms in lactic acid, the central one is seen to be asymmetric (The terminology here is correct since an "asymmetric" carbon atom possesses no element of symmetry and so is actually asymmetric, and not merely dissymmetric The majority of all known optically active substances consist of molecules which contain one or more asymmetric carbon atoms However, the presence of such atoms is neither necessary nor sufficient for optical activity As will be discussed below, many substances containing no asymmetric atoms are active, and, conversely, many containing asymmetric atoms are inactive. Optical activity is caused by the dissymmetry of each individual molecule as a whole, the presence or absence of asymmetric atoms is important only in so far as it determines the symmetry or dissymmetry of the molecule

The Stereochemistry of Olefinic Compounds,-van't Hoff assumed that the carbon atoms in unsaturated compounds have the same tetrahedral form as those in the saturated substances The configuration of ethylene, H2C=CH2, thus becomes XVI. If this configuration is correct, the six atoms in the molecule lie in

the same plane (the plane of the paper in XVI), the H-C-H bond angles have the tetrahedral value of 100° 28′, the C-C-H angles (or, more precisely, the angles between the carbon-hydrogen bonds and a straight line passing through the carbon atoms) is 125° 16', and the carbon-carbon distance is 0 58 times that in ethane, CH3-CH3

Although erroneous in some respects (see below), van't Hoff's configuration of ethylene appears to be correct in all essential stereochemical details. In particular, it leads to correct predictions of the numbers of stereoisomeric forms of suitably substituted ethylenes Indeed, its significant features can be deduced directly, and without reference to the tetrahedral carbon atom, from considerations of isomer numbers. (As was true also in the above discussion of the saturated compounds, the assumption must be made here that all the theoretically possible stereoisomers corresponding to the structural formulae considered are known ) The fact that ethylene is the only known substance with the molecular formula C2H4 shows that the lines bisecting the two H-C-H angles must be along continuations of the line joining the carbon atoms; otherwise, at least two stereossomeric substances, with the configurations XVII and XVIII should be possible (For the sake of both simplicity and generality, the geometry of the two bonds constituting the double bond is not indicated here explicitly.) Moreover, the planes defined by the two CH2 groups must be either identical with, or at right angles to, each other,

since otherwise the molecule would be dissymmetric and the substance would be optically active. Finally, the decision between the planar and perpendicular models can be made by a consideration of the nature of the isomeric substances with the structure ments (or conformations) are consistent with the assumption of

give rise to a greater number of isomers than could be accounted CHR=CHR The planar model permits the two configurations XIX and XX, whereas the perpendicular model permits XXI

and XXII. Now, XIX and XX must represent optically inactive diastereomers since, with each, the plane of the molecule is a plane of symmetry; on the other hand, XXI and XXII must represent a pair of enantiomorphs since they are nonsuperposable mirror images of each other, with neither plane nor centre of symmetry. In the particular case in which R is the carboxyl group, CO2H, two substances, fumaric and maleic acids (qv), are known, each of these acids is optically mactive, and the two differ markedly in nearly all their properties (see above). Consequently, they must be diastereomers and cannot be enantiomorphs Since numeious further examples of similar type are known, and since optical activity has never been encountered in substances with the structure CHR = CHR (unless R represents a dissymmetric group), the necessary conclusion is that the planar model is correct, in agreement with van't Hoff. The configuration XIX is commonly said to be cis (Latin cas, on this side), whereas XX is said to be trans (Latin trans, across)

From considerations of isomer number alone, no information can be obtained regarding the values of the bond angles or of the interatomic distances in ethylene and its derivatives; consequently, the angles and distances derived from van't Hoff's configuration, with the tetrahedral carbon atoms, cannot be verified by purely chemical procedures Physical investigations (see Spec-TROSCOPY; X-RAYS AND CRYSTAL STRUCTURE; ELECTRON DIF-FRACTION) have shown, however, that it is precisely in such respects that van't Hoff's model is incorrect. Thus, in ethylene, the H-C-H and C-C-H angles are more nearly equal to 120° than to 109° 28' and 125° 16', respectively; and the carbon-carbon distance is more nearly o 87 than o 58 times that in ethane. Moreover, the modern quantum-mechanical picture of the double bond is rather different from that provided by the tetrahedral model XVI. Nevertheless, these defects in no way limit the usefulness of the simple model for the prediction and interpretation of the observed numbers of stereoisomers.

Stereochemistry of Acetylenic Compounds.- Just as with ethylene, van't Hoff assumed that the carbon atoms in acetylene. H-C-C-H, are tetrahedral. He accordingly wrote the configuration as XXIII. In agreement with this linear model, no stereoisomers, to which configurations like XXIV and XXV must be

$$H-C \bigoplus_{XXIII} C - H \quad C \equiv C \quad C \equiv C$$

assigned, have ever been encountered. (In XXIV and XXV, as in XVII and XVIII, the geometry of the bonds constituting the multiple bond is not indicated explicitly) Moreover, recent physical evidence supports the linear arrangement of the atoms. Consequently, although van't Hoff's model of acetylene is inaccurate in several respects (analogous to those in which his model of ethylene is inaccurate, see above), it leads always to correct predictions of the numbers of isomers.

Free Rotation.-Certain limitations must be imposed upon the general statement that two molecules correspond to different substances unless they are exactly alike with respect to the relative positions in space of all their atoms. For the structure H<sub>3</sub>C-CH<sub>2</sub>, for example, an infinite number of geometrical arrangetetrahedral carbon atoms, these include the two represented by XXVI and XXVII, as well as all the further ones obtainable from either XXVI or XXVII by rotation of one CH<sub>2</sub> group with

respect to the other about the carbon-earbon bond. If each of these conformations represented a distinct substance, then an infinite number of stereosomers with the structure in question should cast. Only a single substance, ethane, is known however Smilar considerations apply to nearly all further structures in which multivalent atoms are joined by single bonds. It is evident, therefore, that, if the geometrical interpretation of stereosomerism is to be maintained, some further assumption, which restricts the predicted numbers of somers, is required.

The assumption generally adopted for this purpose is contained in the rule that any two conformations (such as XXVI and XXVII, or any other two of the infinite number of possible ones) are to be considered equivalent if they differ only by the rotation of one or more parts of the molecule about one or more single bonds. Thus, XXVI, XXVII, etc. are equivalent; all these conformations correspond to the same substance, ethane, and all are said to represent the same configuration. Although this rule has a number of exceptions (see Optically Active Biphenyls, below), it is swiftently general to find application throughout the same of the same of the same configuration and the same of th

A common alternative statement of the above rule is that rotation about single bonds is free. The use of the term "free rotation" suggests that, in ethane for example, no forces operate to make any one conformation more stable than any other, so that each molecule of the substance spends equal fractions of its time in each of its possible geometrical arrangements. This interpretation is obviously consistent with the fact that stereoisomeric forms of ethane, differing by rotation about the carbon-carbon bond, do not occur; nevertheless, it is probably incorrect. From a combination of spectroscopic and thermochemical data, the conclusion has been drawn that the "eclipsed" conformation XXVI is less stable (ie., has a higher energy) than the "staggered" one XXVII by about 3,000 calories per mole. If this conclusion is correct, most of the molecules at any one time must have arrangements rather close to the staggered one XXVII. Stereoisomerism is still impossible, however, since each molecule must spend part of its time in each of the conformations, and since the transition from any one conformation to any other is rapid and easy.

In nearly all other substances for which data are available, the situation seems to be similar to that in ethane. Certain conformations seem always to be appreciably more stable than others differing from them by rotation about one or more single bonds, but stereoisomers are not encountered because the transition from one conformation to another is easy. In general, stereoisomers can be expected to occur only if there are two or more essentially different geometrical arrangements of the atoms, between which transitions are not easy. A transition may be considered easy at ordinary temperatures if it can be undergone by a molecule possessing an energy much less than about 20,000 calories per mole above the average. This is because, as a result of the statistical variations in energy (see KINETIC THEORY OF Marries), the number of molecules possessing the required excess energy is then sufficiently great to permit an appreciable rate of interconversion; consequently, the separation of the isomers clearly impossible in ethane, since a molecule of this substance requires an excess energy of only approximately 3,000 calories

per mole for a complete rotation of 360° about the carbon-carbon bond On the other hand, the existence of the stereosomener malerc and fumaric acids, to which the configurations XXVII and XXIX, respectively, have been assigned, shows that only such molecules a sposses at least 20,000 caltors per mole of excess

energy can undergo the transition; or, in other words, that the energy of the perpendicular arrangement XXX (or of its enantiomorph, cf. XXI and XXII) must be at least 20,000 calories per mole higher than that of either XXVIII or XXIIX Just as the nonexistence of stereosomers in ethane (and the like) is attributed to the freedom of rotation about the carbon-carbon single bond, so also the existence of stereosomenism between maleic and fumaric acids (and the like) is attributed to the lack of free rotation about the double bond.

It is interesting that van'! Hôff's models of ethane and ethylene CXXVI and XVI, respectively are consistent with the presence of free rotation about the single bond and the lack of it about the double bond. Since the two carbon atoms in ethane are pointed by just one linkage, no forces exist in the model XXVI to favour any one conformation over any other. Consequently, rotation might be expected to be easy in the molecule also. On the other hand, since the two carbon atoms in ethylene are joined by two bonds, the model XVI is held rigidly in the planar form. Consequently, the content of the proposition of the content of the proposition of the model of the content of the proposition of the model of the content of the

Plane Projection Diagrams.—The use of three-dimensional models of the sort employed by wart Hoff becomes extremely cumbersome if the molecule to be represented is even moderately complicated. Moreover, such models cannot be depicted very conveniently on a plane surface, such as a printed page; even the relatively simple dangama XXVII and XXVII, for example, are not too easily intelligible, and the situation rapidly becomes worse as the complexity of the molecule increases. Consequently, some simpler method of representation is highly desirable.

The convention has been generally adopted of representing the three-dimensional models by what are called plane projection diagrams or, more simply, plane configurations. Thus, by definition, the diagrams XXXI and XXXII represent the dextro-rotatory and laevorotatory forms, respectively, of glyceralded, the solution of the plane of the destro-rotatory described by the plane of th

specify the absolute configurations (i.e, the true three-dimensional forms of the actual molecules) The diagram XXXI, for example, can be considered the projection of either XXXIII or XXXIV; similarly, XXXII can be considered the projection

either of XXXV (identical with XXXIV) or of its enantiomorph XXXVI (identical with XXXIII).

The usefulness of the plane configurations like XXXII and XXXII. (The CH2OH group is not affected by the rotation XXXII lies in the fact that they make possible the unique representation of relative configurations. Thus the statement that a given substance CPRST (where P, R, S and T are any specified atoms or groups) has the configuration XXXVII implies that its true three-dimensional form is really XXXVIII (or XXXIX) if that of the dextrorotatory glyceraldehyde is really XXXIII (or XXXIV), respectively In other words, the plane projection diagrams define the configurations of the substances to which they refer by comparing them with that of glyceraldehyde; they do not

give the absolute configurations of the corresponding substances any more than XXXI gives that of the dextrorotatory glyceraldehyde

Considerable care must be exercised in the use of the plane configurations, since errors and inconsistencies can easily be introduced It might appear, for example, that the diagrams XXXI and XXXII are identical since a rotation of 180° about a vertical axis lying in the plane of the paper would transform either into the other. Consequently, if XXXI and XXXII are to represent enantiomorphs, the convention must be adopted that a rotation which takes the figure out of the plane in which it is drawn inverts the configuration (ie., changes it into that of the enantiomorph) Further similar conventions also must be adopted if further similar discrepancies are to be avoided. Unfortunately, however, no unanimity exists at present among chemists as to exactly what all these remaining conventions are, consequently, the conventions outlined below, although they are self-consistent and generally satisfactory, cannot be said to be universally adopted.

Although a rotation of 180° out of the plane of the paper inverts the configuration, as stated above, any rotation within the plane of the paper leaves the configuration unchanged. Thus, XL, XLI and XLII are equivalent to XXXI and, like it, represent dextrorotatory glyceraldehyde On the other hand, the dia-

gram XLIII is configurationally undefined since it cannot be obtained from either XXXI or XXXII by any sort of rotation, whether within or out of the plane of the paper; in other words, it does not represent explicitly either the dextrorotatory or the laevorotatory enantromorph.

It is to be noted that freedom of rotation does not in general exist about the single bonds in plane projection diagrams of the present type (see Free Rotation, above). This is because a rotation about any bond in such a diagram requires that that part of the diagram which is rotated leave the plane of the paper. If this part is dissymmetric, then, according to the convention adopted it is inverted in the process, so that the resulting configuration is not equivalent to the original one. For example, a rotation by 180° of the lower part of XXXI about the upper carbon-carbon bond changes this configuration into the enantiomorphic one

since it is symmetric and so identical with its own mirror image ) These remarks, of course, do not imply any corresponding lack of freedom of rotation about the single bonds in the actual molecules or in the three-dimensional models, they have reference instead only to the conventions which must be adopted if the plane configurations are not to lead to self-contiadictions.

If a molecule contains a ring of atoms, its configuration may be expressed on a plane surface in either of two ways. When one of these methods is used, the diagram is written as if no ring were present, and then the fact that a ring is present is indicated, more or less as an afterthought, by the drawing in of the necessary bonds as long, and frequently curved, lines. Thus, the configura-tion of  $\alpha$ -d-glucose (see Carbohydrates) is often written as XLIV. When the second method of representation is employed, the ring is drawn as if it were a plane polygon approximately at right angles to the plane of the paper, and the substituents at-

tached to the ring atoms are represented by the appropriate symbols above and below the plane of the ring. Thus, the configura-tion of  $\alpha$ -d-glucose can be written as XLV; this diagram is to be considered equivalent to XLIV. Plane projection diagrams like XLV do not imply knowledge of the corresponding absolute configurations A molecule of glucose in which the upper horizontal line (of XLV) is in front of the paper, and the lower line is behind it, would be the enantiomorph of a molecule in which the upper line is behind the plane of the paper, and the lower line is in front of it; since the diagram does not signify explicitly which line is in front, and which is behind, it can be considered the projection of either absolute configuration. Neither do these diagrams imply that the rings are completely planar (see Strain Theory, below); they imply rather that the average positions of the atoms of the ring lie within a single plane.

The fact that the plane projection diagrams of the above types do not give the absolute configurations is not a defect, but rather a desirable feature. This is because the absolute configurations are not known with certainty. Any diagram which implies the absolute configuration might, therefore, be incorrect, but the present diagrams do not suffer from this disadvantage of implying more knowledge than is actually possessed. (Although no experimental method exists for the determination of the absolute configurations of optically active substances, these configurations could in principle be found by theoretical calculations The various attempts which have been made to carry through such calculations, however, have been extremely complex mathematically and have required the introduction of numerous very rough approximations Moreover, the answers obtained with different sets of approximations have not always been in agreement,)

The representation of an ethylenic compound is relatively easy since the two carbon atoms joined by the double bond, and the four other atoms joined by single bonds to these two, lie in the same plane. Consequently, diagrams like XXVIII and XXIX for maleic and fumaric acids, respectively, represent the absolute configurations. Such diagrams need no further discussion.

If a molecule contains several rings, several double bonds, or both rings and double bonds, the representation of its configuration may be rather difficult. In such instances, the conventional scheme just outlined often must be supplemented by the use of heavy and broken lines to represent bonds to atoms in front of to those employed in preceding sections of this article. Examples of such molecules are given below

Use of Plane Projection Diagrams for the Prediction of the Number of Stereoisomers .- The foregoing rather general considerations can be made more definite by a discussion of some specific examples of stereoisomerism. The dextrorotatory and laevorotatory glyceraldehydes are represented by the diagrams XXXI and XXXII, as has already been mentioned. That these two diagrams correspond to enantiomorphs is shown (according to the conventions adopted) by the fact that each can be considered identical with the reflection of the other in a mirror which is halfway between them and perpendicular to the plane of the paper Since there is only one asymmetric atom in the molecule, and no further source of molecular dissymmetry, these two enantiomorphs are the only possible stereoisomeric forms (As usual, the racemic modification is not considered a distinct substance.)

A molecule of tartaric acid. HO<sub>2</sub>C-CHOH-CHOH-CO<sub>2</sub>H. has two asymmetric carbon atoms (the two designated by asterisks). Since there are two possible configurations about each such atom, one might anticipate altogether 2×2, or 4, distinct stereoisomers, which could be represented by the diagrams XLVI-XLIX. Of these, however, the first two are equivalent masmuch as either is

transformed into the other by a rotation of 180° in the plane. Since these two equivalent diagrams are mirror images of each other, they must represent a substance which is identical with its own mirror image, and so optically mactive; they are, therefore, equivalent forms of the plane configuration of meso tartaric acid (see above). The optical inactivity of this substance follows also from the presence of a plane of symmetry in either of the two diagrams (s.e., from the fact that the upper half of either diagram is identical with the reflection of the lower half in a mirror perpendicular to both the plane of the paper and the central carboncarbon bond). On the other hand, the last two configurations, XLVIII and XLIX, are not equivalent since neither can be transformed into the other by any rotation in the plane. Since they are mirror images of each other, they must be enantiomorphs, and so one must represent the dextrorotatory, and one must represent the laevorotatory, tartaric acid. In a way which cannot be described in this article; XLVIII has been shown to belong to the dextrorotatory enantiomorph, and XLIX has been shown to belong to the laevorotatory one. Thus, the existence of the three known tartaric acids can be accounted for, and the prediction that no further stereoisomers are possible can be made. (The diagrams XLVIII and XLIX have centres of symmetry, but neither the molecules which they represent nor the three-dimensional models of which they are projections do; conclusions regarding the presence or absence of centres of symmetry cannot easily be drawn from the plane projection diagrams of this type. However, see the discussion of the cyclic compounds, below.)

The trihydroxyglutaric acids, HQ2C-CHOH-CHOH-CHOH-CO2H, have the three asymmetric carbon atoms marked by asterisks. (The central carbon atom may appear not to be asymmetric since two of the groups attached to it are structurally identical. It is customary, however, to regard such atoms as asymmetric since the attached groups may differ in configuration. Atoms of this type are sometimes said to be pseudoasymmetric.) some might expect 23, or eight stereoisomeric forms, but, as with the tartaric acids, the number is reduced somewhat by the occurrence of meso forms. Only the four nonequivalent configurations

and behind the paper, respectively, or by other devices analogous L-LIII can be drawn, and, in agreement with prediction, only four stereoisomeric substances are known It is easily seen that L and LI represent two different meso forms since each has a plane of symmetry (passing through the central CHOH group

and perpendicular to the paper), and that LII and LIII represent a pair of enantiomorphs

The aldohexoses (see Carbohydrates) have five asymmetric atoms in the pyranose structure (cf the configurations XLIV and XLV of α-d-glucose). Since no meso forms are possible, 25, or 32 different optically active stereoisomers should exist. As has already been mentioned, all these forms are known

The cyclohexane-1,2-dicarboxylic acids, like the tartaric acids, contain two equivalent asymmetric carbon atoms, consequently, they also exist in two enantiomorphic forms, LIV and LV, and one meso form LVI. It is readily verified that the configurations LIV and LV are mirror images of each other, and that neither possesses a plane or centre of symmetry. On the other hand, LVI has a plane of symmetry perpendicular both to the ring and to

LVI the bond joining the two asymmetric atoms; it is, therefore, identical with its mirror image.

The isomerism of the cyclohexane-1,2-dicarboxylic acids (as well as that of other analogous cyclic compounds) is frequently described by the statement that the optically active forms LIV and LV are trans, whereas the meso form LVI is cis This nomenclature is convenient since it expresses clearly and concisely the relative positions of the substituent groups with respect to the plane of the ring. However, it has given rise to much confusion since it suggests a false analogy with the cis-trans isomerism in ethylenic compounds like maleic and fumaric acids (see above). Indeed, the statement is often encountered that the isomerism of the cyclic compounds is due to a restriction of rotation by the more or less rigid ring, just as that of maleic and fumaric acids is due to a restriction of rotation about the double bond. In the former substances, however, the rigidity of the ring is not significant; the isomerism, being due to the presence of two asymmetric atoms, would persist if the ring were perfectly flexible, or even if it were broken to form a noncyclic compound (so long as the asymmetry of the carbon atoms is not destroyed).

In cyclohexane-1,4-dicarboxylic acid, cis and trans forms again exist. Here, however, both the cis form LVII and the trans form LVIII have planes of symmetry and so are optically inactive.

111111

carboxylic acids) is not due to the rigidity of the ring, no conceivable rotation about any bond or bonds in the ring could

transform either isomer into the other, even if the ring were perfectly flexible.

Alanine anhydride (dimethyldiketopiperazine), with a six-membered ring, exists in cis and trans forms. Here, the trans form LIX has a centre of symmetry (at the centre of the ring) and so it is optically inactive (The presence of the centre of symmetry is apparent if the ring in LIX is visualized as lying in a plane perpendicular to that of the paper; on the other hand, if the con-

figuration is written instead in the equivalent manner as LX, the presence of the centre of symmetry cannot be so easily seen.)
The cis form has neither plane nor centre of symmetry, and so it exists in the two enantiomorphic forms LXI and LXII.

Optically Active Allenes and Their Analogues .-- van't Hoff pointed out that, if his tetrahedral model of the double bond (see above) is correct, the two CH2 groups in allene, H2C=C= CH2, should he in planes which are at right angles to each other; and that a substance with the structure RSC=C=CRS, where R and S are any two different atoms or groups, should exist in the enantiomorphic forms LXIII and LXIV. It was not until 1935,

however, that this prediction was verified by P. Maitland and was verment of the time the optically active diphenyldi-\alpha-naphthylallene LXV. In the same year, E. P. Kohler, J. T. Walker and M. Tishler reported the preparation of the similar

The isomerism of these two substances (like that of the 1,2-di- optically active allene LXVI. It is of interest that neither of these substances contains an asymmetric atom.

Although the existence of optically active allenes was not confirmed until comparatively recently, several analogous substances have been known for a longer time. These substances may be considered related to the allenes proper by the replacement of one or both of the "two-membered rings" (i.e., double bonds) by larger rings. Two typical pairs of enantiomorphs are represented by the configurations LXVII and LXVIII, and LXIX and LXX.

$$C_{\text{H}_{1}C}$$
 $C_{\text{C}}$ 
 As with the allenes, none of these substances contains an asymmetric atom

Optically Active Biphenyls .- In 1922, G. H Christie and J. Kenner found that the dinitrodiphenic acid LXXI can be separated into a pair of enantiomorphs. The present interpreta-tion of this fact is that the molecules of the two substances have the configurations LXXII and LXXIII The two rings here are considered to lie in approximately perpendicular planes. Since a rotation of 180° about the central carbon-carbon bond would transform other enantiomorph into the other, the assumption must be made that such rotation is impossible. The factor responsible for this restriction of rotation is presumed to be the size of the four substituents attached to the rings. In order for a molecule to pass from one enantiomorphic form to the other,

it must, at some time during the process, assume a configuration in which the two rings are coplanar; if this should happen, however, the substituent groups mentioned would be forced to come so close together that they would get in one another's way. In other words, it is difficult, or impossible, for the large nitro and

other words, it is unicula, or impossible, in the large interaction arrows, groups to slip past one another.

Evidence to support this interpretation of the optical activity of the dinitrodiphenic acid LXXI is provided by the observed regularities in the occurrence of optical activity in related subcontains no substituents that are themselves dissymmetric) can be active only if, first, neither of the two rings individually possesses a plane of symmetry except for the plane of the ring itself; and, second, several bulky substituents are present in the ortho positions Thus, the substance LXXIV cannot be obtained in optically active forms although the two rings are presumably not coplanar, the plane of the ring with the nitro and carboxyl

groups is a plane of symmetry of the molecule. Moreover, the further substance LXXV cannot be obtained in optically active forms although the noncoplanar configuration would be dissymmetric; the fluorine atoms are apparently too small to restrict the rotation. Intermediate cases are known in which the ortho substituents are large enough to permit optical activity, but not large enough to prevent a more or less rapid loss of activity resulting from spontaneous interconversion of enantiomorphs, such

$$\begin{array}{c|c}
F & F & NO_2 \\
\hline
 & CO_3H & NH_2 \\
\hline
 & LXXVII \\
\end{array}$$

a substance is represented by the structure LXXVI, (All attempts to racemize the dinitrodiphenic acid LXXI have been unsuccessful.)

A few further examples of similar type are given by the substances LXXVII-LXXXI. The naphthalene derivative LXXVII may be considered an optically active biphenyl with only three

ortho substituents; a more typical example is provided by LXXVIII. In LXXIX and LXXX, the presence of only two ortho substituents is sufficient to permit an easily lost activity. In LXXXI, some not completely conclusive evidence suggests that even a single ortho substituent, if it be sufficiently large, may permit activity.

As with the allenes and their analogues, none of these substances possess asymmetric atoms.

Optical and Geometrical Isomerism .-- As has already been mentioned, stereoisomerism is often subdivided into optical and geometrical isomerism. The distinction between these two types of isomerism does not now appear to be as significant as it did (+)-Chlorosuccinic Acid

stances It has been found that a derivative of biphenyl (which when it was first introduced; nevertheless, it has been retained by most chemists for historical reasons. A simple and precise definition of optical and geometrical isomerism appears to be impossible On the one hand, many pairs of substances must be considered both optical and geometrical isomers of each other at the same time, and, on the other hand, no complete unanimity exists among chemists as to exactly where the dividing line between these two types of isomerism is to be drawn. The following remarks are devoted to a brief statement of the basic principles involved, and they make no claim to either completeness or preciseness (or even to complete self-consistency).

A typical example of geometrical isomerism is provided by maleic and fumaric acids, to which, as was stated above, the configurations XXVIII and XXIX, respectively, have been as-

signed The characteristic feature of these two substances which is of interest here is that, as a result of the rigidity of the double bond, the two carboxyl groups, the two remaining carbon atoms, and the two remaining hydrogen atoms are held in the same plane In general, two stereosomers are said to be geometrical isomers of each other if they differ only in the relative positions in space of six coplanar atoms or groups of atoms (With certain nitrogen compounds, either one or two of these atoms or groups may be missing See Stereochemistry of Nitrogen, below.)

A slightly different example of geometrical isomerism is illustrated by the cyclohexane-1.4-dicarboxylic acids, LVII and LVIII Here, the significant six atoms or groups are the hydrogen atoms, the carboxyl groups, and the carbon atoms contained in the two HCCO2H groups Since the six-membered ring is presumably somewhat flexible (see *Free Rotation*), and since it is presumably not completely planar (see *Stram Theory*, below) the atoms and groups under consideration are not held rigidly in the same plane. Consequently, the situation with these acids is not exactly similar to that with maleic and fumaric acids. Nevertheless, the average positions of the atoms and groups are doubtless coplanar (and lying in a plane perpendicular to that defined by the average positions of the atoms forming the six-membered ring); consequently, the isomerism may again be considered geometrical.

In the cyclohexane-1,2-dicarboxylic acids, LIV, LV and LVI, the hydrogen atoms, carboxyl groups, and carbon atoms of the two HCCO2H groups are not coplanar, even on the average. Consequently, these substances may be called optical rather than geometrical isomers of one another. This conclusion seems logical in any event, in consequence of the close analogy with the tartaric acids, which are often given as typical examples of optical isomers. However, a number of writers prefer to classify the mactive cis acid LVI as a geometrical isomer of the two enantiomorphic trans acids LIV and LV, which are themselves optical isomers of each other. This is merely one example, out of many, of the difficulties encountered in the attempt to define unambiguously the distinction between optical and geometrical isomerism.

In spite of the difficulties briefly referred to, the distinction between optical and geometrical isomerism is clear and unambiguous in a large number of instances. In such instances, it provides a convenient method of classification (if it is not considered to possess more fundamental significance than it actually does).

Walden Inversion .- In 1893, P Walden discovered the cycle

of reactions indicated below	:	
HO <sub>2</sub> C—СН <sub>2</sub> —СНОН—СО <sub>2</sub> Н	PCl₅	HO <sub>2</sub> CCH <sub>3</sub> CHClCO <sub>3</sub> H
(+)-Malic Acid	KOH	(-)-CHLOROSUCCINIC ACID
Ag <sub>2</sub> O↑		Ag₃O↓
$HO_2C-\!\!-\!\!\!\!\!\!-\!$	PCl <sub>5</sub>	$\mathrm{HO_2C-CH_2-CHOH-CO_1H}$
(1) 0	KOH	( ) 25

Thus, by treating either of the optically active malic acids first with phosphorus pentachloride (in chloroform solution) and then with potassium hydroxide (in aqueous solution), he was able to transform it into its own enantiomorph, similarly, by treating either of the active chlorosuccine acids first with silver oxide and then with phosphorus pentachloride, he was able to transform it also into its enantiomorph (In each sequence of reactions, considerable racemization occurs, so that the activities of the final products are not very great Othes similar sequences were discovered subsequently, however, in which relatively little racemization occurs).

It is evident that, in one (and only one) reaction of the two in each of these sequences (ie, in either the reaction with silver exide or the one with phosphorus pentachloride, but not in both), the entering substituent at the asymmetric atom does not take up the same relative position in space as that formerly occupied by the substituent which it replaces. The change in configuration which thus results is called an inversion or, more precisely, a Walden inversion (The expression "Walden inversion" was innoduced by E Fischer in 1906 Originally it referred to the complete sequence of reactions by which the ontically active substance is converted into its enantiomorph, and not to the single eaction in which the inversion of configuration occurs Later, lowever, the expression seems more usually to refer to the single eaction, it is so used in this article ) The problem of identifying he particular reaction in which the inversion occurs is a difficult From evidence which cannot be described here, however, he conclusion has been drawn that inversions occur in the reacions of the above scheme in which phosphorus pentachloride and octassium hydroxide participate, but that there is retention of onfiguration in the ones with silver oxide. It is to be especially noted that the fact that the sign of rotation changes in the first we types of reaction but not in the last is purely accidental; the ign of rotation often changes in reactions which are considered o proceed with retention of configuration, and, conversely, it often remains the same in reactions which are considered to proeed with inversion. No necessary relation exists between the onfigurations and signs of rotation of nonenantiomorphic sub-

By 1946 the view was commonly held that every reaction in which one substituent atom or group is replaced by another is companied by an inversion of configuration about the atom at which the replacement occurs. Reactions, like that between hibrorescurne acid and silver oxide, in which no net inversion is onsidered to occur, are interpreted as proceeding in two steps, with an inversion meach; two mersions, of course, are equivaent to a retention. No inversion is considered to occur at atoms t which no substitution takes place.

A probable mechanism of the Walden inversion is shown schenatically in fig. 2. In part a, representing an early stage of the eaction, the reagent R approaches the carbon atom from the side poparie the substituent S; in part b, representing the mid-point of the reaction, the atoms or groups R and S are equidistant from he carbon atom, which is no longer tetrahedral; and in part c, epresenting the conclusion of the reaction, the displaced subtituent S as departing, and the entering one R; is attached to the arbon atom. In the process, the molecule has been "turned sade-out" like an umbrella in a path wind.

a. An early stage b. Mid-point c. Conclusion

FIG. 2 -A PROPOSED MECHANISM OF THE WALDEN INVERSION

Optically Active Series.—The sign of the rotation produced y an optically active substance can occasionally be reversed by change in the experimental conditions (see Specific Rotation, love).—'A further factor, which similarly introduces confusion to stereothering classification is that a parent substance often

gives derivatives of identical configuration but with opposite sign of rotation For example, the salls and esters of the laewrotatory lattic and, CH2-CH0H-CO-H, are destroratory; those of the destroratory and are laevrotatory. For these reasons, it will seem destrobate to include in the complete name of an optically active substance and sis independent of the sign of rotation. This symbol would then remain unchanged when the substance, under different conditions, exhibits different signs of rotation, on when it forms derivatives of composite rotation, or

when it forms derivatives of opposite rotation.

It may be doubted whether any completely general and completely unambiguous classification of configurations of the type desired is possible; certainly, no such classification has as yet been derived. Nevertheless, a scheme has been developed wheth armounds of the complete of the compound of the complete of the compound this scheme consists in dividing configurations into those of the so-called d-series and those of the I-series (or p-series and L-series, respectively) on the basis of the genetic relationships among them. A substance is then said to belong to the d-series (or I-series) are series; and consists of the genetic relationships among them.

A substance is then said to belong to the d-series (or I-series), respectively, and so on

In order that an optically active series may be set up, some particular substance must be defined as belonging to the d-or lesens, so that the remaining substances may be related to it. Originally, Emil Fischer chose the instural dextroordatory glucose as the prototype of the d-series, and, accordingly, he named this substance d-glucose Later, dextroordatory glyceraldehyde, XXXII, was chosen instead (M. A. Kosanofi, 1905), these two conventions lead to the same assignment of series, so that no ambiguity results.

The way in which the optically active series are built up can be illustrated by a few examples. As has been mentioned before, (+)- and (-)-glyceraldehyde are by definition assigned the configurations XXXII and XXXIII, respectively. Also by defintion, they are said to belong to the d- and l-series, so that their

complete names are d(+)- and l(-)-gy/ceruldehyde, respectively. By well-known methods (see Carsoursparts), the aldehyde group (CHO) of each of these substances can be changed into a CHOH-CHO group. Since this larger group contains an asymmetric carbon atom not present in the original, each of the glyceraldehydes can give rise to two products (which, not being canatiomorphs, need not be formed in equal amounts). Thus d(+)-glyceraldehyde gives rise to LXXXIII and LXXXIII, which are, therefore, said to belong to the d-series. Similarly,

l(-)-glyceraldehyde gives rise to LXXXIV and LXXXV, which are said to belong to the l-series.

The procedure can be continued further. Each of the tetrose LXXXII-LXXXV can be transformed into two pentoses, each of which can in turn be transformed into two hexoses, and so on. In each reaction, the two products belong to the same optically active series as the substance from which they were made. In general, and without explicit reference to the sequence of reactions starting with the glyceraldelydes, the optically active series to which any monosuccharide belongs may be said to be determined by the configuration about the asymmetric carbon atom farthest carbon atoms is written vertically and with the carbonyl group at the top, the hydroxyl group upon the atom in question is to the right of the chain in the d-series, and to the left in the l-series

If the glyceraldehydes are oxidized, they give the glyceric acids LXXXVI and LXXXVII. The first of these, even though it is

laevorotatory, is said to belong to the d-series on account of its genetic relationship to d-glyceraldehyde; it is accordingly called d(-)-glyceric acid Similarly, the substance LXXXVII is called l(+)-glyceric acid In general an  $\alpha$ -hydroxy acid is said to belong to the d-series if it contains the grouping LXXXVIII, and to belong to the 1-series if it contains the grouping LXXXIX instead. If more than one -CHOH-CO2H group is present in the

molecule, this definition of d- and l-series may become ambiguous; consequently, the series are not often employed with such substances (except with the tartaric acids, with which there is no ambiguity).

The arbitrariness of the present definition of optically active series can be made apparent by a further consideration of the glyceric acids. The acid LXXXVI was said to belong to the dseries because of its formation from the d-aldehyde XXXI In principle, however, it could be formed equally well from the i-aldehyde XXXII instead; if, in XXXII, the primary alcohol group at the bottom is oxidized to a carboxyl group, and if the aldehyde group at the top is then reduced to a primary alcohol group, the resulting configuration is XC, which is seen to be

equivalent to LXXXVI. Of course, this second transformation is more complicated than the first, but logically the two are on the same basis. Only considerations of convenience have led to the adoption of the first as the significant one.

Strain Theory.-In 1885 A Baeyer called attention to the fact that nearly all the then known carbocyclic compounds (ie, cyclic compounds with only carbon atoms in the ring, or rings) contained either five- or six-membered rings. To explain this fact, he brought forth a group of ideas now called the strain theory. The angle between any two single bonds formed by a saturated carbon atom had been postulated by van't Hoff to have the tetrahedral value of 109° 28' (see above). Consequently, Baeyer considered that an angle of this magnitude might be assumed to be most stable, so that, if one or more angles in a molecule were forced in some way to have a widely different value, the molecule would be "strained" and therefore, unstable: Now, in cyclo-propane XCI, the C-C-C angles of the three-membered ring must be equal to 600; since this value is much smaller than the preferred roo 28', the molecule is strained. Thus, Baever considered that the difficulty of preparing such a substance is accounted for. Similarly in cyclobutane XCII, the angles would have to be equal th 90° if the four-membered ring is planar; again considerable strain is present, and again the difficulty of preparing the substance appears to be explained. The minimum

removed from the carbonyl group (C=O), when the chain of strain is reached with cyclopentane XCIII, in which the planar ring would require bond-angles of 108°, almost identical with the tetrahedral value. With still larger rings, the strain increases regularly with the size if, as before, the rings are considered to be planar. The six-membered ring of cyclohexane XCIV requires an angle of 120°, the seven-membered ring of cycloheptane requires one of 128° 34', and so on. Thus, the least strain occurs

in just those rings which are easiest to prepare and best known Baever's original ideas, although still considered essentially correct, have undergone extensive modification. In 1946 it was believed (H. Sachse, 1890) that the strain postulated by Baeyer exists only in the three- and four-membered rings, but that no strain exists in the rings of six or more atoms. With the small rings, the least strain results if the rings are planar as assumed by Baeyer, but, with the larger rings, the strain can be relieved completely if the ring is permitted to be puckered. With cyclohexane, for example, two different strain-free configurations are possible; these are shown in XCV (the so-called boat-form or C-form) and XCVI (the so-called chair form or Z-form) Ap-

parently, transitions among the various forms of these puckered rings are so easy that isolation of stereoisomeric substances, differing only in the form of the ring, is impossible.

The assumption that the rings with six or more atoms are puckered and stram-free permits the conclusion to be drawn that such large rings should be as stable as those with five atoms, and, in fact, as stable as the noncyclic chains. This conclusion is verified experimentally. There is no significant difference, referable to strain, between, say, cyclotriacontane, with 30 atoms in the ring, and cyclopentane, with only 5; nor is there any significant difference between either of these substances and any of the typical paraffin hydrocarbons (see Paraffin Hydrocarbons, Chemistry of). In particular, neither ring can be broken easily by ordinary chemical reagents, and the heats of combustion of the two cyclic substances (see Thermochemistry), per CH2 group, are practically identical. (In contrast, the threemembered ring in the strained cyclopropane XCI is easily broken by reagents like bromine, hydrogen in the presence of a platinum catalyst, and hydrogen chloride, which have no similar effects upon cyclopentane, cyclotriacontane, or a paraffin hydrocarbon; and the heat of combustion of cyclopropane, per CH2 group, is appreciably higher than that of either cyclopentane or cyclotriacontane.)

The reason why Baeyer was misled into believing the large rings to be strained was that, experimentally, such rings are difficult to prepare. In 1946 this fact was interpreted differently. The difficulty of preparing cyclotriacontane, for example, was then explained as the result, not of any assumed instability of the product, attributable to strain, but rather to the improbability that the two ends of a chain of 30 carbon atoms will happen to come close enough together to permit being joined to each other by a bond. The relative ease of forming the five-membered ring in cyclopentane, on the other hand, is attributed to the relatively great probability that the ends of a much shorter chain of only five carbon atoms will come close enough. In other words, the fact that the five- and six-membered rings are the most easily formed of all is explained as the result of two opposing effects; a lesser extent) four-membered rings, and the probability factor, since different methods of formation of a given salt, such as which causes the ease of formation to decrease more or less regularly as the size of the ring increases

An important service performed by the strain theory consists in providing a reasonable explanation of the nonexistence of certain substances For example, cyclopropyne XCVII is unknown although, as far as the ordinary rules of valence are concerned, it would appear to be a perfectly reasonable substance However, if it existed, it would be extremely strained since the normal value of C-C=C bond angles is 180°. Similarly, cyclohexene might be expected to be obtainable in cis and trans forms, analo-

gous to maleic and fumaric acids, respectively. Only the cis form XCVIII is known; the trans form XCIX would be too highly strained to be capable of existence. Moreover, camphor C (see Camphors) has the two asymmetric carbon atoms marked with the asterisks Since these atoms are nonequivalent, meso forms are impossible, and so two pairs of enantiomorphs might be expected Only one such pair is known. This is the one in which the attachment of the -C(CH3)2- "bridge" to the outer six-membered ring is cis; the second pair of enantiomorphs, in which the attachment is trans, would be too strained to be capable of existence.

## STEREOCHEMISTRY OF NITROGEN

The general principles essential to the understanding of the stereochemistry of the elements other than carbon differ in no significant respect from those essential to the understanding of the stereochemistry of carbon itself. Since these principles are described in considerable detail in the preceding sections of this article, they need not be discussed further here. Moreover, since the factual material relating to the stereochemistry of the remaining elements is relatively restricted (although rather extensive in an absolute sense), a brief survey of the field is sufficient to bring out the important features.

In all optically active compounds known up to 1899, the molecular dissymmetry was dependent upon the spatial arrangement of the valencies of carbon In that year, however, W. J. Pope and S. J. Peachey discovered that quaternary ammonium salts of the type [NQRTZ]+ X- (where Q, R, T and Z represent four dissimilar hydrocarbon radicals) could be resolved into enantiomorphs, and hence that the valency configurations of other elements besides carbon could have sufficient permanence to make their stereochemical investigation possible. (J. A. Le Bel had stated earlier that he had obtained an optically active substance of this type, but his work was shown to be incorrect.) Thus a wide field of research was opened. Further work on quaternary ammonium salts showed. (1) that, since molecular dissymmetry could no longer be demonstrated when two of the hydrocarbon radicals were identical, the ion [NQRRT]+ probably has a plane

the strain, which operates against the formation of three and (to the configuration about the nitrogen atom may be); and (2) that,

$$NQRT + ZX \rightarrow [NQRTZ]^+X^- \leftarrow NRTZ + QX$$

never yielded isomeric modifications, the valencies linking the four hydrocarbon radicals to the nitrogen atom are most probably equivalent. Only two configurations of the ammonium ion satisfy these conditions, namely, the pyramidal configuration I and the tetrahedral configuration II, of these, the first has been definitely disproved by W H. Mills and E H Warren (1925), who showed

that an ammonium salt, containing an ion of the type III, can be resolved into optically active components. It can indeed easily be seen that, if the two rings in this ion were attached to the base of a square pyramid, as in IV, the ion would have a plane

$$\begin{bmatrix} CH_1 & CH_1$$

of symmetry and the compound would be nonresolvable. In the ammonium ion, the nitrogen atom must accordingly have the tetrahedral configuration II corresponding with the asymmetric configuration of its derivative III.

The amine oxides are another class of compound in which a nitrogen atom forms bonds to four distinct other atoms or groups In these also, the radicals appear to be tetrahedrally disposed about the nitrogen atom, for amine oxides of the type V have been obtained in optically active forms by J. Meisenheimer (1908).

The configuration of the trivalent nitrogen atom is of special interest on account of the number and importance of the comof symmetry (no centre of symmetry is possible here, whatever pounds in which the element is present in this state. The numerous attempts made to obtain optically active compounds of the type NQRT have all given negative results, but it is not afte to conclude from this fact that these compounds have a planar configuration, it is possible that instead they have the dissymmetric pyramidal configuration VI but are racemized easily by passage through an intermediate planar configuration, thus

It is reachly verified that VIII is the enantiomorph of VI, and that VIII is symmetric so that its probabilities of reverting to'll and VIII are equal. That this second explanation of the optical inactivity of ammes of the form NORT is the correct one has been shown by studies of spectra, of dipole moments, of crystal structure, and of electron diffraction.

In compounds of trivalent narrogen of the type -X = N - Y, where the natrogen atom is directly linked to only two other atoms, and, therefore, to one of them by a double bond, the strenchemistry of the nitrogen atom was established at an early date by the classical stereochemical methods ( $t \in N$ ) consideration of isomer numbers and not with the use of the physical methods employed with the amines). Thus, coimnes can generally be prepared in two isomeric modifications if the two substituents attached to the carbon atom doubly bonded to the instrogen are dissimilar. The two forms are represented by the configurations IX and X. That this interpretation is correct is supported by the

fact that the isomerism is repeated in the O-methyl ethers XI and XII, for which no alternative structures are possible. In these configurations, IX-XII, the carbon, introgen and oxygen atoms, and the atoms of the groups R and T joined directly to the central carbon atom are considered to lie in the same plane. The situation is thus closely analogous to that in the ethylenic compounds considered previously, like maleic and fumaric acids; the only spifficient difference is that the nitrogen atom here forms three bonds whereas the corresponding carbon atom in the ethylenic compounds forms four. (Sometimes, the statement is made that the unshared pair of electrons on the introgen, represented by the pair of dois, acts as a fourth valence bond.

The above interpretation of the isomerism of the oximes, due to A. Hantzsch and A. Werner (1890), is confirmed by the optical activity of the cyclic oxime XIII, demonstrated by W. H. Mills

and A. M. Bain (1910); the molecule of this compound can be dissymmetric only if (i) the hydroxyl group does not be in the plane perpendicular to that of the six-membered ring, and (2) the C-N-O bond angle is not 180°. These are exactly the same geometrical conditions postulated by Hantzech and Werner. (For further discussion of the stereochemistry of the oximes, see

Further examples of stereoisometic nitrogen compounds, which we their isometism to restricted rotation about a double bond to the nitrogen atom, include the N-methyl oximes XIV and XV, the azo compounds XVI and XVII and the azony compounds XVIII and XIX. The so-called stable and labile diszohydrates (see Diazo Comprounds Novement about only dispersion to be seen to a considered by Hantsech to be

R-C-T	R-C-T	R-N	RN
O—N—CH <sub>3</sub>	H <sub>1</sub> C-N-0	N—R	R-N
xIV	xv	xvi	XVII
R-N	R-N	R-N	R-N
O-N-R	RNO	и—он	HO-N
XVIII	XIX	xx	XXI

stereosomers of each other with the configurations XX and XXI, expectively, this view, however, up to 1946 had never been definitely shown to be correct, and it has been denied by other authors. It is evident that a marked difference exists between the configurational stability of those compounds of trivalent introgen in which each nitrogen atom forms three single bonds and that of those other compounds in which each nitrogen atom forms one single and one double bond. The theoretical reason for this difference is not understood

#### STEREOCHEMISTRY OF THE REMAINING ELEMENTS

For reasons of convenience, the various remaining elements are classified below on the basis of their co-ordination numbers. In general, a given element in a given compound is said to have a co-ordination number N, or to be N-co-ordinated, if in the molecules of that compound each atom of the element in question is joined to N distinct other atoms by bonds that are not broken ionically in solution For example, in sulphuric acid, H2SO4, the co-ordination number of sulphur is four, since each sulphur atom is joined to four oxygen atoms by bonds of the type stated, similarly, the co-ordination number of oxygen in the same substance is one, since the oxygen-hydrogen bonds are broken ionically in solution and so do not contribute to the co-ordination number. In those instances in which the "nonionizable" union between each atom and each of its neighbours consists of a covalent single bond, the co-ordination number of each atom is equal to its valence.

Elements of Co-ordination Number 3.—Sulphonium salts [SQRT]\* X\*, in which three dissimilar hydrocarbon radicals are linked to the sulphur atom, were shown to be dissymmetric by W. J. Pope and S. J. Peachey and by S. Smiles (1900); the sulphonium ion, therefore, has a nonplanar configuration as in XXII. Other analogous compounds of sulphur are the sulphum esters XXIII, the sulphoxides XXIII vand the sulphilimines XXV, each

of these has been shown to have a similar nonplanar configuration, since optically active representatives of the three classes have been obtained, principally by H. Phillips and J. Kenyon (1925-27)

Optically active selenonum salts (analogous to the above suiphonum salts) were obtained by W. J. Pope and A Neville (1902), and optically active telluronium salts were obtained by T. M. Lowry and F. L. Gilbert (1925). Consequently, the conclusion can be drawn that 2-co-ordinated selenoum and tellurium are nonplanar, even though attempts to obtain active selenoxides and tellurium oxides (analogous to the sulphoxides) have failed.

That trivalent arsenic is able to maintain a pyramidal configuration has been shown by the resolution of an arsine, AsRQT, with three dissimilar substituents. In this respect, arsenic resembles sulphur, selenium and tellurium rather than introgen.

Optically inactive stereoisomers of presumably the cis-trans type have been obtained when two trivalent arsenic atoms are present in a ring

Elements of Co-ordination Number 4 .- In the first short period (see Periodic Law, The), besides carbon and nitrogen, the elements beryllium and boron can have co-ordination number four, and there is evidence that the atoms of each of these elements then have the four radicals tetrahedrally disposed about them This was demonstrated for beryllium by the production of an optically active compound of the type XXVI (W H Mills and R A Gotts, 1926), and for boron in a similar way by H<sub>2</sub>N-CH<sub>2</sub>-CH<sub>2</sub>-NH<sub>2</sub> (or of two nitrito groups, NO<sub>2</sub>, by an J Boeseken and J Meulenhoff (1924).

The molecular dissymmetry of silicon compounds of the type SiORTZ has been established by F. S Kipping, and the investigation of the configuration of 4-co-ordinated copper and zinc by the method used for 4-co-ordinated beryllium has shown that their valencies are also tetrahedrally distributed. Phosphorus and arsenic, like nitrogen, have also been shown to have the tetrahedral configuration when 4-co-ordinated-phosphorus through

the optical activity of a phosphine oxide XXVII (I. Meisenheimer and L Lichtenstadt, 1911), and arsenic through that of an arsine sulphide XXVIII. Optically active arsine oxides ROTAS-O- and arsonium salts [ROTZAs]+ X- are also known The existence of diastereomers and of meso forms has been demonstrated with compounds containing two such asymmetric phosphorus or arsenic atoms.

It is not universally true, however, that when an atom is linked directly to four other atoms these must be arranged around it tetrahedrally Thus, many compounds of 4-co-ordinated platinum containing a complex of the type PtA2B2 occur in two mactive, but evidently stereoisomeric, modifications, typical examples include the doubly charged cation  $[Pt(NH_2)_2(\hat{C}_6H_3N)_2]^{++}$  and the neutral molecule  $Pt(NH_2)_2Cl_2$  This isomerism is clearly incompatible with a tetrahedral arrangement of the radicals about the platinum atom and is to be explained most simply by the supposition that 4-co-ordinated platinum has a plane configuration, and that the isomers are of the types XXIX and XXX (known as cis and trans, respectively).

Elements of Co-ordination Number 6 .- Werner's proof that substances like the compounds of metallic salts with ammonia (formerly regarded as "molecular compounds") are coordination compounds in which a certain number of atoms or groups, most frequently six, are directly attached to the metallic atom (CoCl3.6NH3, for example, having the structure XXXI) brought with it the problem of determining how these six groups are disposed about the central atom. If it is assumed that the valencies by which they are attached are equivalent (and this is supported by the absence of isomerism which should otherwise occur), three arrangements are possible: the plane hexagonal XXXII, the prismatic XXXIII, and the octahedral XXXIV. (For ease of visualization, the respective geometrical figures are outlined, the central atom is represented by a large dot, and the valence bonds are not shown. A substituent is supposed to occupy

each of the positions marked by a corner of the figure.)

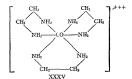
A decision among these three possible configurations was obordination positions together in pairs through four-membered matic, but in only two if it is octahedral, the alternative arrange-



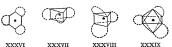
chains, as can be done, for example by the threefold replacement of two molecules of ammonia, NH4, by one of ethylenediamine,



oxalato group "O2C-CO5 or the like) so as to produce a complex in which the metallic atom forms a common member of three symmetrical five-membered rings, as in XXXV Since it seems

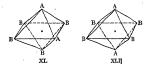


most probable that only adjacent co-ordination positions can be bridged in this way, the possible configurations for the tricyclic ion are those indicated by the dotted lines in the four different diagrams XXXVI-XXXIX Of these, the first three are evidently

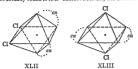


symmetrical, but the last is dissymmetrical, for it possesses only twofold and threefold axes of rotation Experimental investigation of the salts of these tricyclic ions has shown that they can be produced in optically active forms. The ions are thus dissymmetric and must consequently have the last configuration XXXIX It is, therefore, to be concluded that in such compounds the six

valencies of the central metallic atom are octahedrally disposed. This conclusion is confirmed by the occurrence of a different type of stereoisomerism shown by complexes of the type MA2B4,



such as are contained in the diacidotetrammine salts of cobalt and chromium These compounds should exist in three isomeric tained by investigating the compounds formed by linking the co-forms if their configuration is hexagonal and in four if it is prisments are then those in which the two groups A lie at the ends (1) of an edge as in XL (cis compound), and (2) of a diagonal The number of as in XLI (trans compound) of the octahedron isomers actually found is two. Moreover, in dicyclic derivatives of



this type like [en2CoCl2] + Cl-, where en represents ethylenediamine, the isomer with the cis configuration can be obtained optically active, whereas the other, the trans isomer, cannot be resolved These facts are in accordance with the configuration XLII for the cation of the cis isomer, and XLIII for the cation of the trans isomer

Billitonapril — J. H. van't Holf, La Chimne dans l'Espace (1875),
Arrangement of Atoms in Space (1877), A. Werner, Leirbuch der
Sterrechtem (1904), F. M. Jaeger, Lectires on the Frinziphe of Symmetry (1917), G. Wittig, Sterechteme (1930), K. Freudenberg,
Sterechteme (1933); R. L. Shinner, R. Adams and C. S. Marvel,
"Sterechtome (1933); R. L. Shinner, R. Adams and C. S. Marvel,
"Sterechtome (1933); R. L. Shinner, R. Adams and C. S. Marvel,
(G. W. W.); W. H. M.)

STEREOCOMPARATOR, an instrument for comparing two astronomical photographs of the same star field, commonly combined with a Blink microscope (q v).

STEREOPHOTOGRAMMETRY. In the earliest applications of photography to surveying, use was made of various simple graphical constructions or calculations in order to determine bearings and angles of elevation or depression from the camera station In order to simplify these constructions or calculations, the photograph was usually exposed in a vertical plane Two photographs, taken from the ends of a known base and treated in this manner, thus enabled a complete survey to be made of all visible ground in the area common to the pair. (See Photogrammetry.)

STEREOSCOPE. An optical instrument used for obtaining from two slightly different pictures (se., pictures or photographs of the same object but from a slightly different point of view), the impression of a single picture in relief. See BINOCULAR IN-STRUMENT

STEREOSCOPIC VISION: see VISION.

STEREOTYPING. A process of producing duplicate printing plates from a form of type or blocks by pouring molten metal on a matrix made in plaster of paris or papier-maché (See Print-ING.)

STERILITY is a term denoting failure of reproduction. It occurs throughout animal and plant life, but this article will be restricted to sterility in the human species. In searching for causes that contribute to the sterility of a couple, both sexes joined in marriage are considered. Through modern methods of investigation and treatment, many couples have been helped to rear children that would otherwise not have been born. In the human, absolute sterility is comparatively rare. It exists in individuals congenitally deficient in development of the sex apparatus and in rare cases of hermaphroditism and intersex or neuter individuals. The tact that by and large, at least 85% of married couples have children indicates the potential fertility of the vast majority of the population The incidence of sterile marriages varies in certain localities between 10% and 15%. As a rule, one or several barriers to conception may be discovered by careful investigation in one or both partners. Many of these sterility factors are acquired and many are amenable to correction, eventually leading to restored fertility unless the sex organs, particularly the sex glands, have been removed by surgical operation or by X-ray exposure or were destroyed by infection.

The concept of sterility underwent considerable change after 1900 owing to (1) increasing realization of the need for investigating both man and wife separately and conjointly, (2) greater appreciation of the general constitutional condition of each partner which is better assayed, (3) advances in investigative methods of estimating the physical, chemical and biologic factors involved. (4) newer concepts of endocrine disturbance, especially of the sex glands. (s) improved results of animal breeding and of artificial insemination. Although the ultimate cause or causes are not always ascertainable, many childless couples have become parents as a result of a thorough investigation which revealed and led to the elimination of the deterrent factors. There is thus much more hope for such barren marriages than was formerly the case.

Causative Factors.-The time factor as an index of sterility has been increasingly reduced so that in the opinion of some investigators six months of marriage without conception (providing contraceptive measures are not used) should lead to an inquiry into the reasons for the conceptional failure. The causes may be trivial or more serious. The earlier they are discovered the more amenable they may be to correction Of first importance is a careful clinical medical history of both married partners which includes the nature and number of surgical operations, unusual accidents, especially those affecting the genital organs, and exposure to X-ray A history of such diseases as mumps, malnutration, obesity, diabetes, hypertension and other metabolic and infectious disorders that the physician considers in appraising the general health of the individual helps to estimate their possible effect on the reproductive function and the chances of conception taking Occupational disorders following exposure to noxious chemicals, alcoholism, excessive smoking, morphinism, syphilis (hereditary and acquired), gonorrhoea, are among deleterious causes. Severe mental and physical strain and exhaustion affect the reproductive organs Psychic depression is particularly important in the male but not infrequently affects the female's ovarian function Excessive venery is unfavourable to both sexes from the reproductive point of view. Change of climate and of occupation not infrequently influences ovarian function unfavourably by inducing transient amenorrhoea and infertility in women.

Age has long been known to be a factor. Although many women 40 years old or more may conceive for the first time, their chances are not so great as those which favour younger women Should there be other physical obstacles, the matter of age becomes of great importance as the power of reproduction in females wanes just before and disappears at the menopause. For these reasons the effort to have children should be made earlier and the advantages of marriage in the early third decade of life need no further elaboration.

Proper sex instruction has value if given during high-school age

Contraception frequently masks sterility, leading to much loss of time when corrective measures may have been helpful. It is important therefore to make certain by appropriate examinations that no actual barriers are present early in married life before couples resort to contraception.

Concerning the investigation itself, each partner in the marriage is subjected to a thorough physical examination with special reference to the reproductive organs. The examination includes certain laboratory tests of the blood and urme and a basal metabolic rate determination Special examination is first made of the husband's semen par-ticularly for the number of spermatozoa, their morphological char-acteristics and biological activity when admixed with the gential secreons of the wife Examination of the seminal ejaculate itself is made when spermatozoa cannot be found in the vaginal and cervical canals within one or several hours after intercourse. If the husband fails to produce spermatozoa a testicular biopsy can determine whether this fault is due to blockade in the excretory duct (vas deferens) or whether

nate as the to diocease in the eventory direct (was deserms) or whether A nonsurgical method of assectationing whether the fallopian tubes or oldities are open or obstructed was made available by W. H. Cary and I. C. Rubin independently in 1924. As these dicte carry the oven the contract of the contra except by a surgical abdominal operation (laparotomy) which enabled the surgeon to inspect the canal of the fallonian tubes and probe it the surgeon to inspect the cann of the fallopian tubes and probe at the purpose consisted of the purpose to the purpose consisted of the purpose to the purpose to the purpose to the purpose to the purpose the purpose to the purpose the purpos can actually sterilize the woman

In 1910 I C Rubin adopted oxygen to insuffate the utreus instead of injecting solutions. Soon thereafter oxygen was replaced by CO<sub>0</sub> as the latter gas was found to be bette tolerated by the organism, after passing into the addominal cavity from where it was rapidly selvoride to the property of the control of the property of the pro

An important question in the case of the female is whether she ovulates regularly or rergularly or, in rare instances, not at all Although the pattern of the meistrual habit is againfant as a rule, the ownant function in an appreciable number of woman in bot normal, and the state of the sta

Therapeutic Measures—A therapeutic method used to advantage after about 1900 in case of stenily associated with delayed menstrain periods as low voltage X-ray irradiation to the ovanes. In more than 80%, the measural cycle was restored to normality by this method and me to than 1900 to the stenil to the steni

About 15% of infertile couples can be aded by a single measure such as uterotubal neutral by using additional therapeutic surroutes an extension substantial content of the surroutes and the surroutes and the surroutes and the surroutes and the surroutes are surrouted in about 50% of sterile marriages. The difference in the results of treatment depends upon the groups of the surroutes and the surroutes are surrouted to the overset. Cortisone has been found to be a powerful stimulant to the overset.

Rophysical and chemical studies recently made on the mucas of the cervice in relation to the vaishibity and transport of the spermatrous also had a promising future in the 1950s. Attention to the psychosomatic aspects of the sternlity problem as regards husband and wife here brought light on time which was appreciated for a long time has become better understood through psychoanizate study. For case of hopeless male sterility, as in azoospermia and cryptorcham, artificial unmeniantion, now increasingly in vogas, has provide a hoon to the Manawilla much can be accomplished by proper early education and Manawilla much can be accomplished by proper early education and prevention of acquired faults.

STERLING, JOHN (1806—1844), British author, was born at Kames Caste in Bute on July 20, 1806. He belonged to a family of Scottish origin which had settled in Ireland during the Cromwellian period. He was the son of Edward Sterling (1773—1847), who was for many years a leader writer on The Times, John Sterling was educated it Glasgov university and at Trinity college and Trinity Hall, Cambridge. At Cambridge he was a member of the famous "Aposthesi," club, With F. D. Maurice he purchased the Athenseum.in 1883 from J. Silk Buckingham, which was not a success.' In 1834 he was ordained and became curate at Hurstmanneaux, where his bill tutor Julius Hare was view. Acting on the adviceor'd hispolycial hard resigned his curacy in 1835, but, according to Carlife, the hydrian resigned his curacy suggest, given the opinions of, the, chapter, Heidel at Ventour on

Sept 18, 1844. Sterling owes his fame to the vivid Life by Carlyle, to whom, with Hare, his papers were entrusted

STERLING, a city of Colorado, US, 1:28 mi NE of Denver. on the South Platte niver and federal hiphways 6 and 138, served by the Burlington Route and the Union Pacific lailway systems, the county sea of Logan county. The population was 7,534 mi 1950 and 7,411 mi 1940 by the federal census. The city was founded in 1881 and incorporated in 1883. In 1900 the population

STÉRLING, a city of Whiteside county, III, U S, on the north hank of Rock river, I ton W. of Chacago It is on the Lincoln highway and the Hennepin canal feeder, and is served by the Butington Route and the Chucago and North Western railways, and by motor bus lines in all directions. Population was 12,817 in 190, and was 11,345 in 190, by the federal care Rock Falls (pop 7,983 in 1950) is just across the river router shave abundant water power and large manufacturing dustries, making agricultural implements Sterling was chartered as a city in 1845.

STERLING, a term used to denote money of standard weight or quality, especially applied to the English gold sovereign, and hence with the general meaning of recognized worth or authority, genume, of approved excellence The word was formerly derived from the name of "Easterlings" given to the north German mer-chants who came to England in the reign of Edward I and formed a guild in London Their coins were of uniform weight and excellence, and thus, it was supposed, gave the name of the moneyers to a comage of recognized fineness. This theory is based on a statement of Walter de Pinchbeck, a monk of the time of Edward I. The word, however, occurs much earlier in the French form esterlin (11th or 12th century) and the Latin libra sterilensium (1145); the Latin sterlingus occurs in an ordinance of 1184 and in a statute of Edward I ("denarius Anglia qui vocatur sterlingus") The derivation favoured by the Oxford Dictionary is from the late O.E. \*steorling, "coin with a star", some of the early Norman pennies carry a small star. In early instances the word often occurs in the phrase "pound of sterlings," originally a pound weight of such pennies, 240 of which went to the "pound sterling" of silver of 5,760 grains, 925 fine. "Sterling silver" was originally silver having the same degree of purity as these pennies; later silver of standard quality, and so marked The word was borrowed by most European languages and is there applied to English money. (See Money, Mediaeval.)

(W. D. C.)
STERN, DANIEL: 566 AGOULT, MARIE CATHERINE SOPHIE
DE FLAVIONY

STERNE, LAURENCE (1713-1768). English humorist, was the son of Roger Steme, an English officer, and great-grand-so of an archeshap of York. He was born at Gomein, and the state of the sta

He was also a prebendary of York cathedral.

Sutton was Steme's residence for 20 uneventful years. He kept up an intimacy which had begun at Cambridge with John Rall-Stevenson (1718—1785), witty and accomplished epicturean, owner of Skelton Hall ("Crazy Castle") in the Cleveland district of Yorkshire. Stevenson's vanous occasional sallies in verse and prose—his Fables for Grown Genslemen (1761-1770), and his Gray Talles (1795), bear a resemblance in spirit and trum of thought to Sterne's work, interner as they are in Herrary genius. In F. Topham, R. York havyes, over the bettownl of an office in the gift

of the archbishop This sketch, in which Topham figures as Trim the of the archoistop I loss sacton, in World Tophan Ingues as a func-section, and the author as Lony Slim, gives an cannet of Stene's powers as a humoret. It was not published until after his death, while it appeared in 1769 under the title of A Political Romance, and after-ward the History of a Warm Watch-Cost. The his ratt two volumes, "Fristran Shandy were issued at York in 1753 and advertised in London

on Jan 1, 1760, and at once made a sensation

For the last eight years of his life after this sudden leap out of obscurity we have a faithful record of Sterne's feelings and movements scuricy we have a latitudi record of sterne's teenings and movements in letters to various persons, published in 1775 by his only child, Lydia Steine de Medalle, and in the Letters from Yorack to Elsa (1766–1767), also published in 1775 At the end of the sermon in Tristram he aliminated that, if this sample of Yorack's pulpit eloquence was liked, intimated that, if this sample of You'ck's pulpit eloquence was itsed,
"then ear now in this passession of the Sampers and much nooth may
they do it." Accordingly, when a second extinon of the first installment
of Trastraw was called for in three months, two wolumes of Sermoss
by Yorke were announced Although they had little or none of the
Steme's cleant-cleanted was far from being universally injured
by the molecorous freaks as a humoist. Loud Fauconberg presented
the nathor of Traitram Shandly with the prepetual caracy of Convoid

the author of Tratems Sheady with the perpetual curacy of Cowold To this new residence he went in high spirits with his success, "fully determined to write as hard as could be," seeing no reason why he should not gove the public two volumes of Shandysm every year and type the seed of the seed of the seed of the seed of France, and he came back after two and a half years very httle stronger. He was overgoed with his reception in Fars He contained the seed of of another set of sermons—more pronouncedly Shandean in their ec-

of another set of sermons—more pronouncedly Shandean in their ex-centracity—be quited England again in the summer of 1796, and trav-elled in Italy as far at Napies. The muth said and adsorts volume and the said of the This despatched, Sterne turned to a new project, The Sentimental Journey through France and Italy. Its plan admitted of any length that the author choose, but, after seeing the first two volumes through the press in the early months of 1768, Sterne's strength failted, and be due in his bologapa, at Old Bood street, London, March 18, three weeks

after the publication.

atter the publication.

An excellent citizen of Sterne's works, edited by George Saintsbury, was issued in sax volumes in 1894. See also J J Texte, Rousseau et les origines da cosmopolitime interiori (1895), Thayer, Laurence Sterne in Cermany (1005); Walter Sichel, Sterne. a Study (1910). In MeVille, Lipé and Leiters of Leurence Sterne, 2 vol. (1911). G. Rabuzzani, Sterne in Italia (1920), W. L. Cross, The Life and Times of Laurence Sterne, pres ed. (1920).

STESICHORUS (c. 640-555 B.C.), Greek lyne poet, a native of Himera in Sicily, or of Mataurus, a Locrian colony in the south of Italy. The story of his being struck blind for slandering Helen and recovering his sight when he recanted is told by Plato among others. We possess about 30 fragments of his poems, none of them longer than six lines. They are written in the Doric dialect, them longer than six lines. They are written in the Doric dialect, with epic liennes; the metie is decipiled-tenchase. Briff as they are, they show us what Longinus meant by calling Steachorus "most like Homer"; they are full of epic granders, and have a stately sublimity of the stately sublimity of the stately sublimity of the stately sublimity. The stately sublimity of the stately sublimity

STETHOSCOPE, a medical instrument used in listening to the sounds produced in the heart, lungs and other organs. This is known as auscultation (q.v.), which is a means of physical examination used in the diagnosis of diseases, especially those of the heart and lungs. The single stethoscope is a straight wooden or metal tube with a small flattened bell, the surface of which is usually covered with ivory or bone at one end, which is placed against the body of the patient, and a large flat disk at the other end, for application to the ear of the observer. In the "binaural" stethoscope, which has the advantage of flexibility, the tube is divided above the bell into two flexible tubes which lead to both (F. L. A.)

STETTIN (Szczecin), Poland, formerly capital of the Prussian province of Pomerania, Germany, on the Oder, 17 mi above its entrance into the Stettiner Haff, 30 mi from the Baltic, 84 mi NE of Berlin by rail, and at the junction of lines to Stargard-Danzig and Kustrin-Breslau Pop (1946) 72,948; (1939) 268,915 Stettin is said to have existed as a Wendish settlement in the 9th century, but its first authentic appearance in history was in the 12th cen-tury, when it was known at Stedyn From the beginning of the 12th century to 1637 it was the residence of the dukes of Pomerania, one o whom gave it municipal lights in 1243 Alteady a leading centre of trade it entered the Hanseatic league in 1360. The Pomeraman dynasty became extinct in 1617, and in 1648 Stettin was ceded to Sweden In 1678 it was taken from Sweden by Frederick William, elector o Brandenburg, but it was restored in 1679, only, however, to be ceded to Plussia in 1720 by the Peace of Stockholm. It was fortified more strongly by Frederick the Great. Stettin was the bittipplace of the empress Catherine II of Russia.

empress Catherine II of Russia.

The main part of the town occupies a high gate on the lieft bank of the main and the control of the lieft bank of the lieft

basis containing range and subcribuses. During world war it Sectin suffered severely from frequent bombung ranks. STEUBEN, FREDERICK WILLIAM AUGUSTUS HENRY FERDINAND, BARON VON (1730–1794), German soldier, born at Magdeburg, Prussia, Sept 17, 1730, was a desoluter, oron at magneticuter, revensal, sept. 17, 1736, was a fore-seendant of a noble family, which for generations had produced soldiers seendant of a noble family, which for generations had produced soldiers make a produced of produced to the contract of the second of produced of the Seven Year's War, where he so distinguished masself as to attract the attention of King Frederick, who appointed him as his add-de-camp (1765). After the close of the Seven Years' War, he resigned camp (1762) After the close of the Seven Years' war, he resigned from the army and became court chamberlain for the Prince of Hobenzollern-Hechingen, and, after ten years applied unsuccessfully for a smilar position at the court of the margrave of Baden In 1777, his old friend the count of St. Germain, then the French minister of

war, persuaded him to go to the assistance of the American colonists war, persuaded him to go to the assistance of the American coionists. Steuben arrived at Portsmouth, N H, on Dec. 1, 1777, and offered his services to congress as a volunteer In March 1778 he began drilling the inexperienced soldies at Valley Forge, and by May he was made inspector-general or drill master. He trauned the solders admirably adapting Prussian millitary deas to the needs of his pupils. Results of his work were shown in the next campaine, particularly at Monmouth, where he reliable the disordered, retreating troops of Gen. Charlie Lee his work were shown in the next campaign, particularly at Monmouth, where he railled the disordered, retreating troops of Gen. Charles Lee where he was a superior of the charles Lee where he was a superior of the charles Lee where the charles are the charles and the court-martial which tried Maj John André in 1780, and after Gen Horatio Gates's defeat at Candein was placed in command of our charles and expedite the recruits for the Southern Army. "organic, discipline and expedite the recruits for the Southern Army." In April 1781 he was superseded in command of Viginia by La Agreetic, and later took part in the signed 19 (Astown Returing from the service after the war, he passed he last years of his life at Yagnatia, Pennyalvania and New Jersey gave him grants of land for his services, and Congress passed a vote of thanks and gave him a gold-lited sword in 1745, and here granted him a pennson of \$4,000 milled sword in 1745, and here granted him a pennson of \$4,000 milled sword in 1745, and here granted him a pennson of \$4,000 milled sword in 1754, and here granted him a pennson of \$4,000 milled sword in 1859); and George W. Greene, Ph. German Elmen in the War of American Independence (Cambridge, Mass., 1596); Rudolf Consan, "The Army of the American Revolution and its Organican Historical Review, vol. 2021 pp. 435-50 (W. M. Wei, X. X.)

\*\*STEUBENVILLE\*\*, a city of eastern Ohn, U.S., on the

STEUBENVILLE, a city of eastern Ohio, U.S., on the Ohio river, 40 mi. W. of Pittsburgh, Pa.; the county seat of Jefferson county. It is on federal highway 22 and is served by the Pennsylvania and the Nickel Plate railroads, motorbus and truck lines, river packets and barges. Two highway bridges span the Ohio. Pop. (1950) 35,872. The city lies on a plain 700 ft, above sea level, surrounded by hills rising 300-500 ft. higher, in a beautiful and fertile region containing rich deposits of coal, oil, gas, clay and building stone. The manufacturing industries are large and varied, including steel and steel products, paper products, heaters, bousehold uteralis, electrical parts, prefabricated houses, trailers, the plate products and back.

Steubenville was planned in 1797, immediately after the erection of

the county, on the site of Fort Steuben (built 1786 and named after Baron von Steuben) It was incorporated in 1805. The Steubenville Herald-Star, one of the oldest newspapers in the tristate district, was established in 1806

STEVENAGE, a market town and urban district of Hertfordshire, Eng., on the Great North road at mi. N. of London Pop (1951) 6,627 Area 7.2 sq mi Silk stockings are manufactured Beside the old town, with its coaching inns, Norman-Early English church and 16th-century grammar school, is Stevenage New Town, planned (1946) to cover nearly of so mi

STEVENS, ALFRED (1823-1906), Belgian painter, was born on May 11, 1823, in Brussels, where he studied under F. norm on May 11, 1023, in Bussess, where he studied under r. Navez, director of the academy, who worked in the tradition of J. A. D. Ingres. Going to Paris in 1844, Stevens worked under C Roqueplan and at the École des Beaux-Arts, where Ingres was then professor. Stevens mainly worked, and from 1849 exhibited, in the French capital, which from the mid-1850s provided material for his pictures, usually conversation pieces and small informal full-length portraits of fashionable women set in Second Empire hôtels. In the elegant genre tradition of Gabriel Metsu, J E. Liotard and L L Boilly, they reflect neither largres' academism, Eugène Delacroix's romanticism nor Gustave Courbet's new realism 'typical are "L'Invi-tation" (late 1860s), "Les dermers jours de veuvage" (1870s, both in Brussels private collections) and "Le Sphyinx Parisien" (c. 1880). Stevens died in Paris on Aug 24, 1906

See C Lemonnier, Alfred Stevens (Brussels, 1906). (D C. T T)

STEVENS, ALFRED GEORGE (1817-1875), English sculptor, was born on Dec 30, 1817, at Blandford, Dorset. He travelled in Italy, 1833-42, spending a year (1841-42) under Beitel Thorwaldsen (g.v.) in Rome In 1845-47 he taught at the new School of Design, Somerset house, London, and in 1850-52 designed cast-metal hearth furniture, stoves, etc., for Hoole and Company, Sheffield, some of which attracted attention at the 1851 Great exhibition In the 1857 competition for the Wellington monument in St. Paul's cathedral, London, he was placed sixth, though his design was the only one adapted to the nave arch under which the monument was to stand In 1852, however, he was given the commission and, despite vicissitudes, the complex marble structure the commission and, despite vicusistudes, the complex marine structure with its allegones and bronze equestina statue was nearly complete at his death (in Hampstead, May 1, 1875). For Dorchester house, Lon-don, he carried out decorations in 1838-01 (caryatid manthepiece and many drawings to Dorchester house and other piolects now in the Tate gallery, London), and these best display the new vigour he many drawings (on LOTChesser Mosses and State Spiley the new vigour has the gallery London), and these best estimates of the spile of t

STEVENS, HENRY (1819-1886), U.S. bibliographer, was born in Barnet, Vt., on Aug. 24, 1819. He studied at Middlebury college, Vermont, and graduated from Yale in 1843, teaching to pay his way and for a time acting as a government clerk. In this capacity he won the friendship of Col. Peter Force, who employed him to collect books, pamphlets and manuscripts for the American archives on his return to Yale and during his year at the Cambridge, Mass., law school. His commissions from Force and other collectors took him abroad, where he ransacked the European capitals for rare Americana for the Smithsonian institution, the Library of Congress and such private buyers as John Carter Brown and Jam At the suggestion of Sir Anthony Panzzi, the librarian of the British museum, he also supplied that institution with many American hooks

books. Strong that at Hamptess, London on Peb. 26, 285. Strong pile ninet mobile ablebenemit was his redemption of the Franklin manuscripts, which were finally disposed of to the U.S. government. He wrote Catalogue of the abricant Books in the Library of the British Museum (1865), Historical Nugaest, Bibliothica American of the British Museum (1865), Historical Nugaest, Bibliothica American on America (1869), Benjamine Franklin't Life and Writing's (1887), Recollections of Mr. James Leion. . and the Formation of His Library (1885)) and Thomas Harde's (1905) cidettly by his son, H N. Streng.

STEVENS, JOHN (1749-1838), U.S. inventor, was born in New York city in 1749, graduated from Columbia university in 1768, subsequently studied law and was admitted to the New 11 1700, SUDSEQUENTLY SELUCION AW SIGNAMS AGMITTED TO the New York bain 11771. In 1736 he becames a capitaln it the Revolutionary army, and later colonel of his own regiment. From 1737 to 1782 he served the treasurer of the state of New Jersey. In 1784 he built as home out what was then it is island of Broboten, subsequently, when

connected with the mainland, known as Stevens point, where he resided for more than half a century until his death on March 6, 1838. He purchased the ferry to New York and much of the main New Jersey shote Along the road leading to the ferry landing he began the development

Along the room rather of the other of the city of Hoboken

The problem of safe and speedy transportation across the Hudson

The problem of safe and speedy transportation across the Hudson

In 1788 he built the first multitubular boiler on record for use in his marine ne dult the first multitudual police on record for use it als marine engines. In a desire to protect this invention he petitioned congress for a patent law, which he outlined, and which was passed as the Patent law of 1790, the foundation of the present patent system. He was the first to apply the principle of screw propulsion to navigation, building in 1802 a steamboat with two underwater propellers of screw type in the stern which successfully crossed the Hudson several times and the stem which successfully crossed the Hudson several times and failed only because the inefficient bioliers of that day could not generate enough power to make the screw device practical. He turned then which field the was a pomen: But a few days after Fullon's successful trail of the "Clermont" Stevens launched the "Phoenix," the engine of which was built by Stevens hamel, whereas that of the "Clermont" was imported from England Fullon having icceived a monopoly grant of analystation rights on the Hudson, Stevens sent the "Phoenix" by sea to Philadelphia, the first voyage of a steamship on ocean waters. by sea to Philadelphu, the first voyage of a steamship on ocean waters. Sevenes was also intersected in railways, writing in 1822 a paraphile sevenes was also interested in railways, writing in 1822 a paraphile ways and Steam Carriages over Caul Mesugation. On Feb 6, 1815, the ways and Steam Carriages over Caul Mesugation. On Feb 6, 1815, the solution the first railway chatter granted in America for a railway between the Delaware and Raritan rivers, but it was not until 1830 that formed the Canadica and Ambor Railway company and not until by his sons Robert L. Stevens (qv. v) and Edwin A. Stevens (24) and Edwin A. Stevens. See A. D. Turnbull, John Stevens, A. American Record (1928); J. E. Watkins, Biographical Shetches of John Stevens, Robert L. Stevens (1848).

STEVENS, ROBERT LIVINGSTON (1787-1856), U.S. mechanical engineer, was born at New York city on Oct 18, 1787. the son of John Stevens (q, v), whose mechanical ability he inherited. Whereas the father spent most of his thought on the improve-ment of motive power and machinery of steamboats, the son made ment of motive power and machinery of steamboats, the son made many advances in construction, strengthening hulls, reducing weight, distributing stram and improving the lines to gain speed. He designed the strain of the strain of the strain of the strain of the first of Hudson river steames to go from Albany to New York during daylight, with this steamer and the "North America," the Stevens family in-sugarated a day line on the Hudson. In 1821 he built the ferryboat "Hobboan" on modern lines and introduced the pilot slip which directed

the boat's entrance to the landing place.

In 1830 he was made first president of the Camden and Ambov rail-In 18,0 he was made first president of the Camden and Amboy raile-way and went to England to Inspect equipment already in use the On the outward voyage he designed the "T" rail with a broad base, long known as the Stevens or American rail and now universally used He contracted in England for 500 tons of such rails, the first made, and exclude the such as the such as the such as the such as the such exclude the such as the such as the famous "John Bull" which he brought to the U.S. on his return and which is now in the Smit-sonian institution He made many improvements on railway locomo-tives, introducing the pilot truck in 18,34, the begue truck shortly after-ior order to promote adhesion to the rails and drawing power. When order to promote adhesion to the rails and drawing power. When recorded to the such as the such as the such as the such as the recorded to the such as the such as the such as the such as the recorder to the such all crossorses with broken stone and served between stone blocks could not be furmished fast enough for his readede he recorred to log laid crossives with broken stone and graved between and discovered that he had found a bed more serviceable and commented that the had found a bed more serviceable and compared to the state of th

Stevens, Edwin A. Stevens (1893).

STEVENS, THADDEUS (1792-1868), U. S. political leader, was born in Danville, Vi., April 4, 1792. He graduated from Dartmouth college in 1814, moved to York, Pa., was admitted to the bar (in Maryland) and for 15 years practised at Gettyaburg, Pa. He frequently appeared in behalf of fugitive shores before the Penalest Parameter of the Penalest Parameter of the Penalest Parameter of the Parameter

from the joint committee what became the 14th amendment, and also the Reconstruction act of Feb 6, 1867 He advocated the Freedmen's bureau bills and the Tenure of Office act, and went beyond congress in nureau ones and the l'enure of Omce act, and went beyond congress in favouring the confiscation of property in Confederate states. He led congress in the struggle with Pres Andrew Johnson, reported the impeachment resolution and was chairman of the committee appointed to drait the articles of impeachment. He died at Washington, D.C.,

STEVENSON, ADLAI EWING (1835-1914), vice-president of the United States, 1893-97, was born in Christian county uen, or the Onifen States, 1893-97, was born in Christian Country, Ky, on Oct 23, 1835. He studied at Centre college, read law and commenced practice at Metamora, Ill. He was a member of the 44th Grover Cleveland's first administration. He was given the Democratic nomination for vice-president in 1892 so that the west should be represented on the ticket which Cleveland, an exsterner, headed. In 1897 he was chairman of a commission sent to Europe to work for international bimetallism He was again nominated for vice-president international himetalism He was again hominated for vice-pressurer on the ticket with W J Bryan in 1900, and in 1908 he was unsuccessful as the Democratic candidate for governor of illinois He wrote a pleasant book of reminiscences, Something of Men I Have Known STEVENSON, ADLAI EWING (1900—), US lawyer

and public official, was born in Los Angeles, Calif., on Feb 5, 1900, the son of Lewis Green Stevenson, secretary of state of Illinois, 1914-16, and grandson of Adlai Ewing Stevenson (q.v), vice-president

1914-16, and grantson of ratins awaig sections (1917).

of the U.S., 1893-07] public schools in Bloomington, Ill, and Choate school, Wallingford, Conn., and in 1912 was graduated from Princeton auliversity, Princeton, M.J. In 1918 he served as an appendice seamed in the U.S., and an appendice seamed in the U.S., and a served. two years, he was assistant managing editor of the Bloomington Dasly

(w) years, ne was assent managing contor on the Diodomington Dmiy Pandiograph, owned by his family, 1920-15 In 1926 he was graduated from Northwesten university law school and began to practise law in Chicago, Ill. He later served in the Agricultural Adjustment administration in Washington, D. C., and was assistant to the secretary of the navy, 1941-44. In 1945 Stevenson headed a Fordgn Economic administration mission to Italy, and in 1944 he was a member of a war department mission to Europe. He 1944 he was a member of a war department misson to Europe. He became assistant to the sectorary of state in 1943 and was adviser to the US chegation at the United Nations Conference on International US delegation at the United Nations Conference on International US delegation at the UN, general assembly, New York city, 1946-497, in 1948 the conference of the Property of the United National US delegation at the UN general assembly, New York city, 1946-497, in 1948 the UN greater of the UN great of the UN g

was the only son of Alan Stevenson, partner in a West Indian house in Glasgow, and was born in that city on June 8, 1772. He was educated at Anderson's college, Glasgow, and at Edinburgh university. He assisted his stepfather, Thomas Smith, in lighthouse schemes, and at 19 was sent to superintend the erection of a lighthouse on the island of Little Cumbrae Subsequently tion of a lighthouse on the island of Little Cumbrae Subsequently he succeeded Sunth as engineer to the Commissioner of Northern Lighthouses, and from 1707 to 1843 he designed and built a large number of lighthouses, the most important being had on the Bell Bished, from which the admirably sailing directions for the coasts of Great Britain and Iriend were prepared. Stevenson published an Account of the Bell Rock Lighthouse in 1824, contributed to the Encyclopiada Britainsia, and worter various papers read before learned societies. Whe dent at Eduburgh on July 1850.

THE WINDOWN, ACHERN LOUIS BA. FOUR. (1850–1872 WINDOWN, ACHERN LOUIS BA. FOUR. (1850–1872 WINDOWN, ACHERN LOUIS BA. FOUR.

1894), British essayist, novelist and poet, was the only child of Thomas Stevenson, civil engineer, and his wife, Margaret Isabella Balfour. He was born at 8 Howard Place, Edinburgh, on Nov. 13, 1850. He suffered from infancy from great fragility of health. and nearly died in 1858 of gastric fever, which left much constitutional weakness behind it. He went to school, mainly in Edinburgh, from 1858 to 1867. As his health improved it was hoped that he would be able to adopt the family profession of civil engineering, and in 1868 he went to Anstruther and then cvil eignteering, and in 1808 ne went to Anstruther and then to Wick as a pull engineer. In 1871 he had so first andwared as to receive the silver medial of the Ediniungs Society of Arts for a paper except the silver medial of the Ediniungs Society of Arts for a paper except the silver properties and the silver properties of the templeor's life, it straineds his physical endurance too much, and in 1871 the was called in 4875. In 2878, 3-first river Sidney-Carlier, but was relicatively exchanged for sixty at the Ediniuntly har, to which he was called in 4875. In 2878, 3-first river Sidney-Carlier, but was to prove the closes of the driends and gard also the loval and admirable editor of his works and his correspondence

He was now labouring, with extreme assiduity, to ground himself in the forms and habits of literary style. In 1875 appeared, anony-mously, his Appeal to the Clergy of the Church of Scotland, and in that year he ma de the first of many visits to the forest of Fontainebleau, that year he made the first of many visits to the lorest of Fontanebleau, Meanwhile at Mentone in the winter of 1873-1874, he had grown in mind under the shadow of extreme physical weakness, and in the following spring began to contribute essays of high originality to one or two periodicals, of which the Cornthil, then edited by Leshe Stephen, was at first the most important. Stevenson made no attempt to was at first the most important. Sevension made no attempt to practise at the bar, and the next years were spent in wanderings in France, Geimany and Scotland. Records of these journeys were published as An Inland Voyage (1878), and as Travels with a Donkey in the Cevennes (1879). During these four years Stevenson's health, which was always bettered by hie out of doors, gave him little trouble At Fontainebleau in 1876 Stevenson had met Mrs Osbouine, the lady who atterward became his wise, she returned to her home in California in 1878, and in August of the following year, alarmed at news of her illness, Stevenson hurriedly crossed the Atlantic He travelled, from lack of means, as a steerage passenger and then as an emigrant, and in December, after hardships which seriously affected his health, he arrived in San Francisco. In May 1880 he married, and moved to the rived in San Francisco In May 1880 he married, and moved to the desolate mining camp which he has described in *The Silverado Squatters*. Some of his most pognant and most enchanting letters were written during this romantic period of his life. In the autumn of 1880 he returned to Scotland, with his wife and stepson, who were received at once into the Edinburgh household of his patents. But the condition of his health continued to be very alarming, and they went almost immediately to Davos, where he remained until the spring of almost immediately to Davos, where he remained that the spring or 1881. In this year was published Virginibus pherisque, the eathest collection of Stevenson's essays. He spent the summer months in Scotland, writing articles, poems, and above all his first romance, The Sea-Cook, afterward known as Treasure Island, but he was driven back to Davos in October In 1882 appeared Familiar Studies of Men and Books and New Arabian Nights His two winters at Davos had done him some good, but his summers in Scotland invariably unded the benefit He therefore determined to reside wholly in the south of Europe, and in the autumn of 1882 he settled near Marsellles This did Europe, and in the autumn of 18% he settled near Marseille: This did not suit him, but from March 1881; to July 1884, he was at home at a charming house called La Solitude, above Hyères, this was in many ways to be the happest station in the pannil and hurrying pilerimage ways to be the happest station in the pannil and hurrying pilerimage and also the more important Treasure Island, which made Stevenson for the first time a popular writer He planned a vast amount of work, but his schemes were all frustrated in January 1884, by the most serious lilness from which he had yet suffered. The attack was followed by long prostration and incapacity for work, and by continued relapses in July he was brought back to England, and from this time mental In July Be was orought oack to Enguind, and Itom tims time until August 1887 Stevenson's home was at Bournemouth. In 1885 be pub-lashed, after long indecision, his volume of poems, A Chid?: Garden of Verset, an inferior story, The Body Statcher, and that admirable romance, Prince Otto, in which the peculiar quality of Stevenson's style was displayed at its highest. He also collaborated with W. E. Henley in some plays, Beau Austin, Admiral Guinea and Robert Macaire Early in 1886 he struck the public taste with precision in his wild symbolic tale of The Strange Case of Dr. Jekyll and Mr Hyde. In the summer of the same year he published Kidnapped, which had been written at Bournemouth

Stevenson printed privately as a pamphlet, in June 1887, a brief and touching sketch of his father In July he published his volume of lyrical poems called *Underwoods*. The ties which bound him to Englyrical poems called Underwoods. Ine tres winch bound min to oug-land were now severed, and he determined to remove to another hem-sphere. He sailed from London, with his wife, mother and stepson, for New York on Aug. 17, 1887. He never set foot in Europe again. His memoir of his friend Professor Fleeming Jenkin was published soon. This memory of his memo reviessor revening Jenkin was puomsene soon after his departure. After resting at Newport, he went for the winter to be under the care of a physician at Saranac Lake in the Adirondacks. In this retract he was very quest, and steadily active with his pen, writing both the greater part of the Master of Ballanarea and many of his finest later essays. He had undertaken to contribute a monthly essay writing both the greater part of the Mastier of Ballastirae and many of its finest later easies. He had undertaken to contribute a monthly essay to Saribner's Magazine, and these essays, twelve in number, were publication of the Mastine and the Saribner's Magazine, and these essays, twelve in number, were publicated and the Mastine and the Saribner's Magazine, and the season of the Mastine the Saribner's Magazine, and the season as the Saribner's Mastine season as the Saribner's Mastine Saribner's Mast months' cruising found themselves at Samoa, where he landed for the first time about Christmas day 1889 On this occasion, however, though strongly drawn to the beautiful island, he stayed not longer though strongly drawn to the deathful island, he wayed not longer than are weeks, and proceeded to Sydney, where eath in 1890, he pub-lished, in a blaze of tighteous anger, his father Damien an Open Letter to the Rev Dr Hyde of Honolulu, in vandacation of the memory of Father Damien and his work among the lepers of the Pacific. Mean-

while his volume of Ballads was published in London

while his volume or bancar was punished in London
The last four years of his unquiet hir ever spent at Samoa, in circumstances of such health and vigour as he had never previously enjoyed, and in surroundings singularly picturesque. In November 1850
he made his abode at Valluna, where he took a small barrack of a me made his adoute at vacations, where he uson a small barrack of a wooden box 500 ft above the sea, and began to build himself a large house close by The natives gave him the name of Tustala He took up the cause of the deposed king Matafa with extreme ardour, and he wrote a book, A Footnote to History Eight Years of Trouble in Samoa (1892), in the endeavout to win over British sympathy to his native friends In the autumn of this year he received a visit at Valima from the countess of Jersey, in company with whom and some others he wrote the burlesque extravagance in prose and verse, called An Object of Pity, privately printed in 1893 at Sydney Whenever the cultivation of his estate and the vigorous championship of his Samoan retainers gave him the leisure, Stevenson was during these years almost wholly occupied in writing iomances of Scottish life The Wrecker, an adventurous tale of American life, which mainly belonged to an earlier time, was written in collaboration with Lloyd Osbourne and finally published in 1892, and toward the close of that very eventful namy phonished in 1692, and toward the close of that very eventum and busy year he began The Justice Cleik, alterward Weir of Hermiston In 1893 Stevenson published the Scottish romance of Castriona, written as a sequel to Kudnapped, and the three tales illustrative of Pacific ocean character, Island, Nights' Entertainments But in 1893 the uniform good fortune which had attended the Steven-sons since their settlement in Samoa began to be disturbed. The whole family at Valima became ill, and the final subjugation of his protégé iamiy at vaiima oceame ii, and the final suguigation of his protege Matatata, and the destruction of his party in Samoan politics, deeply distressed and discouraged Stevenson. In a series of letters to The Times he exposed the policy of Chef Justice Cedercrant, and the president of the council, Baron Senfit. He so influenced public opinion that both were removed from office. In the autumn of that year he went for a change of scene to the Sandwich Islands, but was taken ill there, and was only too glad to return to Samoa In 1894 he was greatly cheered by the plan, suggested by friends in England and carried out by them with the greatest energy, of the noble collection of his works in 28 volumes, since known as the Edinburgh edition. In Sept. 1894 was published The Ebb Trde, the latest of his books which he saw through the press Of Stevenson's daily avocations, and of the temper of his mind through these years of romantic exile, a clear idea may be obtained by the posthumous Vailima Letters, edited by Sidney Colvin obtained by the postnumous Valima Letters, cutted by Statey Colvin in 1895. Through 1894, he was engaged in compoung two romances, neither of which he lived to complete. He was dictating Weir of Hermitton, apparently in his usual health, on the day he died. This was Dec. 3, 1894, he was gaily talking on the verandiah of his house the Valima when he had a stroke of apoplexy, from which he never recovered consciousness, and passed away painlessly in the course of the evening His body was carried next day by 6c sturdy Samoans, who acknowledged Stevenson as their chief, to the summit of the precipitous peak of Vaea, where he had wished to be buried, with the Pacific ocean at his feet.

The charm of the personal character of Stevenson and the romantic vicissitudes of his life are so predominant in the minds of all who knew visisatudes of his life are so predominant in the mands of all who have him, or lived varish earshot of his legand, that they made the ultimate position which he will take in the history of English interature some-man of letters in his generation is similated, and the acknowledged fastmation of his character was deepened, and was extended over an oxtremely wide circle of readers, by the publication in 1899 of his Letters, which have subdused even those who were rebellious to the entertainment of in books. It is therefore from the point of whee of its charm that the genius of Stevenson must be approached, and in this respect there was between himself and his books, his manners and his

respect mere was between nimeer and ms books, ms manners and ms style, his practice and his theory, a very unusual hamony. The personal appearance of Stevenson has often been described he was tall, extremely thin, dark-haired, restless, compelling attention with the lustre of his wonderful brown eyes. Whatever may be the ultimate order of reputation among his various books, or whatever posterity may ultimately see fit to ordain as regards the popularity of any of them, it is difficult to believe that the time will ever come in which Stevenson will not be remembered as the most beloved of the writers of that age which he did so much to cheer and stimulate

(E, G, X.)

R. L. Stevenson's other works include: Memories and Portraits (1887); The Merry Men and other Taies and Fables (1887); The Stevenson's other Taies and Fables (1887); The He Flaux, with other Memories and Essays (1894); and the post-humous works, Songs of Traves and Essays (1894); and the post-humous works, Songs of Traves and Essays (1894); St. testes (1895), completed by Gr. A. T. Quiller Coults, A. Steenenson Medical (1895), and the Equation (1895) (1895). See the Letters of Stevenson to his

1 1 1 Aug.

Family (1899), with the critical and biographical preface by Mr. Sidney Colvin, Vailina Letters, to Sidney Colvin (1895), and the Life of Robert Louis Stevenson by Graham Ballour (1991) A complete edition of Stevenson's works was issued at Edinburgh in 1894-98.

plete edition of Stevenson's works was issued at Edinburgh in 1804-89. 
Bulliographies of the works of R. L. Stevenson were published by 
See Ptof. Walter Ralegh, R. L. Stevenson were published by 
See Ptof. Walter Ralegh, R. L. Stevenson (1892); Isobel Stong and 
Loyd Cobourne, Memorate of Valima (1903); F. A. Swinnetton, 
R. L. Stevenson - a critical study (1914); G. Balforn, The Lofe of 
R. L. S. Works, travels, freudes and communication (1919); R. O. 
Masson, Life of R. L. Sievenson (Edinburgh, 1933); A. S. John 
Accck, Robert Loui Stevenson In work and in personality (1911), J A Stewart, R L Stevenson, Man and Writer (2 vols, 1924), G. S Hellman, The True Stevenson: A study m clarification (1915).

STEVENSON, WILLIAM (d. 1575), probable author of the English comedy Gammer Gurton's Needle, was born at Hunwick, Durham, matriculated in 1546, took his M. A. degree in 1553, and became B D in 1560 Stevenson was a fellow of Christ's college, Cambridge, from 1551 to 1554 and from 1559 to 1561. He was made a prebendary of Dunham in 1560-61 and died in 1575 Gammer Gurton's Needle is the second extant English comedy, properly so-called William Stevenson is known to have written a play which was acted at Christ's college in 1553-54; and in the accounts of Christ's college for 1550-60 is the entry, "Spent at Mr Stevenson's plaie, 5s." Contemporary Punitan writers in the Marprelate tracts allude to Dr. John Bridges, dean of Salisbury, author of A Defence of the Government of the Church of England, as the reputed author of Gammer Gurton's Needle, but he obviously could not be properly described as "Mr S" He took his M.A. degree at Pembroke college, Cambridge, in 1560. He may possibly have been a coadjutor.

unings, in 1905. He may possinly mave usen a cosquitor.

Bee Elenny Bandluy's easy prefixed to his edition of the papy in Research of the control of the con

STEVENS POINT, a city of central Wisconsin, U.S., on the Wisconsin and Plover rivers; county seat of Portage county. It is on federal highways 10 and 51, and is served by the Green Bay and Western and the Soo Line railways. Pop. in 1950 was 16,564. The village was incorporated in 1858. Manufactures include paper, lumber, furniture and leather.

STEVENSTON, manufacturing town and parish of Ayrshue, Scotland. Pop. (1951) 9,392. It is situated about 1 mi. from Saltcoats on the coast of the Firth of Clyde, 29 mi. S W. of Glasgow by rail. There are coal mines, large ironworks and foundlies, and along the shore, the works of Nobel's Explosives company. Pop. of civil parish (1951) 13,695.

STEVINUS, SIMON (1548-1620), Dutch mathematician, was born in 1548 at Bruges and died in 1620 at The Hague or in Leyden. He was director of the "waterstaet," and afterwards quartermaster-general. Stevinus was known to his contemporaries by his military methods and inventions; he invented defence by a system of sluices which was of great importance in the Netherlands. He also invented a carriage with sails which was used on the seashore and carried 26 passengers.

In his Statics and Hydrostatics (Leyden, 1586) he enunciated the important theorem of the triangle of forces. This gave a new impetus to the study of statics, which had previously been founded on the theory of the lever. He discovered the hydrostatic paradox that the downward pressure of a liquid is independent of the shape of the vessel, and depends only on its height and base.

In 1586 he published a pamphlet of a few pages, the French translation of which is entitled La Disme enseignant facilement expédier par Nombres Entiers sans rompuz tous Comptes se rencontrans aux Affaires des Hommes. In this he treated decimal fractions. Decimal fractions and fractions had been employed for the extraction of square roots some five centuries before his time. but nobody before Stevinus established their daily use. He declared the universal introduction of decimal coinage, measures and weights to be only a question of time. His notation is rather unwieldy. He printed little circles round the exponents of the different powers of one-tenth. For instance, 237 1000 was printed 237 @ 5 @ 7 @ 8 @, and the fact that Stevinus meant those encircled numerals to denote mere exponents is evident from his James Stewart, the black knight of Lorn, by Joan or Joanna, employing the same sign for powers of algebraic quantities, eg, widow of King James I From Murdoch, duke of Albany, were 9 @ -14 @ 9-6 @ -5 to denote gs'-142"+6x-5

A number of his writings were translated into Latin by W Snellius There are two complete editions in French of his works (Leyden, 1608 and 1634) by Albert Girard See Steichen, Vice et travaux de Simon Steum (Blussels, 1846), M Cantor, Geschichte der Mathematik

STEWART, STUART or STEUART, the surname of a family which inherited the Scottish and ultimately the English crown Their descent is traced to a Breton immigrant, Alan the son of Flaald, which Flaald was a brother of Alan, steward (or seneschal) of Dol in Brittany This elder Alan, whose name occurs in Breton documents before 1080, went on crusade in 1097, and was apparently succeeded by his brother Flaald, whose son, the younger Alan, enjoyed the favour of Henry I., who bestowed on him Mileham and its barony in Norfolk, where he founded Sporle Priory By the daughter of Ernulf de Hesdin (in Picardy), a Domesday baron, he was father of at least three sons. Jordan, who succeeded to the family office of steward of Dol: William. who inherited Mileham and other estates in England, and who founded the great baronial house of Fitz Alan (afterwards earls of Arundel); and Walter, who was made by David I. steward (dapter) or seneschal of Scotland The Scottish king conferred on Walter various lands in Renfrewshire, including Paisley, where he founded the abbey in 1163 Walter, his grandson, third steward, was appointed by Alexander II. justiciary of Scotland, and, dying in 1246, left four sons and three daughters. The third son, Walter, obtained by marriage the earldom of Menteith, which ultimately came by marriage to Robert, duke of Albany, son of Robert II. Alexander, fourth steward, the eldest son of Walter, third steward, inherited by his marriage with Jean, granddaughter of Somerled, the islands of Bute and Arran, and on Oct. 2 1263 led the Scots against Haakon IV, king of Norway, at Largs He had two sons, James and John The latter, who commanded the men of Bute at the battle of Falkirk in 1298, had seven sons: (1) Sir Alexander, whose grandson George became in 1389 earl of Angus, the title afterwards passing in the female line to the Douglases, and in 1761 to the duke of Hamilton; (2) Sir Alan of Dreghorn, ancestor of the earls and dukes of Lennox, from whom Lord Darnley, husband of Queen Mary, and also Lady Arabella Stuart, were descended; (3) Sir Walter, who obtained the barony of Garlies, Wigtownshire, from his uncle John Randolph, earl of Moray, and was the ancestor of the earls of Galloway, younger branches of the family being the Stewarts of Tonderghie, Wigtownshire, and also those of Physgill and Glenturk in the same county; (4) Sir James, who fell at Dupplin in 1332, ancestor of the lords of Lorn, on whose descendants were conferred at different periods the earldoms of Athole, Buchan and Traquair, and who were also the progenitors of the Stewarts of Appin, Argyllshire, and of Grandtully, Perthshire; (5) Sir John, killed at Halidon Hill in 1333; (6) Sir Hugh, who fought under Edward Bruce in Ireland, and (7) Sir Robert of Daldowie. ancestor of the Stewarts of Allanton and of Coltness James Stewart, the elder son of Alexander, fourth steward, succeeded his father in 1283, and, after distinguishing himself in the wars of Wallace and of Bruce, died in 1309. His son Walter, sixth steward, who had joint command with Sir James Douglas of the left wing at the battle of Bannockburn, married Marjory, daughter of Robert the Bruce, and during the latter's absence in Ireland was entrusted with the government of the kingdom. He died in 1326, leaving an only son, who as Robert II. ascended the throne of Scotland in 1371. Sir Alexander Stewart, earl of Buchan, fourth son of Robert II, who earned by his ferocity the title of the "Wolf of Badenoch," inherited by his wife the earldom of Ross, but died without legitimate issue, although from his illegitimate offspring were descended the Stewarts of Belladrum, of Athole, of Garth, of Urrard and of St. Fort. On the death of the "Wolf of Badenoch" the earldom of Buchan passed to his brother Robert, duke of Albany, also earl of Fife and earl of Menteith, but these earldoms were forfeited on the execution of his son Murdoch in 1425, the earldom of Buchan again, however, coming

James Stewart, the black knight of Lorn, by Joan or Joanna, widow of King James I From Murdoch, duke of Albany, were descended the Stewarts of Ardvoirlich and other families of the name in Perthshire, and also the Stuarts of Inchbreck and Laithers. Aberdeenshire From a natural son of Robert II were descended the Steuarts of Dalguise, Perthshire, and from a natural son of Robert III the Shaw Stewarts of Blackhall and Greenock The direct male line of the royal family terminated with the death of James V. in 1542, whose daughter Mary was the first to adopt the spelling "Stuart" Mary was succeeded in her lifetime in 1567 by her only son James VI, who through his father Lord Darnley was also head of the second branch, there being no surviving male issue of the family from progenitors later than Robert II. In James V, son of James IV. by Margaret, daughter of Henry VII, the claims of Margaret's descendants became merged in the Scottish line, and on the death of Queen Elizabeth of England, the last surviving descendant of Henry VIII, James VI of Scot-land, lineally the nearest heir, was proclaimed king of England, in accordance with the arrangements made by Lord Burghley and Elizabeth's other advisers The accession of James was, however, contrary to the will of Henry VIII, which favoured the heirs of his younger sister Mary, wife of Charles Brandon, duke of Suffolk

By the usurpation of Cromwell the Stuarts were excluded from the throne from the defeat of Charles I at Naseby in 1645 until the restoration of his son Charles II on May 8, 1660 On the death of Charles II without issue in 1685, his brother James, duke of York, ascended the throne as James II., but he so alienated the sympathies of the nation by his unconstitutional efforts to further the Roman Catholic religion that an invitation was sent to the prince of Orange to come "to the rescue of the laws and religion of England" Next to the son of James II, still an infant under his father's control, Mary, princess of Orange, elder daughter of James II, had the strongest claim to the crown; but the claims of the prince of Orange also, even apart from his marriage, were not very remote, since he was the son of Mary, eldest daughter of Charles I. The marriage had strengthened the claims of both, and they were proclaimed joint sovereigns of England on Feb. 12, 1689, Scotland following the example of England on April 11. They left no issue, and the Act of Settlement, passed in 1701, excluding Roman Catholics from the throne, secured the succession to Anne, second daughter of James II., and on her death without issue (1714) to the Protestant house of Hanover descended from the princess Elizabeth, daughter of James I, wife of Frederick V., count palatine of the Rhine George, elector of Hanover, eldest son of Sophia (youngest child of the princess Elizabeth), and Ernest, elector of Brunswick-Lüneburg, or Hanover, became sovereign of Great Britain and Ireland The female issue of James II. ended with the death of Anne. James, called James III by the Jacobites and the Old Pretender by the Hanoverians, had two sons-Charles Edward, the Young Pretender, who died without legitimate issue in 1780, and Henry Stuart, titular duke of York, commonly called Cardinal York, on whose death in 1807 the male line of James II. came to an end. Henry was also the last descendant in the lineal male line of any of the crowned heads of the race, so far as either England or Scotland was concerned In the female line, however, there are among the descendants of James I representatives of the royal Stuarts who are senior to the house of Hanover, for Philip, duke of Orleans (brother of Louis XIV.), married, as his first wife, Henrietta, daughter of Charles I., and, as his second, Charlotte, granddaughter and heiress of the princess Elizabeth (daughter of James I ). By the former, through their daughter, the queen of Sardinia, he was ancestor, among others, of the princess Maria Theresa of Bavaria, who in 1910 was "heir of line" of the house of Stuart, her eldest son, Prince Rupert, being at that time heir to the throne of Bavaria.

Abstract of the Evidence to Prove that Sir William Stewart of Jed-Abstract of the Evudence to Prove that Sr. William Stemat of Julworth, the Paternal Ancestor of the Present Earl of Goldway, must the
Scond Son of Sr. Alexander Stewart of Darnley (180-1), Riddell,
Stewartsan (1813), W. Townend, Decendants of the Starst (1885),
R. W. Eyton, History of Surephine (1858), vol. vu. Balley, The Succession to the Explait Crown (1897), Skitton, The Royal House of
Starst (1880), J. H. Round, Skidner in Peerage and Family History
(1996), The Royal Starst (1891), The Dark Chart pedigree of the
house is that which was prepared one Starst (1891), and T. F. HonLorentz (1892), and C. Starst (1892), and T. Starst
Lorentz (1892), and C. Starst
Lorentz (1892), and Lindsay

STEWART, SIR DONALD MARTIN (1824-1900). British field marshal, son of Robert Stewart of Forres, Elginshire, was born at Mount Pleasant, near Forres, on March 1, 1824 He entered the Bengal army in 1840, and served in 1854 and 1855 in the frontier expeditions against the Mohmands, and Afridis Aka and Bari Khel (medal and clasp) In the Indian Mutmy in 1857 Stewart, after a famous ride from Agra to Delhi with despatches, served on the staff at the siege and capture of Delhi and Lucknow, and afterwards through the campaign in Rohilkhand For nine years he was assistant and deputy-adjutantgeneral of the Bengal army, commanded the Bengal brigade in the Abyssinian expedition in 1867, and became a major-general in 1868 He reorganized the penal settlement of the Andaman Islands, where he was commandant when Lord Mayo was assassinated, and, after holding the Lahore command, was promoted heutenant-general in 1877, and commanded the Kandahar field force in the Afghan War in 1878. On hearing of the Maiwand disaster he despatched Roberts with a division on his celebrated march from Kabul to Kandahar, and himself led the rest of the army back to India by the Khyber Pass. Promoted general in 1881, he was for five years commander-in-chief in India, and afterwards member of the council of the secretary of state for India until his death. He was promoted to be field marshal in 1894, and appointed governor of Chelsea Hospital in 1895. He died at Algiers on March 26, 1900.

See G R. Elsmie, Sir Donald Stewart (1903).

STEWART, DUGALD (1753-1828), Scottish philosopher, was born in Edinburgh on Nov. 22, 1753 His father, Matthew Stewart (1715-1785), was professor of mathematics in the university of Edinburgh (1747-1772) Dugald Stewart was educated at Edinburgh and Glasgow. At 19 he acted as substitute for his father in the chair of mathematics at Edinburgh. From 1785 to 1820 he was professor of moral philosophy in the university, though he retired from the active duties of the chair after the death (1809) of his second son, which was a great blow to him He died at Edinburgh on June 11, 1828.

Stewart's principal work is Elements of the Philosophy of the Human Mind (3 vols 1792, 1814, 1827). He also wrote Philosophical Essays (1810), and The Philosophy of the Active and Moral Powers (1828). His philosophical views are mainly the

reproduction of those of his master Reid

STEWART, SIR HERBERT (1843-1885), British soldier, born on June 30, 1843, at Sparsholt, Hampshire, was educated at Winchester and entered the army in 1863. Returning from service in India in 1873, he entered the staff college and the Inner Temple. He served in South Africa in the Zulu War and against Sikukuni, and was present at Majuba (1881), where he was made prisoner and was present at Majuna (1997), where the mas made present for a month. In Aug. 1882 he was placed on the staff of the cavalry division in Egypt, and took possession of Cairo after Tel-el-Kebir (Sept. 13, 1882). In 1884 he commanded the cavalry under Sir Gerald Graham at Suakin. For his services in Egypt he was made KCB, and was assistant adjutant and Q.M.G. in the south-eastern district in England (April-Sept. 1884). He then joined the expedition for the relief of Khartoum, and commanded the relief column sent by Lord Wolseley across the desert of Metemma. On Jan. 17, 1885, he repulsed an enemy charge near Abu Klea. He was promoted major-general, but died on the way back from Khartoum to Korti, on Feb. 16, 1885, and was buried

near the wells of Jakdul.

STEWART, WILLIAM (c. 1480-c. 1550), Scottish poet and translator, descendant of one of the illegitimate sons of Alexander Stewart, earl of Buchan, the "Wolf of Badenoch," was a

hanger-on at the court of James V Portions of his minor verse are preserved in the Bannatyne and Maitland Folio MSS. His chief work is a metrical translation of Hector Boece's History, in obedience to the command of James V, who entrusted Bellenden with its translation into Scots prose

Stewart's version remained in ms till 1858, when it was edited by W Turnbull for the "Rolls Series" (3 vols) The ms is now in the library of the university of Cambridge

STEWART, SIR WILLIAM (c 1540-c 1605), Scottish politician, began life as a soldier in the Netherlands, where he became a colonel In 1582 he was in Scotland, where James VI made him captain of his guard Having visited the English court in the king's interest in 1583, Stewart helped to free James from Wilham Ruthven, earl of Gowne, and to restore James Stewart, earl of Arran, to power, he was made a privy councillor and for a time assisted Arran to govern Scotland In 1584 he captured Gowrie at Dundee In 1594 he was knighted and was given lands at Houston He died before 1606

STEWART, WILLIAM DOWNIE (1878-1949), New Zealand politician and publicist, was born at Dunedin on July 29, 1878 In 1914 he entered parliament as member for Dunedin West, holding this seat from 1919 to 1935 after his political career had been interrupted by a period of war service with the Otago regiment in 1916-17 He was minister of customs 1921-28, of internal affairs 1921-24, of industries and commerce 1923-26, of finance 1926-28 and 1931-33, and attorney-general and acting prime minister in 1926 He was joint author (with J E. Le Rossignol) of State Socialism in New Zealand (1910). He died at

Dunedin, NZ, Sept. 29, 1949. STEYN, MARTINUS THEUNIS (1857-1916), last president of the Orange Free State, was born at Winburg in that State on Oct. 2, 1857 He was a student in Holland and later in England at the Inner Temple, and was called to the English bar in Nov. 1882 After his return to South Africa he practised as a barrister at Bloemfontein, and in 1889 was appointed state attornev of the Free State. A few months afterwards he became second pusne judge, and in 1893 first pusne judge of the high court. His decisions won him a reputation for ability and sound judgment In 1895, upon the resignation of President F. W. Reitz, Steyn was the candidate of the pan-Dutch party for the vacant post. The election resulted (Feb 1896) in a decisive victory for Steyn As president he linked the fortunes of his State with those of the Transvaal, a policy which led to the extinction of the republic. He took part in the peace negotiations at Klerksdorp in April 1902, but was prevented by illness from signing the instrument of surrender at Pretoria on May 31 In 1908-1909 he was vice-president of the Closer Union Convention, where he showed a conciliatory attitude

STEYNING (sten'ning), town in Sussex, England, 12 mi W N.W. of Brighton by a branch of the S.R. Pop. (1931) 1,885. The church of St. Andrew retains a series of Norman pier-arches in the nave. The Anglo-Saxon church of Stevning mentioned in Domesday is attributed to St. Cuthman, who is said to have settled here before the oth century, and whose shrine became a resort for pilgrims. In 1086 Steyning was a thriving port, with a market, a mint and two churches. Its decay began in the 14th century owing to the recession of the sea, and it received another blow in the suppression of its priory by Henry IV.

STEYR, a town in Upper Austria at the junction of the Steyr with the Enns, seized by Germany in 1938. It is an old town, dominated by a 10th century castle. Two important new suburbs, Steyrdorf and Ennsdorf, lie across the streams. Steyr is a centre

of the iron and steel industry. Pop. (1939) 44,821.

STIBNITE, a mineral consisting of antimony sulphide, Sb<sub>8</sub>S<sub>8</sub>, occurring as bladed or acicular orthorhombic crystals; an important ore of antimony. It was mentioned by Dioscorides and Pliny under the names stimmi, stibi and platyophthalmon (πλατυόφθαλμον); the last name refers to the use which the ancients made of the powdered mineral for darkening the eyebrows to increase the apparent size of the eyes. The Arabic name al-kohl (now strangely corrupted to alcohol) had reference to member of the university of St. Andrews. He was in orders, and a the same use. Antimonite is also a common name for this species.

The crystals are prismatic in habit, deeply furrowed longitudinally, and usually terminated by acute pyramidal planes There is a perfect cleavage (O10) parallel to the length of the crystals, and the basal plane (001) is a plane of gliding, the latter gives rise to very characteristic transverse striations or nicks on the cleavage surfaces of crystals which have been bent The colour is lead-grey, and the lustre metallic and brilliant, crystals become dull on prolonged exposure to light Cleavage flakes of extreme thinness transmit a small amount of red light, but are more transparent for heat rays. The mineral is quite soft (H=2), and has a specific gravity of 46 Stibnite occurs with quartz in beds and veins in gneisses and schists, or with blende, galena, etc., in metalliferous veins. Magnificent groups of brilhant crystals, up to 20 in in length, were formerly abundant in the antimony mine of Ichinokawa, on Shikoku island, Japan Large, but dull, crystals have also been found at Lubilhac in Haute-Loire, France Prismatic and acicular crystals often penetrating tabular crystals of barytes, are common at Baia Sprie in Rumania (formerly Felsőbánya, Hungary). (L. I. S)

STICK-INSECT, an insect of the family Phasmatidae (see ORTHOPTERA), so named because of a resemblance to twigs of trees and shrubs, upon which most phasmids live and feed body and legs are long and slender, and the protective resemblance to twigs is enhanced by the usually brown, gray or green coloration and the immobile attitudes assumed. Some species are further protected by an armature of sharp spines. Many are wingless; when winged the tegmina are short, but the hind wings are often large and beautifully coloured, though usually kept folded over the abdomen. As in the leaf-insects (q.v), to which phasmids are closely allied, the eggs closely resemble seeds. Stickinsects attain their largest size and greatest profusion of species in the tropics, one Australian species, Palophus tstan, reaching a length of 10 in. A few smaller forms occur in southern Europe, and 25 species are known from the United States, among them Diapheromera femorata, which sometimes defoliates oak forests Phasmids freely regenerate amputated legs and antennae; under certain conditions the stump of an antenna will regenerate a leg (SEE RECENERATION IN ANIMALS). (T, H, HL.)

STICKLEBACK, a group of small fishes (Gasterosteus) in the temperate some of the northern homisphere. The majority has been some the temperate some of the northern homisphere. The majority has been some that the some that the some that the same than the some than the

Sticklebacks are short-lived animals said to reach an age of three or four years. In spring each male selects a territory, which he farcely defends and to which he invites all females, until the nest is filled with owa. At this pernod he assumes a dress of blue and red. The eggs are comparatively large, one female depositing from 50 to 100.

The three-spined stickleback (G. couleatus) is found everywhere in northern and central Europe, northern Asia, and North America. The ten-spined stickleback (G. pangitins) is smaller than the three-spined species, rarely exceeding 2 in in length. Its geographical range nearly coincides with att of the other species, in, and is armed with 15 short spines. It is common round the British coasts. At suitable localities which are sheltered from the waves and overgrown with seawed, especially in rock pools and shallows covered with Zostera, one or two males establish themselves with their harens. The elaborate nest is constructed by binding together suitable fronds of seawed.

STIGAND (d 1072), archbishop of Canterbury, is first mentioned in 1020. He was then chaplain to Canute and afterward

to his son, Harold Harefoot, and after the death of Canute appears to have acted as the chief adviser of his widow, Emma In 1043 he was consecrated bishop of Elmhain and in 1047 was translated to Winchester, he supported Earl Godwine in his quarrel with Edward the Confessor, and in 1052 arranged the peace between the earl and the king In this year the archbishop of Canterbury, Robert of Jumièges, having been outlawed, Stigand was appointed to the archbishopric, but Pope Leo IX and his two successors refused to recognize him In 1058, however, Benedict X gave him the pall, but this pope was deposed in the following year Stigand is said by Norman writers to have crowned Haiold in Jan 1066, but this ceremony was probably performed by Aldred archbishop of York Stigand submitted to William, and assisted at his coronation. But the Conqueror was anxious to get rid of him. In 1070 he was deposed by the papal legates and was imprisoned at Winchester, where he died, probably on Feb 22, 1072 Stigand was an avaricious man and a great pluralist, holding the bishopric of Winchester after he became archbishop of Canterbury, in addition to several abbeys

See E A Freeman, The Norman Conquest (1870-76), vols. ii., iii. and iv., and J. R. Green, The Conquest of England (1899), vol. ii. STIGMA'TIZATION, the impression of stigmata. Origi-

nally, the process of marking or branding slaves and criminals. The aposalie Paul is the first to speak of singmata in a religious sense. He reminds the Galatians of the distinctive "marks (stagmata) of the Lord Jesus" in opposition to the old mark of cricumcision. "I bear the marks of the Lord Jesus in my body! (Gal. 5.17). Paul's stigmata were scars of wounds received during his apostolate from persons opposed to his preaching (II Cor 17:24 f).

Specifically, stigmatization is a phenomenon observed in a number of Christian saints and mystics for which no satisfactory natural explanation has been offered as yet. It consists of the appearance, on the body of a living person, of wounds or scars corresponding to those of the crucified Chrisi

The first and most celebrated stigmatization of this kind is that of St Prancis of Assis (178-1296). His biligraphers, Thomas of Celano, St. Bonaventure and other contemporares tell us that early one morning, Sept 14, 1244, while Prancis was praying on mount La Verna, a sax-winged seraph appeared to him bearing between his wings the form of one crucified and clearly the figure of Christ. When the apparition vanished, a great love of God was felt in Franci's soul and in his body there appeared an impression of the wounds of the Lord Jesus The reproduction of a lancewound, fresh and bleeding, was seen on his side, whence thereful after blood came out, on many occasions staining his garments. His hands and feet seemed perforated in the middle. Pope Alexander IV and many other witnesses declared that they had seen the stigmata both before and after his death.

According to Dr. A Imbert-Gourbeyre, up to 34r cases of stigmatization have been recorded after the time of St. Francis In 300 cases, the stigmatized person was a woman. Better known stigmatists of modern times are. Catherine Emmerch of Muenster, (1774-1824), Mary von Mfert of Kaltern, Tyrol, (1873-68); Louise Isteau of Bost de Haine, (1856-89). Two renowed cases of stigmatization belong to the 20th century, those of Gemma Galgani of Lucca, Italy, (1878-920) and of Theresa Neumann of Konnersreuth, Germany, German is the last stigmatist to be canonised by the Roman Catholic Church (May 2, 1940). However, she was declared a saint not on account of the stigmata to five for her berlov intrue. Gemma received the stigmata on June 8, 1899. In addition to the wounds in her hands, feet and side, she experienced also the stigmata to the ecrown of the story and the stigmata of the crown of the story and the st

The case of Theress Neumann attracted the attention of scholars and scientists for several years. Born on Good Friday, April 3, 1998, the received the first stigmats on the upper surface of her hands and feet on Good Friday, April 2, 1926. On this occasion, her eyes began to bleed profusely, a phenomenon that used to occur whenever she meditated on Christ's suffering. Stigmats on the lower surface of her hands and feet appeared on the follows.

lowing Good Friday, Apill 15, 1927, and in subsequent years speedy recovery of Vale college after the War of Independence those on her side, shoulder and brow became manifest. They his mellectual and theological breadth helped to secularize and were witnessed by thousands within the first decade of their appearance and became an object of study and investigation meteorological statistics; he imported silkworms and books or (Minichevier medicinische Wickienschrift, Nov. 18, 1927). It silk culture; he corresponded with many litterati; he undertool has been often observed that real stigmata cannot be cured, that the study of Hebrew at the age of 40 and became an ablt the wounds remain fresh and show no sign of suppuration even scholar, in short, his hunger for knowledge was insatiable Or Franklin's recommendation he was made a doctor of divinty.

atter months and years of exposure

BERLIOGRAPHY—Celano, the two Flate S Francisca, edition (London, 1908), St Benaventure, Legenda S Francisca (London, 1904), K Hase, Franz son Assun (1802), is an equitve augments and conclusions are criticized by P. Sabatter in his Fre de sont Franços d'Assure (1804), A Imbert-Gomberc, La dispositione (1804), G. Francisco (1904), J. Teodorowicz, Konnerresult in Lichte der Mythle und Psychologie, Bing tir by B. Kitsung (1904).

STILHENE, a glistening colourless crystalline hydrocarbon meltung at 1x3°C, and boiling at 3c6°C, and soluble in alcohol or ether It is prepared either by the action of sodium on benzylidene (benzal) chlouide, CaH, GCHCls, or by passing toluene over heated lead oxide Stübene is symmetrical diphenylethylene, CH<sub>2</sub>CH CHClg, and many of its derivatives are known to exist in two structural forms exhibiting stereoisomerism of the type shown by fumaric and malete cards. It is chiefly of interest as being the basis of several important synthetic dyes. Stiffener accomplexes, 44 Chaimineotilhene-2-drishiphonic acid, Stiffener accomplexes, 14 Chaimineotilhene-2-drishiphonic acid, and coupled with \$\theta-aphthylmine acid by successive treatment with aqueous causite sodia and alkaline inc dust, when diazotises with aqueous causite sodia and alkaline inc dust, when diazotise with account of the stability of the solid property of the stability of the stabi

Shibene colours—Varous cotton yellows and oranges are obtained by boiling p-nitrotoluen-s-sulphonic acid with aqueous caustic soda alone (Chlorazol yellow), in the presence of oxidisable substances such as glycerol, sodium sulphite, or gallic acid (Chlorazol Fast Orange) or with oxidising agents such as sodium hypochlorute (Chlorazol Fast Yellow)

Diphenylacetylene or tolane, C6H5-C CC6H5, colourless crys-

tals melting at 60° C, results from the action of alcoholic potash on stilbene dibromide (G T.M)

STILBITE, a mineral of the zeolite group consisting of hydrated calcium aluminium silicate, CaAl<sub>2</sub>(SiO<sub>2</sub>)<sub>6</sub>+6H<sub>2</sub>O Usually a small proportion of the calcium is replaced by sodium. Crystals are monoclinic, and are invariably twinned, giving rise to complex groups and characteristic sheaf-like aggregates. The colour is usually white, sometimes red, and on the perfect cleavage (parallel to the plane of symmetry) the lustre is markedly pearly; hence the name stilbite (Gr  $\sigma \tau t \lambda \beta \epsilon \nu$ , to shine) given by R. J. Hauy in 1796. After the separation of heulandite from this species in 1818, the name desmine (δέσμη, a bundle) was proposed, and this name is now employed in Germany. The hardness is 3.5 and the specific gravity 2-2. Stilbite occurs with other zeolites in the amygdaloidal cavities of basic volcanic rocks; it is sometimes found in granite and gneiss, and exceptionally in metalliferous veins Beautiful, salmon-pink crystals occur with pale green apophyllite in the Deccan traps near Bombay and Poona; white sheaf-like groups encrust the calcite (Iceland-spar) of Berufford near Djupivogr, Iceland; and crystals of a brick-red colour are found at Old Kilpatrick, Dumbartonshire.

STILES, EZRA (1727—1799). American clergymen and educationalist, seventh president of Vale college, was born on Nov. 20, 729; in North Haven, a parish of New Haven (Connecticut). He graduarde at Vale in 749—55. He also preached in 7790 and was a tutor at Yale in 1749—55. He also preached in 7790 to the Indians at Stockbridge, was admitted to the bar in 778, and practised in New Haven for two years. After pastorates at Newport (R.I.) and Portsmouth (N.H.) he became in 778 president of Yale college and professor of ecclesiastical history processing the result of the results of the New Haven of the New Haven of the Yale college and professor of edivality and lecturing on minny subjects. He died in New Haven on May 12, 1793. His wise administration as president and coossible values.

his intellectual and theological breadth helped to secularize and strengthen the college. He carefully kept thermometric and meteorological statistics; he imported silkworms and books on silk culture; he corresponded with many litterati; he undertook the study of Hebrew at the age of 40 and became an able scholar, in short, his hunger for knowledge was insatiable On Franklin's recommendation he was made a doctor of divinity by the University of Edinburgh in 1765, and he was awarded other honorary degrees in his own country. Dr Stiles published a number of sermons, an Account of the Settlement of Bristol, Rhode Island (1785); and a History of Three of the Judges of King Charles I. (1794). His Literary Diary (3 vol., 1901) was edited by F B. Dexter, who quotes largely from Dr Stiles's Itmeraries Extracts from the Itineraries and Other Miscellames with selections from Dr. Stiles's correspondence prepared by the same editor appeared in 1916. Both give a valuable picture of New England life and contemporary figures.

See the Life of Erra Stiles (1708), by his daughter's husband, Abiel Holmes, the father of Ohver Wendell Holmes, and the life by J. L. Kingsley in Jared Sparks, American Biography (ser. 2, vol vi , 1845).

STILICHO, FLAVIUS (?-408), Roman general and statesman, was the son of a Vandal who had served as an officer in the army of the emperor Valens (364-378). He himself entered the imperial army at an early age and speedily attained high promotion He had already become master of the horse when in 383 he was sent by Theodosius (379-395) at the head of an embassy to the Persian king. Sanor III His mission was very successful. and soon after his return he was made count of the domestics and received in marriage Serena, the emperor's niece and adopted daughter In 385 he was appointed master of the soldiery m Thrace, and shortly afterwards directed energetic campaigns in Britain against Picts, Scots and Saxons, and along the Rhine against other barbarians Stilicho and Serena were named guardians of the youthful Honorius when the latter was created joint emperor in 394 Rivalry had already existed between Stilicho and Rufinus, the practorian practect of the East. Consequently in 395, after a successful campaign against the Germans on the Rhine, Stilicho marched east, with the design of displacing Rufinus; and by connivance with the barbarians he procured the assassination of Rufinus at the close of the year, and thereby became virtual master of the empire In 306 he fought in Greece against the Visigoths, but an arrangement was effected whereby their chieftain Alaric was appointed master of the soldiery in Illyricum (397). In 398 he quelled Gildo's revolt in Africa and married his daughter Maria to Honorius. Two years later he was consul. He thwarted the efforts of Alaric and Radagaisus to seize lands in Italy by his victories on the Danube at Pollentia and Verona in 401-3.

vertical in 401-3.

In a second campaign against Radagaisus, who led a large force of various Germanic peoples into Italy in 495, he surrounded the barbarian chieftain on the rocks of Fissole and starved him into surrender. Early in 408 he married his second daughter Thermanità to Honorius. It was rumoured about this time that Silikho was plotting with Alaric and with Germans in Gaul and the contract of the con

by false promises to quit the church in which he had taken sanctury, was executed on Aug. 23, 408.

The principal sources for the life of Stilkho are the histories of Caudian See T. Hodgkin, Italy and her Inveders, vols. i, and it. (Oriodt, 280.); E. Gibbon, Deckee and Falt of the Romes Empire, edited by J. B. Burry, vol. ii. (1902). P. Villatt, the Borberton Avasibus of Italy Society in the last cauting of the Witter Empire (1809). Mommsen in Hernes xviiii; and K. Birtin, Späirömische Charakterbilder (Leipzig, 1919).

STILL, ANDREW T. (1828-1917), founder of esteopathy, was born in Jonesville, Va., on Aug. 6, 1828. His family moved in 1837 to Macon county, Missouri, and later to the Shawnee

reservation near Kansas City, Kansas Still took an active part and draperies, Venetian and Bohemian glass richly ornamented in the slave question in Kansas, and in 1857 was elected to the Kansas Territorial legislature on the Free State ticket. He began searching for other means than medicine to combat disease and formulated his principles of osteopathy in 1874. He underwent a long period of opposition, but finally, in 1892, founded the American School of Osteopathy at Kirksville, Mo, in conjunction with William Smith, a Scottish physician In 1922 the Andrew T Still College of Osteopathy and Surgery was founded and merged with the original American school. He was the author of The Philosophy of Osteopathy (1899), Autobiography of Andrew T. Still (1897) and Osteopathy, Research and Practice (1910). See "Andrew T Still," Missouri Historical Review, vol. xix, 1924.

by Ray G Hulburt, E R Booth, History of Osteopathy

STILL, JOHN (15437-1608), bishop of Bath and Wells, was born at Grantham, Lines He studied at Christ's college, Cambridge He was appointed in 1570 Lady Margaret professor of divinity, subsequently held livings in Suffolk and Yorkshire, and was master successively of St. John's College (1574) and of Trinity College (1577). Still was vice-chancellor of his university in 1575-76 and again in 1592-93, and was 1afsed to the bishopric of Bath and Wells in 1593 He died on Feb. 26, 1608, leaving a large fortune from lead mines discovered in the Mendin Hills. He was for some time generally believed to be the author of the English comedy Gammer Gurton's Needle, which is now ascribed to William Stevenson (q v.)

STILL ENGINE: See INTERNAL COMBUSTION ENGINES

STILLINGFLEET, EDWARD (1635-1699), English divine, was born at Cranborne, Dorset, on April 17, 1635 He graduated from St. John's college, Cambridge, in 1652, and in the following year was elected to a fellowship. At Sutton, Beds, of which he was vicar, he published (1659) his Irenicum in which he sought to give expression to the prevailing weariness of the faction between Episcopacy and Presbyterianism, and to find some compromise He looks upon the form of church government as non-essential, but condemns Nonconformity. Although in 1680 he published his Unreasonableness of Separation, his willingness to serve on the ecclesiastical commission of 1689, and the interpretation he then proposed of the damnatory clauses of the Athanasian creed, are proof that to the end he leaned towards toleration His rapid promotion dates from 1662, when he published Origines sacrae, or a Rational Account of the Christian Faith as to the Truth and Divine Authority of the Scriptures and the Matters therein contained. In 1665 the earl of Southampton presented him to St. Andrew's, Holborn, two years later he became prebendary of St Paul's, in 1668 chaplain to Charles II., in 1670 canon residentiary, and in 1678 dean of St Paul's He was also preacher at the Rolls Chapel and reader at the Temple. Finally he was consecrated bishop of Worcester on Oct 13, 1689. During these years he was ceaselessly engaged in controversy with Nonconformists, Romanists, Deists and Socinians. His various learning, his dialectical expertness, and his massive judgment, rendered him a formidable antagonist; but the respect entertained for him by his opponents was chiefly aroused by his recognized love of truth. The range of his learning is most clearly seen in his Bishop's Right to Vote in Parliament in Cases Capital. His Origines Britannicae, or Antiquities of the British Church (1685), is a strange mixture of critical and uncritical research. In his closing years he had some controversy with John Locke, whom he considered to have impugned the doctrine of the Trinity. He died at Westminster on March 28, 1699. His manuscripts were bought by Robert Harley, afterwards Earl of Oxford.

A collected edition of his works, with life by Richard Bentley, was published in London, 6 vols. (1710); and a useful edition of The Doctrines and Practices of the Church of Rome Truly Represented was published in 1845 by William Cunningham.

STILL-LIFE PAINTING, the art of painting inanimate objects for their beauty of colour, line or arrangement. It was first developed as an individual branch of easel painting by the artists of the Netherland school of painters. Families of artists chose this simple line of art for their life's work. Gold and siland even jewels, scientifically arranged for scintillating effects. were motifs for some of the most brilliant artists. Simple kitchen utensils of brass and copper, with meat, fish and vegetables. made fine subjects for colour and line. The sparkle of metals, the glitter of wet fish, the deep and rich tones of meat and vegetables-what better material could the painter desire!

Exquisite drawing, with painstaking draughtsmanship as a primary factor, resulted in paintings that were sought not only by the rich burghers, but by visiting princes and ambassadors In every museum may be found these masterpieces, and although not so numerous as the many rows of portraits, genre and religious canvases, they, nevertheless, hold their high place in Dutch art

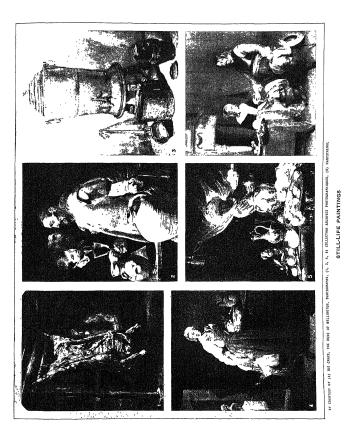
The Flemish and Dutch artists felt, and so did many true lovers of the fine arts of that time, that the subject of a picture was not the only motif worth while; that an arrangement beautifully composed, either for luxurious abundance or for simplicity in colour, tone, values and line, would make a noble work of art, in spite of what higher thought might find in portraying character in the portrait and deep feeling in the religious picture They argued that a well painted still-life was a greater art production than a badly painted Madonna, however well conceived

Subject-matter .- Pictures of the life of the people themselves, their houses, gardens, the interior of the splendidly furmished homes of merchants and aristocrats, rich in hangings and elaborate in table service, made beautiful settings for the painter The everyday life of the people around the artist showed him just what he wanted. Besides, it furnished a subject that was simpler to do than the literary picture, as well as being more straightforward and true People in silk and velvet, visiting in well-appointed rooms to listen to music or to partake of wine and cake or fruit. served on silver or choice porcelain, were none the better as subjects than a girl scouring a brass kettle in the kitchen.

That greatest part of the painter's knowledge, the observation of values, which means rendering the lights and shadows of a subject regardless of local colour, was first thoroughly understood by these artists, and is the basis of all sound painting From the work of these men, still-life developed. The principle is the same, the interiors being to a great extent still-life. There is usually very little expression or movement needed for the figures. However well painted the heads, the clothes, even the glass of amber-coloured wine in the lady's hand, seem almost of the same interest as the head. Take the figures out and the pure still-life is the result. The simple composition of a few peaches on a piece of delft with a silver pitcher and an ornamented glass half full of wine is all that a master like Willem Kalf needs to make a supreme painting

Technique.—Often in the galleries and at exhibitions, critical visitors, some of whom are professional painters, ask. "What is still-life?" Reproducing the roundness and firmness of a red apple is not very different from the modelling of a head. Lovers of painting look for something different in a canvas, something that for them means beauty or truth-and not every one sees the same beauty in a picture painted by a master. Take Velázquez' "Aguador" for an example; to the painter, a quiet study of model-ling, with remarkable still-life; to one with perhaps no ability as a painter, a thoughtful study of a man's head, to another a beautiful head of a boy. Velázquez had a number of interesting still-life pictures. In "The Steward" and "Old Woman Frying Eggs," each has a single figure in the composition, but the pictures are evidently made for close studies of inanimate life, dead fish, meat, jars and glass, masses of objects, scattered all over the canvas Rembrandt's "Flayed Ox" in the Louvre is a great example of noble quality, rich in colour, bold in treatment, closely observed in values, and of great simplicity-a masterpiece.

Pieter Aertsen, early 16th century, one of the first absolute still-life painters, although at times introducing figures in the background of some of his pictures, painted pictures of meats, vegetables, etc., in the kitchen or larder His large canvas in Uppsala, representing a butcher-shop with a calf's head, a side of beef, a pig's head and sausages, fowl, fish and all sorts of gruesome details of what one expects to find in such a place, is typical. ver cups, flagons and plates of porcelain and delft, oriental rugs. The canvas is overfilled, every small place is crowded, and



Act New York, C. Obsadru, "Le Pourovauca," one of the three most famous partitings by this master of still for the safe about and history shadows and history shadows and history shadows and history shadows the safe of C. Le Sallist Mithers, "P. H. Boohi (AST-ASS), she also his of the small details the burn of the safe of the saf observed Now in Loures. 2. "Aguador de Servina" by Visizauez (1359-1466) Quali tudy of modelling Victoriz and Albert museum (Askiety House). 3. "La Fordiana," tudy of modelling Victoriz and Albert museum (Askiety House). 3. "La Fordiana, Caspana, parte carray, and Charidar tercente works: Charidan (1659-1775) was able to see and reproduce beauty in amule utensis of the kiteinen. In the Metropolitum Museum of



BY COUNTELY OF (5) THE BIAKS NOSEUM (6) THE PHILLIPS MENDRIAL GALIERY, PHOTOGRAPHS, (1, 2, 4, 7) HANDSTARNOI, (3) COLLECTION ARCHIVES PHOTOGRAPHIC

## FISH, FRUIT AND GAME

- "Still Life" by Willem Kaif (1622-93), who needed only the simple composition of a few penches, a pitcher and an ornamental wine glass to make a masterplace. Dutch
- Tange Still Life With Bird's Nest" by Jan Davidsz van Heem (c. 1600-c 1683) Dutch Van Heem's plotures are drawn and coloured exqui-sitely. His use of chiarosouro was very effective
- 3. "Still Life," one of Antoine Vollon's pictures (1833-1900) French.
  Most of this painter's work was done in one sitting He painted somewhat after the Dutch manner. In the Louvre.
- 4 "Lobster, Fruit and Flowers" by Cornellus de Heem (1631-95), son of Jan Davidsz van Heem Dutch
- 5 "Study of Still Life," by Fran Sondars (1579–1657) Flemith, Snyders

  5 "Study of Still Life," by Fran Sondars (1579–1657) Flemith, Snyders

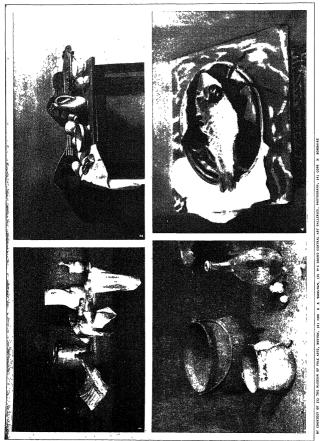
  career in the Rijks museum of till life during the early part of his

  career in the Rijks museum of the Company of the
- 7. "Fish on a Table," a still life by Alexander Adriassen (1587-1661) German



BY COURTESY OF (I) THE RIME MUSEUM, (Z, 4) THE HETROPOLITY N NUSEUM OF ART, NEW YORK, (3) THE INVERSITY OF UPPRALA

## EXAMPLES OF STILL-LIFE ART

- "Fruit and Game" by Jan Weanix (1640-1719), highly described with the survival of 


3 "Hearthstone" by Emil Carleon (1855-1932), characterised by simplicity of treatment and fathful portugal of homely utensit. American surface and simplicity in his drawness. Freech 4. "Finit", by Heart Matthes (1855—). Include the surrouses and simplicity in his drawness. Freech ARTISTIC STILL-LIFE CANVASES "Withher Taile" by Ass absentis Sension Charlot (2025-179); stitled bandling of white generati, as shown in treatment of white just and fouri. Fresch Museum of Fine Arti, Belton 2. "The Table by André Deura (1988). "Who combined the influence of Cesanne and Genouls with the ammirus. Fresch.

4. "Fish" by Henri Matisse (1869-

although correct in drawing, well coloured and a picture most interesting, it is in questionable taste.

Abraham van Beyenn (1630-75) stands eut as one of the forment painters of rish, producing well composed paintings, gloming with bright colours and glistening surfaces. The painting of wei, sparking fish gives opportunities to the student for the study of brilliant light against the deep and rich notes in the wet rish, and as the fish very soon deteriorates in colour and form, the canvas must be painted quickly, in the heat of enthusiasm, thus bringing forth the finest results, the most spontaneous work.

Joachim Buckelaer painted fish, as did Alexander Adriassen and, in their late years, Vollon, Manet and Chase

Jan Davidsz van Heem and his son, Cornelius de Heem, the two most celebrated members of a large family of still-life painters, are separately noticed. Jan was one of the earliest and ablest. The realism of the individual flower or peach was more desired by these painters than the ensemble of the picture. Jan an Huysum (q, v) reached the top as a flower painter whose

style was similar to that of the de Heems.

Willem Kalf, like Willem Classz Heda, had finer perception of tone and envelopment. Both were painters of rich objects that were executed in the adopted style of the Dutch, but with keen observation of values and tonality; they were taught by masters like Vermeer and Terborch.

Frans Shyders' large game compositions are highly decorative, his fruit rich in colour, well drawn and painted, but overfilled with details and without concentration of the modif. No air in them! The pictures of game that his pupil, Jan Fyt, painted are well studied, realistic in the weight of deer and hare, and in the quality of the painting of fur and feathers. Jan Weenix was a highly decorative panter of dead game in luxinous surroundings, garden backgrounds with decorated vases, the implements for the bunt and its soon.

In all this interesting still-life work it was always the manner that was considered superior to the matter, and it was always the school that called for excellence of craftsmanship. Every master had his pupils who followed his style; father taught son, and the son taught his son; it was a trade that had to be learned

Without absolute knowledge of his tools and the preparation of the canvas or panel, one did not count for much in the craft. So-called "visions" were not considered in the Netherlands, as they were in Italy. Pictures that could be studied and loved at short range were called for, and the work could not be carelessly done. Therefore, something was often missing, even in this beautiful work. It left no room for imagnation. It was only for the eye—charming to look at, but nothing to dream about—and was generally the work of the panier and tarely of the artist,

Chardin -- Tean Baptiste Simeon Chardin lifted still-life to a higher plane in art than the Hollanders and Flemings of former years. Understanding their methods, he added to their technique air and light as the aim to search for. His simplicity saw beauty in his daily surroundings; his honesty rendered them with absolute truth. Every utensil in his kitchen we know-the copper waterfountain, the charcoal brazier, the brass kettles, the handsome water-jar, the bread knife, as well as the large loaf of bread, the herrings, cuts of meat, onions and pieces of china. Chardin's living-room we know, with the straight-backed chairs and the bird in its cage on a stand. We know the housewife with her white apron -and how splendid a white! Chardin's whites are miracles of painting. The white jug and the white fowl in the still-life in the Boston museum are unequalled. Few painters of all time have been able to handle white pigment as Chardin could. James McNeill Whistler was among the few.

Among files earliest pictures was to "Skate." now in the Louver. This was accepted by the academy as his diploma picture, simply painted and freer in treatment than other canvases of his early career. He painted a great many interiors, with one or two figures. Again and again't is the light that predominates, the atmosphere of the from o'r rooms, for we often look through an open door-into another room, and that from full of light. Every figure has its weight, stands soundly on its feet and is well in its distance from the onlower and from the wall behind.

As still-life painting or interior with figure, it has every quality aboven; every colour value is observed; the drawing is easy, never overdrawn, and still never slighted. Chardin's textures are removed as the still and citch is cloth, every edge, the despair of the average painter, if min but well beineded, light and air are over and around every figure or object. This is still-life painting, an answer to "What is still-life?"

Later Still-life Artists—Chardin died in 1779, and for meatly a century there were no still-hie panters of note; there was practically no interest in notione more. When Courbet started his bold and vigorous manner of panting, he was alone, he pantied what he saw and in a manner of bis own invention. Whatever in nature looked worth panting he paintied—figures, landscape, marines and still-life. His still-life canvases are done truthfully and spontaneously, and are of a flat, well-coloured technique. Several of his pictures have a stag in them, similar in motion to those of Snyders or Wentis. But with more weight, and greater organality.

Manet was an artist who painted for excellence, and his stilllife work, of which he did a great deal, is always of a high order Simple and full of high, the canvas is never overfilled. Manet was also an individual who saw with his own eyes and painted in a flat manner. Jocal colour and values being purposely shighted.

Antoine Vollon painted landscapes, but is better known for his still-life, in which he was very prolific. Most of his work was done in one sitting, and in a decorative, well-arranged, somewhat Dutch manner.

Vollon's picture of "Fish" in the Luxembourg is a splendid piece of painting, with its dark shadows, almost monotone, and the wet and slimy fish in brilliant light. His reputation was widespread.

Bonvin and Fantin-Latour were men of well-mented reputation Fantin-Latour's flower paintings are tastefully arranged and finely executed Bonvin's work, simple and truthful, is based on Chardin's methods.

Of the American painters, William M. Chase (1849—1916) painted fish, pots and brass kettles, and pictures of great brilliancy Julian Alden Weir's flowers are noted for their equisite delicacy and beauty. (See also Painting; Flower Painting) (É CN.)

BIBLIOGRAPHY.—R. Warner, Dutch and Flowish Flower and Fruit Painters of the 17th and 18th Centuries (London, 1928), A. E. Bye, Still Life Paning (1921); E. L. Koller, Still Life and Figure Draums; H. E. A. Furst, The 4rt of Still Life Painting (London, 1927). See also the bibliography under Painting.

STILLMAN, WILLIAM JAMES (1828-1901), American painter and journalist, was born at Schenectady (N. Y), June 1, 1828. He graduated at Union college, Schenectady, in 1848. He studied art under Frederick E. Church and carly in 1850 went to England, where he fell so much under the influence of Rossetti and Millais that on his return home in the same year he speedily became known as the "American Pre-Raphaelite." He studied art under Yvon in Paris, returned to the United States and devoted himself to landscape painting on Upper Saranac Lake in the Adirondacks and in New York City, where he started the Crayon. When it failed for want of funds, Stillman removed to Cambridge, Massachusetts. He returned to England, and afterwards painted with Ruskin in Switzerland. He was in Normandy in 1861 when the American Civil War broke out. His health was too weak for him to serve in the Northern ranks and he was appointed United States consul in Rome. In 1865 he resigned, but immediately afterwards he was appointed to Crete. He was an editor of Scribner's Magazine for a short time When in London lived with D. G. Rossetti. When the insurrection of 1875 broke out in Hercegovina he went there as a correspondent of The Times, and his letters from the Balkans aroused so much interest that the British government was induced to lend its countenance to Montenegrin aspirations. In 1877-83 he served as the correspondent of The Times at Athens; in 1886-98 at Rome. After his retirement he lived in Surrey, where he died on July 6, 1901. He wrote The Cretan Insurrection 1866-1868 (1874), On the Track of Ulysses (1888), Billy and Hans (1897) and Francesco Crispi (1800).

See his Autobiography of a Journalist (Boston, 1901)

STILLWATER, a city of eastern Minnesota, USA, on the St Croix river, at the head of Lake St Croix, 20 mi. NE of St. Paul; the county seat of Washington county It is served by the Chicago, Milwaukee, St Paul and Pacific, the Chicago, St Paul, Minneapolis and Omaha, and the Northern Pacific railways Pop. (1950) 7,643, and it was 7,013 in 1940 The city has a picturesque situation on bluffs high above the river It is the seat of the state prison (established 1851), a shipping point for the agricultural products of the region, and a manufacturing centre of growing importance Before the exhaustion of the forests, it had a large trade in pine lumber Stillwater was settled in 1843, laid out in 1848, and chartered in 1854. The "Stillwater Convention" of 1848 was the first step toward the erection of Minnesota Territory

STILO PRAECONINUS, LUCIUS AELIUS (c. 154-74 B C ), of Lanuvium, the earliest Roman philologist, belonged to the equestrian order. His aristocratic sympathies were so strong that he voluntarily accompanied O Caecilius Metellus Numidicus into exile. At Rome he divided his time between teaching and literary work. His most famous pupils were Varro and Cicero, and amongst his friends were Coelius Antipater, the historian, and Lucilius, the satirist, who dedicated their works to him Only a few fragments of his works remain. He wrote commentaries on the hymns of the Salu, and (probably) on the Twelve Tables, and investigated the genumeness of the Plautine comedies, of which he recognized 25, four more than were allowed by Varro The rhetorical treatise Ad Herennium has been attributed to him by some modern scholars.

1900), p 148.

STILT (Himantopus himantopus), a bird of the plover famly (see PLOVER), remarkable for the extreme length of its slender legs. The bill is long and straight; the legs red, the wings and back black; the head, neck and

lower parts white

Its food consists of small arthropods, which it obtains by wading in shallow water. It ranges over Europe and Asia, not breeding northward of the Danube valley. The nest is a slight structure on the margin of a pool or lake, and contains four eggs, which resemble those of the ovster-catcher (q.v.) In America, from Oregon southward to Brazil, occurs the black-necked stilt, THE STILT (HIMANTOPUS HIMAN-H. mgricollis, Other species oc-



cur in South America, Australia and New Zealand. The stilts are

allied to the avocets (q.v.), and, like them, spend much time wading in shallow water.

STILTS, poles with footrests fixed at a certain distance above the ground. They were originally designed for use in crossing rivers and marshes. As a means of amusement stilts have been used by all peoples in all ages, as well as by the inhabitants of marshy or flooded districts. The city of Namur in Belgium, which formerly suffered from the overflowing of the rivers Sambre and Meuse, has been celebrated for its stilt-walkers for many centuries. Not only the townspeople but also the soldiers used stilts. The governor of Namur having promised the archduke Albert (about 1600) a company of soldiers that should neither ride nor walk. sent a detachment on stilts, which so pleased the archduke that he conferred upon the city perpetual exemption from the beertax, no small privilege at that time.

The home of stilt-walking at the present day is the department of Landes in Gascony, where, owing to the impermeability of the subsoil, all low-lying districts are converted into marshes. Stilts

used by children are very long, the upper half being held under

the arms, they are not strapped to the leg
STIMSON, HENRY LEWIS (1867-1950), US lawyer and statesman, was born in New York city on Sept 21, 1867, and educated at Yale (AB, 1888) and Harvard (AM, 1889) universities He attended the Harvard Law school and in 1801 was admitted to the New York bar. In 1906 he was appointed U.S. attorney for the southern district of New York state This position he relinquished in 1910 to become the unsuccessful candidate of the Republican party for governor of New York In 1911 he was appointed secretary of war by Pres Wilham Taft, in which office he continued from May 1011 to March 1913 During US participation in World War I he served in France as colonel of the 31st field artillery In 1927 he was sent by Pres Calvin Coolidge as a special commissioner to Nicaragua, where he met Pres. Adolfo Díaz and the rebel leader José Moncada and was instrumental in persuading both leaders to lay down their arms on condition that the U.S would supervise the 1928 election His success on this mission, together with his study of the Philippine question in 1926, led to his appointment, in Dec. 1927, as governor general of the Philippine Islands. He succeeded Maj Gen Leonard Wood, whose policies he continued with notable success. As secretary of state in Herbert Hoover's cabinet from 1929 to 1933, he urged international opposition to Japan's aggressions in Manchuria, He led the U S delegations to the London naval conference in 1930 and the disarmament conference of 1932. He served again as secretary of war from 1940 to 1945. He died Oct 20, 1950, in Huntington, N.Y.

STINKHORN, the popular name of a group of fungi belonging to the Basidiomycetes, so called because of their carnonlike odour. The young plant (egg) resembles a small puff-ball (q.v) but soon splits open at the apex when a stalk emerges with a conical, slimy, evil-smelling head on which the spores are borne. The spores are dispersed by insects attracted by

the odour.

STINK-WOOD, a South African tree, known botanically as Ocotea bullata, and a member of the family Lauraceae. Other names for it are Cape walnut, stinkhout, Cape laurel and laurel wood It derives its name from having a strong and unpleasant smell when freshly felled. It is used for building in South Africa and is said to be a substitute for teak and equally durable The wood is dark walnut or reddish brown to black with a yellow sapwood, and the grain extremely fine, close, dense and smooth

STINNES, HUGO (1870-1924), German industrialist, was born in Mulheim on Feb. 12, 1870. Educated as a mining engineer, he entered his grandfather's firm in 1890, but two years later established a business of his own, with a capital of 50,000 marks. The business expanded steadily and came to include, besides dealing in coal, the ownership of coal mines, barges, river steamers and sea-going vessels. Stinnes organized an international business in coal, including the importation of coal from England He built up a fleet of steamers trading in the North Sea, the Baltic, the Mediterranean and the Black Sea. He also established iron and steel factories. During World War I he commanded a large share of the industrial work required by the German authorities, and rapidly increased his shipping interests. In 1920 he entered the Reichstag as a member of the German People's Party (the former National Liberal party). He began to buy up newspapers, whose democratic opinions were quickly modified in accordance with his own. In 1921 he was reported to be contem-plating the formation of a super-trust to control the whole of German industry. He died in Berlin April 10, 1924. After his death the business, conducted by his son, rapidly shrank In June 1925 a conference of bankers was called to investigate the financial affairs of the trust; and but by bit the great organization was liquidated and sold. In Oct. 1925 a new company was registered at Hamburg under the title of Hugo Stinnes Coal Trade and Shipping Co., Ltd., the Stinnes family retaining 40% of the shares.

STIPPLE AND CRAYON ENGRAVING. Stippleengraving was a little art of prettiness and daintiness, particularly well adapted to the translation of anecdotic pictures of a sentimental, mildly romantic, or domestic character, such as were



BY COURTEST OF (1, 2, 3) FRANK Y SABIN, (4) THE TRUSTEES OF THE BRITISH MUSEUM

# ENGLISH STIPPLE ENGRAVINGS OF THE 18TH CENTURY

Stipple engraving consists of a design drawn in a series or group of dots through an etching ground on a copper plate, and bitten with acid, then completed with dots made directly in the copper by a curved stipple-graver and perhaps a toothed wheel called a roulette

1. "Countes Senicer," engraved by Francisco Bartelarii (1727-1813)
by William Word (1764-1826) star the culnting by George Morland the Mascurate," engraved by John Rachael Smith (1782-1812) after the painting by George Morland (1781-1804). "George Morland (1781-1804)." George Roman (1714-1808)



tuned out in great numbers to supply a vogue in the English sallers' windows, and few native engravers could resist the easy maket during the reggs of George HII, many of which, popular attraction of the new method, while it brought also Italian and in the day, survive only in the colour-prints and, though rarely of much attistic value, are yet now highly valued for their ment in survival. Nevertheless there were in the brief hey-day of the art a few among the multitude of designers and engraves who, realising its limitations, made the most of its qualities, and these, such as J. R. Smith, William Ward and John Jones, the special respectations with the survival of the special possibility of the survival of th

As a separate method, stipple-engraving came to England from France probably about 1764, by way of the crayon manner and the pastel, and these had evolved originally from the dotted manner, to which Ludwing von Siegen refers; in amounting the wonders of his own invention of mezzotint in 1642, as one of the modes of enganing which it was not The dotted manner, a process of punching the plate with awd and mailet, called opps multel, was used for its own sake with pictorial effect by Jan Lutma, an Amsterdam goldsmith, and the son of Rembrandt's sitter; but graven dots had been used earlier as accessory to line-engraving by Guiho Campagnola, Ottavio Leon, and others, while in England the eathlest important engraver of portraits, Whiliam Rogers, in Queen Elambeth's rege, had supplied the face of the Queen, while of Chriefs. If

But in the 18th century, when the crayon and pastel drawings of Boucher and others were popular in France, the aim of the engravers was to reproduce their texture on the copper-plate. The idea was in the air, so to speak, and several were engaged in the attempt to materialize it Thus the invention of the crayon manner was claimed separately by Jean Charles François, Gilles Demarteau, who used his own version of it with artistic feeling. and Louis Marin Bonnet, an ingenious engraver to whom we owe at least the "pastel manner" This was a subtle development of the crayon mode admitting colour variety from a series of plates. as we may see in Bonnet's really fine print, La Tête de Flore, after Boucher, but François seems to have been actually the first in the field The means used to imutate crayon drawing resembled soft-ground etching, though to produce the appearance of the chalk lines the etching-ground was perforated by tools of the roulette order, and various kinds of needles, while, after the usual biting by the acid, the finishing touches were given by graver, dry-point and roulette, though one often fancies the methods of soft-ground had been employed. François taught this crayon engraving, and with it the application of colour in printing à la poupée, to William Wynn Ryland, a young English line-engraver, who had been studying with Le Bas in Paris, and who, when funds were lacking after his return to London, bethought him of the new manner of engraving he had learnt. Then having called Bartolozzi into collaboration, they both medified and developed it as stipple-engraving.

The new method proved very easy of accomplishment, simple and rapid. The outline was etched in a series of dots, and all the shadows were put in with large or closer dots, or tiny groups of dots When all the biting was over, the ground was removed, and the finishing was done with dry-point and stipple-graver, a curved tool. Then the printing was done with black, red, or several coloured inks, a rag-stump, or poupée, being used, and the plate freshly cleaned for each impression. Beginning by translating the pretty pseudo-classical designs of Angelica Kauffman and Cipriani, which acquired a very popular vogue, Ryland and Bartolozzi found the new method exceedingly profitable. To the ready hand of Bartolozzi it came almost as a fairy gift, with the facilities of the medium linking themselves to his sweet caressing sense of beauty. Indeed, he developed it with richer character in its fine shades than the unfortunate Ryland could do, as we may see in many notable prints after Reynolds and other distinguished painters, All the painters of the day were anxious to share in the profits so readily made by the stipple-prints which were filling the print-

attraction of the new method, while it brought also Italian and French engravers to learn it, and work here for the English market. There was also, up to the war with revolutionary France in 1793, a great trade in English prints on the continent, and Bonnet and other French engravers, adopting the stipple method, tried to get a share in this trade by issuing prints with titles often in misspelt English Sir Robert Strange, the eminent line-engraves, launched an indignant tirade against stipple, and even denied its claim to be regarded as engraving at all, though there was no denying its efficacy as a medium for colour-printing, the white of the paper, showing between the tinted dots, affording a peculiarly luminous quality, and thus giving it a superiority over the coloured mezzotint, though it must be admitted that rarely was the stipple or the mezzotint of old time completely printed in colours, some portions invariably being left to be coloured by hand. Nevertheless, the popularity of stipple continued as long as the special subjects for which it was used remained in fashion, and as long as the leading 18th century painters and engravers survived the period of their comparatively short though successful collaboration, but it really wanted with the advent of colour-lithography. Stipple-engraving is rarely practised nowadays as a separate art, though a recent attempt has been made to revive it for original expression by Dorothy Woollard As a medium for original colourprinting it has completely given place to aquatint, woodcut or panting it ass Competerly given piete to adjustin, wooded to wood engaving lithography or relief-etching from several plates where the plates of the plates of the plates of the plates (Spend Western Colors) and the plates of the plates of the (1906). Bightenth Century Prench Colors-Prints (1906); and et 2009). Franken, Bightenth Century Colors-Prints (1906) and et 2009). Campbell Dodgan, Old French Colors-Prints (1944). (MC S.)

STIRES, ERNEST MILMORE (1868—1951), bishop of Long Island, was bom in Norfolk, Va, on May 22, 1866 Herrecoved the degree of B. Litt at the University of Virginia in 1885, and from 1889-91 continued his studies at the Episcopal Heological seminary of Virginia, receiving the degree of D.D. at Trunty college in 1901 The degree of L.D. was conferred upon him at Kenyon college in 1903. He received his first appointment as rector at West Point in 1891, and in 1893 went to the Church of the Good Shepherd in Augusta, Ga. In the same year he was called to Grace church, Chicago, where he remained until 1901. He then accepted a call to 8t. Thomas's church, New York He was consecrated bishop of Long Island on Nov 24, 1925, and he served in that capacity until his retriement in 1941.

He died in Palm Beach, Fla, on Feb. 12, 1951 STIRLING, WILLIAM ALEXANDER, EARL OF (c 1567-1640), Scottish poet and statesman, generally known as William Alexander, was born at Menstrie House, near Stirling, about 1567, and probably educated at Stirling Grammar school. He may also have been to the universities of Glasgow and Leyden. He followed James VI. to England, where he became one of the gentlemen-extraordinary of Prince Henry's chamber. For the prince he wrote his Paraenesis to the Prince . . . (1604), a poem in eight-lined stanzas on the theme of princely duty He was knighted in 1609, in 1614 he was appointed master of requests, and in July 1615 to a seat in the Scottish privy council. In 1613 he began a correspondence with Drummond of Hawthornden In 1621 he received from James I, enormous grants of land in America, including Nova Scotia and New Brunswick, and was appointed lieutenant-governor of the new colony which, however, was ceded to the French in 1632. (See Nova Scotia: History.) From 1626 till his death he was the king's secretary for Scotland, and in 1630 was created viscount Stirling and Lord Alexander of Tullibody. In 1631 he edited and published a translation of the Psalms said to be by James I. In 1639 he became earl of Donovan. He died on Feb. 12, 1640, in London

Alexander's poetical miscellanies and minor verse include Aurora, containing the first fancies of the author's youth (1604); An Elejis on the Death of Prince Henrie, and shorter pieces He also wrote four tragedles, Darius (1603); Croesus (1604); The Alexandreau (1605), and Julius Caesus (1607); the first two of which were published together in 1604 as the Monarchicks Tragedles; they are didactic poems of dialoques rather than plant but they contain some fine solloques Of Alexander's heroic poem north side of the square is the chapel royal, founded by Alex-Donathon only the first book was written Donatedly, or The Order and the T, rebuilt in the 15th century and again 15th by 15th b

3 Vois (cisagow, 1870).

\*\*His Encouragement to Colonies was edited for the Bannatyne Club
by David Lamg (1867), and by Edmund F Slatter, m Sr. W.

\*\*Band Club, Colonies Colonies Colonies Colonies Colonies Colonies
1861, See also F Slamento Crame Scotter Rosel Latter,
1862, 1862, 1874, The Earl of Sirhing's Register of Royal Latter,
1862, 1874, 1

STIRLING, WILLIAM ALEXANDER, titular EARL OF (1726-1783), American soldier, was born in New York city. He served first as commissary and then as aide-de-camp to Governor William Shirley at the beginning of the French and Indian War, and in 1756 he accompanied Shirley to England, where he prosecuted his claim to the earldom of Stirling In 1759 an Edinburgh jury declared him to be the nearest heir to the last earl of Stirling, and in 1761 he returned to America and assumed the title of Lord Stirling by which he was afterwards known in America, He became a member of the New Jersey provincial council and surveyor general of the colony. In 1775 he sided with the patriot cause and was appointed colonel of a regiment in New Jersey. In March he became brigadier-general, and for a time was in command at New York, and supervised the fortification of the city and harbour. At the battle of Long Island he was taken prisoner, but was soon afterwards exchanged, and in Feb 1777 became a major-general. He participated in the battles of Trenton, Princeton, Brandywine and Germantown, and especially distinguished himself at Monmouth He took an active part in exposing the Conway Cabal, presided over the court-martial of General Charles Lee, and enjoyed the confidence of Washington to an unusual degree. In Oct. 1781 he took command of the northern department at Albany to check an expected invasion from Canada He died at Albany on Jan 15, 1783. He was a member of the board of governors of King's college (now Columbia university) and was devoted to the study of mathematics and astronomy.

See W. A Duer, "Life of William Alexander, Earl of Stirling," in Vol ii of the Collections of the New Jersey Hist. Soc. (1847).

STRLING, royal, large and parliamentary burgh, river port and county town of Stirlingshire, Scotland. Pop. (1938), 23,552. It is finely situated on the right bank of the Forth, 394 mi. N.W. of Edinburgh and 29½ mi. N.E. of Glasgow, being served by the L.N.E. and L.M.S. railways. The old town occupies the slopes of a basaltic hill (420 ft. above the sea) terminating on the north and west in a precipice. The modern quarters have been laid out on the level ground at the base, especially toward the south. Remains of a town wall exist at the south end of the Black walk, Formerly there were two main entrances-the South port and the "auld brig" over the Forth to the north, a high-pitched structure of four arches, now used only by foot-passengers. It dates from the end of the 14th century and was once literally "the key to the Highlands." Just below it is the bridge erected in 1829 from designs by Robert Stevenson, and below this again the railway viaduct. The castle crowning the hill is of unknown age, but from the time that Alexander I died within its walls in 1124 until the union of the crowns in 1603, it was intimately associated with the fortunes of the Scottish monarchs. It is approached from the esplanade, on which stands a colossal statue of Robert Bruce The main gateway, built by James III, gives access to the lower and then to the upper square, on the south side of which stands the palace, begun by James V (1540) and completed by Mary of Guise. The east side of the quadrangle is occupied by the parliament house, a Gothic building of the time

ander I, rebuilt in the 15th century and again in 1594 by James VI (who was christened in it), and afterwards converted into an armoury and finally a storeroom. In the plain to the southwest were the King's gardens, now under grass, with an octagonal turf-covered mound called the King's Knot in the centre Farther south lies the King's park. On a hill of lower elevation than the castle and separated from the esplanade by a depression styled the Valley-the tilting-ground of former times-a cemetery has been laid out Here is the Virgin Martyrs' memorial, in memory of Margaret Maclachlan and Margaret Wilson, who were drowned by the rising tide in Wigtown bay for their fidelity to the Covenant (1685); the large pyramid to the memory of the Covenanters, and the Ladies' rock, from which ladies viewed the jousts in the Valley Adjoining the cemetery on the south is the parish church, portions of which may have formed part of the first church, founded by David I Following the Reformation it was divided into two churches, but was restored to its original condition in 1935. The choir (the old East church) was added in 1494 by James IV, and the apse a few years later. At the west stands the stately battlemented square tower The nave (the former West church) is a transition between Romanesque and Gothic, with pointed windows. The crow-stepped Gothic gable of the south transept afforded the main entrance to both churches. The choir is in the Decorated and Perpendicular styles Within its walls Mary Queen of Scots was crowned in 1543, when nine months old, and in the same year the earl of Arran, regent of Scotland, abjured Protestantism; in 1544 an assembly of nobles appointed Mary of Guise queen-regent; on July 29, 1567, James VI was crowned, John Knox preaching the sermon, and in Aug 1571 and June 1578 the general assembly of the Church of Scotland met. James Guthrie (1612-1661), the martyr, and Ebenezer Erskine (1680-1794), founder of the Scottish Secession Church. were two of the most distinguished ministers. To the southwest of the church is Cowane's hospital, founded in 1630 by John Cowane, dean of guild, and now used as a guildhall. Adjoining it is the military prison Near the principal entrance to the esplanade stands Argyll's Lodging, erected about 1630 by the 1st earl of Stirling, Sir William Alexander, the founder of Nova Scotia. On his death in 1640 it passed to the 1st marguess of Argyll and later was made into a military hospital It is a fine example of a baronial town house. Broad street contains Mar's Work, the palace built by John Erskine, 1st (or 6th) earl of Mar, about 1570, according to tradition, out of the stones of Cambuskenneth abbey; the old town house, erected in 1701 to replace that in which John Hamilton, the last Roman Catholic archbishop of St Andrews, was hanged for alleged complicity in the murders of Darnley and the regent Moray; the town cross, restored in 1891, and the house which was, as a mural tablet says, the "nursery of James VI and his son Prince Henry." The Smith institute, founded in 1873 by Thomas Stewart Smith, an artist, contains a picture gallery, museum and reading room Carpet weaving and woollen spinning and manufactures are the staple industries, and ironfounding, carriage-building and agricultural implement-making are also carried on, in addition to furniture factories, cooperage and rubber works and confectionery works. There is some shipping from the small harbour, which is accessible only at high

Stirling, with Falkirk and Grangemouth, returns a member to parliament.

in 1839 from designs by Robert Stevenson, and below this again the milway viaduct. The castle crowning the hill is of unknown east of Stirling, is a thickly-wooded hill on the top of which stands age, but from the time that Alexander I died within its walls the Wallace monument (1869), a branch allower, with a valhalla in 1144 until the union of the crowns in 1603, it was hintmately containing butst of eminent Scotsmen. Castlement above, associated with the fortunes of the Scottish monarchs. It is on the left bank of the Forth, about 1 mi ENE of Stirling, was approached from the esplanach, on which stands a colosal state of founded by David I in 1147 for monks of the order of St August of Robert Bruce. The main gateway, built by James III, gives time. Several Scots parliaments met within its walls. At the access to the lower and then to the upper square, on the south Reformation Mary Queen of Scots bestowed it on the ste earl of side of which stands the palace, begun by James V (1540) and Mar (1562), who is said to have used the stones for his palace completed by Mary of Guise. The east side of the quadrangle is in Stirling All that remains of the abbey is massive, four-occupied by the parliament house, a Gothic building of the time storied tower, the west doorway and the foundations of some of of James III, now used as a barrack-room and stores. On the the walls. The bones of James III and his queen, Margaret of

Denmark, who were buried within the precincts, were discovered in 1864 and reinterred next year under a tomb at the high altar at

the expense of Queen Victoria.

Stirling was known also as Snowdoun, which became the official title of the Scots heralds The Romans probably had a station here In 1119 it was a royal burgh and under Alexander I was one of the Court of Four Burghs (superseded under James III. by the Convention of Royal Burghs) In 1174 it was handed over to the English in security for the treaty of Palasae, being restored to the Scots by Richard I. The earliest known charter was that granted in 1226 by Alexander III., who made the castle a royal residence. The fortress was repeatedly beseged during the wars of the Scottish Independence. In 3504 it fell with the town to the Scottish landependence. In 3504 it fell with the town to the Scottish single in 1314 that Scottish and the Scottish single in 1314 that Scottish single in 1314 that Scottish single in 1314 that III. In the Scottish single in 1314 that III. In 1314 in terms of his compact with Edward III., but the Scots regained it in 1339 in terms of his compact with Edward III., but the Scots regained it in 1339.

From this time till the collapse of Queen Mary's fortunes in 1568, Stirling almost shared with Edinburgh the rank and privileges of capital of the kingdom. It was the birthplace of James II in 1430 and probably of James III and James IV. In 1571 an attempt was made to surprise the castle by Mary's adherents, the regent Lennox being slain in the fray, and seven years later it was captured by James Douglas, 4th earl of Morton, after which a reconciliation took place between the Protestants and Roman Catholics It was occupied in 1584 by the earls of Angus and Mar, the Protestant leaders, who, however, fled to England on the approach of the king. Next year they returned with a strong force and compelled James VI. to open the gates, his personal safety having been guaranteed In 1504 Prince Henry was baptized in the chapel royal, which had been rebuilt on a larger scale. After the union of the crowns (1603) Stirling ceased to play a prominent part on the national stage. The privy council and court of session met in the town in 1637 on account of the disturbed state of Edinburgh In 1641 Charles I gave it its last governing charter, and four years afterwards parliament was held in Stirling on account of the plague in the capital, but the outbreak of the pest in Stirling caused the legislaters to remove to Perth. During the Civil War the Covenanters held the town, to which the committees of church and state adjourned after Cromwell's victory at Dunbar (1650), but in August next year the castle was taken by General Monk. In 1715 the 3rd duke of Argyll held it to prevent the passage of the Forth by the Jacobites, and in 1746 it was ineffectually besieged by Prince Charles Edward.

STIRLING NUMBERS, in mathematics In the year 1730 James Stirling, in his Methodus Differentialis interduced ino analysas two sets of numbers which, because of their uses in various branches of analysis, their properties, and the methods used in their computation, have continued to attract the attention of mathematicians.

One of the latest writers on the subject, Professor Nielsen of Copenhagen has named them "Stirling numbers of the first and second kind" in honour of their discoverer.

**Definitions.**—The Stirling numbers of order n of the first kind may be defined as the co-efficients in the expansion of

by the defined as the co-entral and the expansion of 
$$(1+x)(1+2x)\cdots(1+nx)=1+nS_1x+nS_2x^2+nS_2x^3+\cdots$$

in ascending powers of x, while the Stirling numbers of the second kind are found in

$$\frac{1}{(1+x)(1+2x)\cdots(1+nx)} = 1 - {}_{n}T_{1}x + {}_{n}T_{2}x^{2} - {}_{n}T_{4}x^{3} + \cdots,$$

also in ascending powers of x.

This definition immediately leads to the following theorems: (a) The  $P^{th}$  Stirling number of order n of the first kind is equal to the sum of the products of the first n integers taken P at a time without repetition.

(b) The P<sup>ih</sup> Stirling number of the second kind of order n is equal to the sum of the products of the first n integers taken P at a time with repetitions.

Stirling used the numbers now named after him as a tool for expressing  $v^n$  as a series of factorials

$$\begin{array}{l} x^2 = x(x-1) + x, \\ \tau^2 = x(x-1)(x-2) + 3x(x-1) + 3, \\ \lambda^4 = x(x-1)(x-2)(x-3) + 6x(x-1)(x-2) + 7x(x-1) + x, \\ \lambda^4 = x(x-1)(x-2)(x-3)(x-4) + 1xx(x-1)(x-2)(x-3) + x \\ - x^2 = x(x-1)(x-2) + x^2 $

The coefficients of the various factorials (1:1, 1:31, 1:67, 1:10.57:13) are the String numbers of the second kind. For about 150 years mathematicians considered it important to be able to express algebrate expressions in form of sequences of factorials. The result was a nch literature consisting of memoris dealing with the pecularities of this method of expression. In the year 1846 Weierstrass proved the general futility of this mode of notation, and since then the subject of "factorial notation" has slowly but surely been eliminated as a topic of discussion in mathematical hierature. At present it is used only in certain problems of finite summation, in theories of interpolation, and as nexample illustrating some of the uses of the Stringn numbers.

Applications.—George Boole in his treatise on the calculus of finite differences calls attention to the "system of numbers expressed by  $\Delta^n$  or differences of nothing)" without indicating whether he realized that these numbers were already used by Strling 'The formula given by Boole for  $\Delta^n$  or may well be used for the calculation of the above mentioned coefficients T, i.e., the Strling numbers of the second kind.

$$\frac{1}{n!} {}_{n}T_{m-n} = n^{m} - \left(\frac{n}{1}\right)(n-1)^{m} + \left(\frac{n}{2}\right)(n-2)^{m} - \left(\frac{n}{3}\right)(n-3)^{m} + \cdots$$

The Stirling numbers of the second kind (T) also appear in the expansion of  $(e^{\tau}-1)^{\rho}$ . Thus,

$$\begin{array}{c} \frac{1}{21}(s^p-1)^2 = \frac{s^3}{21} + \frac{sT_1s^2}{31} + \frac{sT_2s^4}{4^4} + \cdots \\ \frac{1}{31}(s^p-1)^2 = \frac{s^3}{21} + \frac{sT_1}{4^4} + \frac{sT_2s^4}{51} + \cdots \\ \frac{1}{4!}(s^p-1)^p = \frac{s^2}{2^p} + \frac{sT_1}{(b+1)!} s^{p+t} + \frac{sT_2}{(b+2)!} s^{p+t} + \cdots \end{array}$$

Formulas.-Of the recurring formulas the most important are

$$_{n+1}S_p = _nS_p + n \cdot _nS_{p-1},$$
  
 $_{n+1}T_p = _nT_p + n \cdot _{n+1}T_{p-1}.$ 

Of the independent formulas developed by various writers, none is suitable for practical purposes, but theoretically the following formulas which appear in a work by Ettinghausen (1826) are important:

$${}_{n}S_{p}=\sum \frac{(n+1)!}{a!\,b!\,c!\cdots x^{a}\,2^{b}\,3^{a}\cdots}$$

for all integral values of a,b,c . . . satisfying the equations:

$$a+b+c+\cdots=p+1,$$
  
 $a+2b+3c+\cdots=n+1,$ 

$$_{n}T_{p}=\sum \frac{(n+p)!}{a!b!c!\cdots i^{a}(2!)^{b}(3!)^{c}\cdots}$$

for all integers satisfying the equations

$$a+b+c+\cdots=p$$
,  
 $a+2b+3c+\cdots=n+p$ .

Relations between the S's and the T's are given by

The second formula is evidently obtained from the first by interchanging the T's and the S's It has also been observed (Amer. Math. Monthly, 1928) that the Striling numbers of the first kind can be obtained by performing the algebraic divisions,

$$\frac{2+x}{(1-x)^{\delta'}} \frac{6+8x+x^2}{(1-x)^7}, \frac{24+58x+22x^2+x^6}{(1-x)^9} \dots$$

while the Stirling numbers of the second kind appear in the quotients of

$$\frac{x+2x}{(x-x)^9}$$
,  $\frac{x+8x+6v^2}{(x-x)^9}$ ,  $\frac{x+22x+58x^2+24x^3}{(x-x)^9}$ ...

The Stirling numbers have many important relationships to the Bernoulin numbers (q, v). Bother numbers (q, v), and the tangential coefficients, and there are numerous formulas connecting them. In fact, there is a way of regarding the Bernoulin numbers as a species of Stirling numbers; that is  $(e^{\omega}-1)^2$  always gives, when expanded, Stirling numbers, and when we let  $\pi=-1$ , we obtain a well-known expansion giving the Bernoulli numbers.

The consideration of  $(e^x - 1)^{-n}$  leads to what may be called ultra-Stirling numbers, a subject which, like the ultra-Bernoulli and ultra-Euler numbers has been very little studied.

and ultra-buier numbers has been very utile studied.

Brittonparty—Cirk. Kraup, Analysé des réprézationneques

Brittonparty—Cirk. Kraup, Analysé des réprézationneques

dralyses (Vienna, 1850); Schläth, "Sur les coefficients du développement du product (1+a) (1+2a); ... | 1+(a-1) a) suivant les puissances accredantes de s." Journal jur des réus end autressandes Malha
(Lerne, 1950). N. Nicken, Traids été démentaire des nombres de Ber
noult (1921). É. Netto, Lehrbuch der Combisationik (Lelpus, 1927).

J. Stellenson, Interpédation (1927).

STIRLINGSHIRE, midland county, Scotland, bounded north by Perthshire, north-east by Clackmannanshire and the Firth of Forth, south-east by Linlithgowshire, south by Lanarkshire and the detached part of Dumbartonshire and south-west and west by Dumbartonshire; land area 288,332 ac., or 450.5 sq mi. In the northwest the Grampians end in Ben Lomond (3,192 ft ) The centre is occupied by the Lennox hills The oldest rocks are the Dalradian schists in the north-west beyond a great fault which runs from near the bottom end of Loch Lomond in a north-easterly direction across Scotland. On the south-eastern side of the fault are the conglomerates and sandstones of Lower Old Red Sandstone age, followed by the Upper Old Red series Then follows the Carboniferous system occupying the rest of the county. The true coal-measures are well-developed between Grangemouth and Stenhousemuir and about Falkirk. Intrusive sheets of basalt have penetrated the Carboniferous rocks and are quarried for road metal; Abbey Craig and Stirling Castle hill are formed of one of the more important of these intrusions. Much boulder clay covers the older rocks and an interesting blue marine clay is found beneath it in the Endrick valley The Carse of Stirling is overlaid by the muds and sands of the 50-ft. raised beach; and traces of the 100-ft. beach also are found.

The chief river is the Forth, which forms most of the northern boundary. The other important streams are the Carron, rising in Campsie fells and slowing to the Forth at Grangemouth; the Endnck, which, rising in Furty hills, emplies itself into Loch Lomond; the Kelvin, which, from its source in Kilsyth hills, slows southwest to the Clyde at Glasgow after a run of 2 z m.; and the Avon, rising in the detached portion of Dumbartonshure, and the Avon, rising in the detached portion of Dumbartonshure, and the Avon, rising in the detached portion of Dumbartonshure, and the Avon, rising in the detached portion of Dumbartonshure, and the Avon, rising in the detached portion of Dumbartonshure, and are are a reason of the Avon, rising in the detached portion of Dumbartonshure, are are, which, like Lock Katrine, and Loch Arklet, in the worth-west area, which, like Lock Katrine, rovides part of the water supply of Glasgow. The Forth and Clyde canal crosses the south-eastern corner of the county from Grangemouth to Castlecary.

History and Antiquities—The wall of Antonius, built by Lollius Urbicus, in A.D. 149, connecting the Forth and Clyde, passed through the south-east of the county, in which it is locally known as Graham's Dyke. At Castlecary and Camelon many relics have been found. The Camelon causeway ran eastwarfs from Castlecary and crossed the rampart at Camelon, whence it proceeded northwards to Stiffing and the Forth, where there was a

station near the present bridge of Drip Thence it crossed the river to Keir and Dunblane in Perthshite After the withdrawal of the Romans the county once more fell into the hands of the native inhabitants, who, however, gradually retired before the advance of the Saxons and Scots By the time of Malcolm Canmore (d 1003) the lowland area had become settled, but the highland tract remained a disturbed and disturbing region until the pacification following the Jacobite rising of 1745-6 The county played a conspicuous part in the struggle for Scottish independence, being particularly associated with many of the exploits of Sir William Wallace and Robert Bruce. The three great battles of the independence were fought in the shire-Stirling Bridge (1207), Falkirk (1208), Bannockburn (1314) James III was stabbed to death in a cottage in the village of Milton after the battle of Sauchieburn (1488), but apart from the disastrous defeat of the Covenanters at Kilsyth (1645) and the transitory triumph which Prince Charles Edward won at Falkirk (1746), the history of the shire practically centres in that of the county town

Agriculture and Industries.—The arable soils are of two kands, locally distinguished as 'crase' and "dryfield," the rest of the land being composed of pasture, moor and peat. The "carse" cetteds along the valley from Buchlywe to the eastern boundary. The soil consists of the finest clays, without stones, but interserved with strate of marine shells. It has been largely stripped of the overlying peat, and by draming, subsoil ploughing and the so of lime has been converted into a rich soil, especially adapted for wheat and beans. The "dryfield," which occupies the valleys and the higher ground bordering the carse, is fertile and sudded for potatoes and turnips, of which there were 5,880 ac in 1938. Oats (14,67 as 2) and wheat (2,997 ac) are the chief grain crops. Beans are also grown. The cattle are comparatively few, but sheep, chefty Black-faced, are rused. The average size of the 1,511 holdings in 1938 was 70½ ac, but over half were of 50 ac and were Birches grow on the lower slopes of the mountains in Buchanan and Drymen, and oaks on the banks of Loch Lomond. Larch and Scots fir are the leading trees in modern plantations.

The coalfield of the south-east supplies the staple industry, and coal is also mined in the east, near the Forth and Clyde canal Iron ore and fireclay are also obtained, while granite, limestone and sandstone are quarried The ironworks at Carron near Falkirk are important and nails are made at St. Ninian's and elsewhere. Woollens are manufactured at Stirling, St. Niman's and Bannockburn; calico-printing and bleaching are established in the south-west, especially at Lennoxtown and Milton, and there are chemical works at Falkirk and Denny, Tanning, iron-founding, paper-making, brewing and distilling are carried on at different places, and shipbuilding at Grangemouth, the chief port, southern and south-eastern districts are served by the LNER from Edinburgh to Glasgow (via Falkirk) and the L M S.R. from Glasgow to Stirling (via Larbert), while branches connect Grangemouth. Denny and other places with the through-lines. One L.N E line crosses the shire, mostly in the north, from Stirling to Balloch, and another goes from Glasgow to Aberfoyle.

Population and Administration.—Fop (est :038) 1733-410. In 1931 Gaelic and English were spoken by 1.039 persons. Falkirk (est. 1938 pop. 38,173) and Stirling (23,552) are large burgls, the small burgls being Grangemouth (13,710). Kileyth (3,763). Denny and Dunlpace (5,995), and Brage-of-Allan (3,890). There are three county districts. The shire returns a member to parliament with Clackmannan, and Stirling, Falkirkh and Grangemouth one member Stirling is the only royal burgl. The shire forms a sherifidom with the counties of Dumbarton and Clackmannan, but there is a resident sherific substitute at Stirling and another at Falkirk. The shire is under school board jurisdiction, and there are high schools at Stirling and Palkirk.

and americal are assist. The starter is tunder school other jurisuition, and there are high schools at Strings and Palkitch poet and scholar, whose original name was Goran Lulja, was born at Wike in Dalecardia on Aug. 7, 1958. He took his degree at Gersfrewid, and spent some years in travelling over every quarter of Europe. Gustavus Adolphus gave him a responsible post at Dorpat in 1630, and raised him next year to the noblity. After the kings death, Christian attached him, as a kind of poet laureste, to fee death, Christian attached him, as a kind of poet laureste, to fee

court in Stockholm His property lay in Livonia, and when the Russians plundered that Province in 1656 the poet, who was in temporary disgrace at the court, was reduced to extreme poverty for two or three years He subsequently became judge at Trondhjem, member of the council of war (1661) and president (1667) of the College of Antiquities at Stockholm He died at Stockholm on April 22, 1672 His greatest poem Hercules (pt 1653) is a didactic allegory in hexameters, written in very musical verse, and with almost Oriental splendour of phrase and imagery Brollops-Besvars Ihugkommelse, a sort of serio-comic epithalamium in the same measure, is another brilliant work masques, Then fangne Cupido (Cupid Caught) (1649), Freds-aft (The Birth of Peace) (1649), and Parnassus triumphans (1651), were written for the entertainment of Queen Christina He can scarcely be said to have been successful in his attempt, in the first two of these, to introduce unrhymed song measures

Stjernhjelm was an active philologist, and left a great number of works on language, of which only a few have been printed. He also wrote on history, mathematics, philosophy and natural science, pro-ducing original and valuable work on every subject he attempted, There is a full list of his writings in the Svenskt biographiskt Lexikon,

vol xv (Uppsala, 1848) STOA, in Greek architecture, a long open building with the roof supported by one or more rows of columns parallel to the back wall A row of rooms may open from the rear of the colonnade, a second story is often added Stoae surrounded the market places and later the sanctuaries and served for nearly all public and private business, commercial and legal, as well as for public promenade Athens, Corinth, Delos and the Asia Minor cities ofter good examples (L T SE)

STOBAEUS, JOANNES, so called from his native place Stobi in Macedonia, the compiler of a valuable series of extracts from Greek authors. Of his life nothing is known, but he probably belongs to the latter half of the 5th century AD From his silence in regard to Christian authors, it is inferred that he was

not a Christian.

The extracts were intended by Stobaeus for his son Septimius, and were preceded by a letter briefly explaining the purpose of the work and giving a summary of the contents From this summary (preserved in Photius's Bibliotheca) we learn that Stobaeus divided his work into four books and two volumes. In most of our manuscripts the work is divided into three books, of which the first and second are generally called Έκλογαι φυσικαι και ήθικαι (Physical and Moral Extracts), and the third 'Ανθολόγιον (Florilegium of Sermones)

As each of the four books is sometimes called 'Ανθολόγιον, it is probable that this name originally belonged to the entire work; the full title, as we know from Photius, was Έκλογων ἀποφθεγμάτων ὑποθηκῶν βιβλία τέτταρα (Four Books of Extracts, Sayings and Precepts). The modern arrangement is somewhat arbitrary, and there are several marked discrepancies between it and the account given by Photius

The introduction to the whole work, treating of the value of philosophy and of philosophical sects, was lost with the exception of the concluding portion; the second book is little more than a fragment, and the third and fourth have been amalgamated by altering the original sections. From these and other indications it seems probable that what survived is only an epitome of the original work, made by an anonymous Byzantine writer of much later date. The didactic aim of Stobaeus' work is apparent throughout. The first book teaches physics-in the wide sense which the Greeks assigned to this term-by means of extracts. It is often untrustworthy; Stobaeus betrays a tendency to confound the dogmas of the early Ionic philosophers, and he occasionally confused Platonism with Pythagoreanism. For part of this book and much of the second book, he depended on the works of Aetius, a peripatetic philosopher, and Didymus.

The third and fourth books, like the larger part of the second, are concerned with ethics; the third, with virtues and vices in pairs; the fourth deals with more general ethical and political subjects, frequently citing extracts to illustrate the pros and cons of a question in two successive chapters.

In all Stobaeus quotes more than 500 writers, generally begin-

ning with the poets, and then proceeding to the historians, orators, philosophers and physicians

It is to him that we owe many of our most important fragments of the dramatists, particularly of Euripides.

Editio princeps (1609), Eclogae, ed T Gaisford (1822), A Meineke (1866-64), Floridegum, ed T Gaisford (1850), A Meineke (1857-1857), C Wachsmuth and O. Hense (1884-94, and 1909)

STOBO, ROBERT (1727-c. 1772), Scottish-American soldier, born in Glasgow, Scot, emigrated to Virginia where he became a merchant and an officer in the militia. He fought in the French and Indian War Held as a prisoner by the French, he escaped in 1759 and joined the successful English assault on Ouebec. Memours of Major Robert Stobe of the Virginia Regiment was published in London in 1800 Stobo is generally considered to have been the basis for the character Lismahago in Tobias Smollett's The Expedition of Humphry Clinker (1771)

STOCK, FREDERICK AUGUST (1872-1942), U.S conductor and director of the Chicago Symphony orchestra for 37 years, was born on Nov 11, 1872, in Julich, Ger

From his father, a bandmaster, he received his early musical training, and he later studied violin and composition at the Cologne conservatory.

Theodore Thomas, founder and conductor of the Chicago Symphony orchestra, discovered Stock when he was a violinist with the Cologne orchestra and invited him to Chicago to join the new orchestra in 1805. He made his debut there as a viola player and six years later became Thomas' assistant and associate conductor

Shortly after the Chicago symphony moved into its new quarters at Orchestra hall in 1905 Thomas died and Stock became his successor He directed from the Orchestra Hall podium for the next 37 years, except for a short period during World War I when public opinion forced his resignation until he could obtain final U.S. citizenship papers

Stock was said to have introduced more scores by U S composers than any other conductor in the country He composed three overtures, two symphonies, a violin concerto, a 'cello concerto, a Festsval March and Hymn to Liberty

He died in Chicago on Oct 20, 1942.

STOCK. The modern business company producing goods or rendering services of an economic nature must initially be supplied with assets-money, property, equipment, materials, etc.which will enable it to perform its functions. The portion of the assets supplied by persons who invest their money at the risk of profit or loss is called the company's capital, and those who provide it are called members of the company. In order that many persons may have an opportunity to invest their funds in such a company, its capital, as authorized by its charter, is resolved into a stated number of shares which in the United States are called capital stock and in England are called capital shares, or, more rarely, company stock.

If the members of the company operate under a partnership agreement, any one of them may be held liable to satisfy all of the company's creditors out of his private estate and is said to have unlimited liability. The laws of the western democracies, however, permit those who desire to undertake a business as a group or company to apply to a designated official for a charter of incorporation. This, when granted, permits them to act as a single legal person or body corporate in business relations with others within such limits as are set forth in the charter and laws. liability of each member of the company to creditors is thereby limited to the sum that he agrees to contribute to the chartered company's capital.

The practice of supplying public and private bodies corporate with needed money in the form of funds subscribed by many persons can be traced back to the middle ages in western Europe. From the beginning of their use a characteristic of funds of this type has been the fact that the subscribers acquired collectively as well as severally given bundles of legal rights, powers, privileges, immunities, liabilities and duties with respect to the user of the fund, themselves, and other persons These rights are private property whose ownership is vested in the subscriber or subsequent holder.

416 STOCK

At first the subscriber to such a fund received no written instrument as evidence of his rights and had to rely entirely upon the books and records of the user of the fund to prove his ownership. But by the close of the 17th century it became customary to give him a certificate that identified the fund, the amount of his participation and the payments to which he was entitled. The transferral of his rights in the fund to another by giff, sale, etc, was then easily accomplished by executing an assignment of the instrument which, in moder times, a generally held to be necotiable.

Trading in such bundles of rights was greatly facilitated by the use of transferable certificates These came to be distinguished from one another not only by the nature of the obligation assumed by the user of the fund, but also by the nature of the payments which the holder of rights was entitled to claim Thus in England and its American Colonies in the early part of the 18th century certificates representing shares in the proprietary capital of a chartered company risked at profit and loss were already called shares of joint stock or simply stock, those that entitled the owner to claim a periodic payment of interest and repayment of a principal sum at some future date were usually called obligations or debentures, and those that entitled him to claim annually only a given sum of money either for a limited number of years, for life, or for an indeterminate period of time were called annuities The persons who acted as brokers and dealers in such bundles of rights were called stock brokers or jobbers, and the market in which they operated came to be called the stock exchange Thus at one time the word stock, when used in its broadest sense, signified all sorts of subscribed funds and rights therein However, early in the 19th century it had already become the practice not only in England but also in the United States to employ the term securities to signify all varieties of such rights and to reserve the word stock to signify only a particular kind of security Today the English concept of stock is quite different from that in use in the United States.

### UNITED STATES

In the United States the term stock is used as a term of law and finance. It signifies a chartered company's proprietary capital that is divided into shares whose owners are members of a body corporate. Collectively, therefore, they own the business carried on by the company or corporation and as owners may obtain a profit or sustain a loss. The extent to which a member of the body corporate participates in the conduct of its affairs and shares in its profits or losses is determined by the number and variety of the shares that he owns. Because it is a constituent part of a capital stock, the share is also generally called stock and the certificate reciting ownership of such shares is called a stock certificate During the last decade of the 18th century, however, shares in the funded debt of the United States and throughout the 19th century in the funded debt of New York city were called stock. But shares in a loan fund, whether for use by federal, state or municipal governments or private companies, are now almost invariably called bonds.

At common law any group of persons may contribute to a fund to be used for bissines purposes under a partnership agreement, but any one of such persons may be sued personally by creditors of the partnership for unpaid debts. However, when such a group of persons is constituted a body corporate a separate legal personality is conferred upon them collectively. It is the legal person with whom creditors have to deal and to whom primarily they must look for sustfaction of their claims. The extent to which the individual member of the body corporate is liable is determined by the laws of the state that has granted the privilege of incorporation. The procedure employed to provide such a body corporate with capital rudnes is regulated by state as well as federal law.

Capital Stock.—The laws of the several states provide invariably that the authorized capital stock of a business corporation shall be reloved into a given number of shares and that these may be further resolved into classes whose bundles of legal rights may differ from one another. Prior to 1912 an ascribed nominal or par value was given to the share. However, while some states missted upon a substantial nominal value, such as \$700, others required less and some set on ominimum limit, even authorizing shares with par value of a tenth of a cent Incorporation taxes and licence fees in other states were based on this par value. As a result, after 1912 most state laws were amended to give incorporators a choice between par value shares and shares of no-par value, but at the same time a minimum paid-in capital with which the company might begin business was prescribed

Subcerbers to capital stock must pay in full the par value of the share or the stated value that has been ascribed by directors of the company to the share of no-par value or remain liable to creditors of the company for the unpaid balance. For this reason, it is the practice to issue definitive share certificates only after such payments have been made and to note thereon that the shares are "full pad and nonassessable." When more than the par value is paid the excess is called a paid-in capital surplus. In the case of no-par value shares any sum in excess of the minimum capital prescribed by the charter may be designated as paid-in capital surplus.

Only enough stock need be subscribed and paid in to meet the minimum capital requirement set by the charter. In consequence, therefore, the corporation may have a paid-in capital stock that is less than its authorized capital stock. When it acquires as assests shares it once had susued, these are called treasury stock and the

issued remainder is outstanding stock.

Powers and Rights of Stockholders.—Collectively the stockholders of record accept the charter, adopt a seal, adopt by-laws, petition the state to amend the charter or dissolve the body corporate, and dispose of corporate assets, but they must place the management of their business affairs in the hands of a board of directors whose membership they elect and may remove. This board appoints a president, one or more voce-presidents, a secretary, a treasurer and a legal representative as officers of the company to administer its affairs. The directors also determine within appart to administer its affairs. The directors also determine within disposition is to be made of the surphis and earnings, and declare dividends.

When there is only one class of stock authorized and outstanding, the bundle of legal rights middent to ownership of one share may be summarized as follows: to receive notice of meetings of the body corporate; to attend these meetings in person or by proxy; to vote in person or by proxy on any resolution that is prosed, especially for election of directors, to share in distributed earnings when and as declared by the board of directors (dividends); to share in capital on liquidation, to receive financial reports and an accounting from directors; to petition a court for an order to inspect the company's books or to protect the company or a group of participants against inequities or acts ultra vises (exceeding their legal powers); to have an opportunity to subscribe to additional shares pror to their offer to the public; and to dispose of shares by girt, sale, hypothecation or otherwise

Classes of Stock—To resolve the capital stock of a company into classes of sherse whose rights, powers and privileges differ from one another has long been a U S as well as an European custom. The rights that usually are modified in one way or another to accomplish this purpose are these. (1) to vote in the election of directors, (3) to share in the earnings, and (3) to share in the assets on dissolution. Although modification usually results in placing one class of stock in a favoured position relative to basic stock with respect to one or more of these three rights, this is not necessarily the result.

Common Stock.—When the authorized capital stock of a corporation consists of only one class of shares, these usually are acid common stock. A favoured class may be distinguished from it solely by the voting power conferred upon it. Thus when power to elect the board of directors is vested in one class of common stock and is denied another, these classes usually are called voting and nonvoting common stock, and may be differentiated by means of prefixing such letters as A or B

Preferred Slock—When a stock is placed in a favoured position with respect to right to earnings it is usually called preferred stock. This is so even though a favoured position is ascribed to it also with respect to a share in assets on dissolution and in voting for directors, Suth stocks have been devised to provide a security

STOCK 417

that has some of the features of a bond without giving the holder thereof power to obtain a judgment against the company for failure to fulfil its promises. This end is effectively attained when the security is part of the capital stock of the issuing company

While a bond is a promise to pay a sum on a given day and if not paid permits the holder to obtain a judgment satisfiable out of the capital of the issuing company, such a promise can be made to the holder of stock subject only to important conditions. In the first place he cannot receive repayment until all creditors have been paid, not can he be paid out of capital stock except by liquidation. For this reason a preference to share in assets before any distribution is made to holders of less favoured stock usually becomes effective only upon dissolution. However, it is of course scrings which could be used for tredemption of a preferred stock. A preferred stock of the latter type is called a redeemable preferred stock of the latter type is called a redeemable preferred stock.

Similarly the promise to pay interest on a debt on a due date permats the cliamant to obtain a pudgment ordering its payment out of capital if necessary and usually also makes the principal due and payable at once on failure to keep the promise On the other hand, the holder of a stock that is preferred as to dividends has no such power to enforce payment. Dividends are payable only when and as they are declared by the board of directors out of "carnings" or surplises net earnings" as the phrases run. When there are no earnings they may not be paid. But even when earnings are available payments may be withheld provided the promise of sundry claimants as observed. When dividends are declared not not provided the promise of such payments and the provided the promise of such payments and payments are available sayments and such payments are available sayments and such payments are available sayments. The control of the provided has provided the promise of the payments are available to the payments and the provided the promise of the payments are available to the payment and the payments are available to the payment are available to the payment are available to the payment and the payment are available to the payment are available to the payment and the payment are available to the payme

On the whole, it is clear that common stockholders, who are in the least favoured position, run the greatest risk of loss and cannot share in profits until holders of stock in more favoured positions have been satisfied. The theory therefore has been advanced that common stockholders should have power to elect a board of directors who while managing the busness for them must satisfy others before satisfying their electors. However, such an arrangement would give no protection to holders of noncumulative preferred stocks (see below). Some, therefore, have conditional or unconditional power to elect the board of directors, others have votting rights per share such as are enjoyed by common stock and still others have no votting rights at all.

Where there are several classes of preferred stock whose order of preference is established they are usually identified as first, second, thurd, etc., preferred stock, or as A, B or C preferred stock. Even within the limits set forth above many variations in the legal rights that constitute preferred stock are possible, and additional rights and protections may be introduced. For this reason it is well to describe some of the types that have such spocial features.

Noncessulative and Cunstilative Cilims: to Dividents.—It is common practice to ascribe a dividend presumed to be paid annually to a preferred stock as a given per cent of par value, or as a given sum when the share has no par value, before any dividend may be paid to common stock. When a dividend is not declared in any given year on such a preferred stock, even though there are earnings, it is lost to the stockholder, and the stock is cailed non-cumulative preferred. At time it is therefore protected by giving the holders the right to elect a board of directors to serve until a dividend has been paid. However, a better means of preventing remaining unpud shall have prior claim upon future earnings and must be paid in full before a dividend may be paid to common stock. A stock with this type of claim to dividends is called a cumulative preferred stock.

Additional Participation in Dividends—Unless it is otherwise specified, a preferred stock does not share in any earnings that remain for distribution after its ascribed dividend has been paid, but specific provisions may be inserted that give it some surfights. For this reason a distinction is made between participations of the provision of the preference of the provision of th

ing and nonparticipating preferred stocks.

The terms on which a preferred stock is to participate in any distribution of earnings that normally would go to common stock must be clearly set forth in the charter or in the resolutions that create the preferred stock Its participation is said to be "simple" when both common and preferred stock share equally per share in dividends out of earnings that remain after the preferred stock has received its regular ascribed dividend and a like payment per share has been made to common stock Usually a preferred stock with such rights is called participating preferred stock. When preferred stock participates before common has received payments equal to the regular dividend of the preferred stock it is said to participate "immediately" Participation may also be limited to given percentages or sums, according to priorities that are allocated to several classes of preferred and common stocks, which are then said to participate "specially" Such participating features, however, are much more common in England than in the United States

Redeemable Stock.—Only when the charter of the company so provides may it redem a class of stock and remain in operation Under no circumstances is redemption at the option of the holder, for such a right would put him in the position of a creditor. Redemption must remain optional with the company. The provision creating the stock may provide that it may be redeemed in part by call on and after a given date, or that it must be redeemed, if at all, in whole. The price at which it may be redeemed must also be stated. While the privilege of redemption at par value is more common than redemption at a premium, the latter arrangement does not have such a depressing effect on the market value of the shares.

Consentible Stock.—Holders of stock are sometimes given the privilege of converting it into another form of security at their option. As a rule conversion results in the surrender of some priority rights. Thus preferred stock is usually convertible only into common. The charter of the company may set forth the conditions and terms under which a given stock is convertible into another, but if enough unissued common stock is available an offer to convert preferred stock into common may originate with the directors. When a preferred stock is nonparticipating the conversion privilege is often of value because when dividends paid titled its holders can obtain the higher dividend rate by converting their shares into common.

Conversion of nonvoting preferred into voting common and redemption of voting preferred has often played a role in struggles to elect boards of directors because the number of voting shares could be increased by conversion and decreased by redemption.

Protected Preferred Stock—When the company has a preferred stock outstanding, the directors may, at their option, set up a reserve out of earnings that can be drawn upon to pay dividends to the preferred stock in years when earnings may be insufficient for that purpose. Such a requirement may also be set forth in the charter provision that creates the preferred stock. Under these conditions a preferred stock is said to be protected.

Guaranteed Stocks.—When one company for a valid consideration agrees to be responsible for the payment of dividends on stock issued by another company, such stock is said to be guaranteed, Guaranteed stocks originate almost entirely among railway companies. The consideration received by the guarantor usually a long-term lense of the issuer's entire property, subject to a rental payment that is sufficient to pay interest and amortization on the lessor's outstanding bonds and a given dividend per share its outstanding stock. Usually the guaranteed stock has been subsequently purchased in the market by the guarantor.

Stocks with Rights.—The holders of common stock have a premptive right to an opportunity to subscribe to new issues of the common and also often of preferred stock before these are offered to others or the public. When such an offer is made to them it is usually at a price that is below the market price of like shares and they are said to have rights to a privileged subscription. While the right to this privileged subscription is open the outstanding stock that possesses it is quoted in the market with "rights-on." holders entitled to them the shares are quoted "ex-rights" Finally when the privilege for making use of the warrants has expired, the stock is again quoted without any additional notation Canada generally follows US practice because the bulk of its company capital comes from its southern meighbour.

#### GREAT BRITAIN

In England since 1862, the term stock has signified a subscribed fund, resolvable into parts as small as pounds, shillings and pence, for use as corporate capital or a loan. The opportunity to subscribe acts small sums was devested morder that persons of modest means might invest as much or as little in money as they deem desirable, for otherwise they would have to commit themselves to subscribe to indivisible units which in the case of loan funds are boads, usually of an ascribed value of foco, or in the case of proprietary capital shares of a par value of not less than \$I\_{TO}\$, but usually also of fico. The subscriber to, or subsequent purchaser of, participation in such a fund receives a certificate that usually sets forth briefly the purpose for which the fund has been subscribed, the rights of the holder and the number of pounds, shillings and pence in the fund that it represents

The pnec that £100 of stock will bring in the market naturally depends upon the net return per annum to the holder and the pnec that other investors are willing at the time to pay for it. Its price is therefore usually quoted at £100 as par or a penetralge over or under that figure. While the price of bonds is quoted in the same way, the price of shartes in the capital of a company is quoted in pounds, shillings and pence per share because these may be issued and traded when only part paid.

The bodies corporate that make use of funds of stock can be either public or private. In the fanacial markets public funds are classified as either "government" or "municipal" and each of these categories is resolved into British, colonial and foreign subclasses. When they are used by chartered private companies these funds are either loans called debenture stock or constitute a part of the capital of the company. When they are of the latter type they are called company stock. Company stock is convettible into full pand shares and vice verse and may even have voting rights.

BIBLIOGRAPHY —Guthmann and Dougall, Corporate Financial Policy, 2nd ed. (New York, 1948), Albert Crew, English Companies Under the Companies Act of 1929, 3rd ed. (London, 1930). (A. H. Sr.)

STOCKARD, CHARLES RUPERT (1879—1939), U.S. biologist and anatomut, was born in Washington country, Miss. on Fb. 27, 1797. He was educated at the Massistipp Agricultural and Mechanical college and at Columbia university, where he received his doctorate in 1906. He was granted his medical degree by the University of Wurzburg in 1922. After completing his studies at Columbia, he joined the faculty of the medical college of Cornell university and was professor of nantomy there from 1911 until his death. Stockard attracted international attention by his morphological investigations and by his experimental production of monstrotities. He died in New York city on April 7, 1939.

STOCKBRIDGE, a town of Berkshire county, Massachusetts, U.S.A., on the Housatonic river, served by the New York, New Haven and Hartford railroad. Pop. (1950) 2,311; (1940) 1.815. It is a summer and autumn resort and a region of historic interest. Within its area of 24 sq mi. are Lake Mahkeenac or Stockbridge Bowl, Ice Glen (where caverns are lined with ice even in midsummer) and Monument mountain (1,710 ft.). Most of 'Tanglewood," home of the Berkshire Symphonic festival and the Boston Symphony orchestra's Berkshire music centre, is in Stockbridge, overlooking "the Bowl." In 1736 a plantation 6 mi, square (including the present town of Stockbridge) was laid out for the Mohican Indians who had come to the Housatonic valley from the west bank of the Hudson when white settlements began to encroach on their territory, and among whom John Sergeant had established a mission in 1734. In 1739 this "Indian town" was incorporated as the town of Stockbridge. The Indians had a school and a church with Jonathan Edwards in charge from 1750 to 1758. Many of them fought on the American side during the Revolution. In 1783-88 nearly all of them moved to New York, and by 1829 most of them had gone to Wisconsin.

STOCKBROKER, an agent who deals in stocks and shales He need not be a member of any recognized stock exchange, nor of an association of stock exchanges. He need not confine his energies to dealing in only such securities as those which are quoted in a stock exchange. The broken member of the London stock exchange is an agent for the buying and the selling of stocks and shares of any description, and his status is kept stript clear from that of a stock)obber, so far as the London stock exchange rules are concerned

The broker, if a stock exchange member, acts as an agent, seldom as a principal. He does not as a rule buy from a client nor sell to a client. He buys or sells on behalf of the client, and takes a certain amount of commission, the extent of which is laid down in stock exchange rules for members of the stock exchange as his remuneration for doing the business. He is not allowed, in the London stock exchange, to buy roo shares from a client say at  $L_5$  and sell them simultaneously to another client at  $L_5$  5°. To do this would be acting as a principal, the part assigned to a stockpobber

The young man who would become a broker in a London stock exchange usually finds that a good way of achieving his end is to obtain a seat in the office of a stock exchange firm, entering either as a junior or a clerk, and gradually working his way through the various stages which stand between the outsider and the fullblown member of the stock exchange He can become a member without delay, provided he is not less than 21 years of age and is able to obtain three sureties who will guarantee, in the sum of £500 each, the fulfilment of his obligations for four years from the date of his admission. If the candidate has served as a clerk in the stock exchange for four years previous to the lodging of his application form, two sureties, or recommenders, only are required, who must each enter into an obligation as above mentioned. but for £300 apiece The scale of the London stock exchange charges, both for admission fee and annual subscription, is substantially less in the case of the experienced man. The candidate for membership must obtain with a very small proportion of exceptions a nomination, the price of which varies considerably, When first created several years before World War I, a nomination reached the value of £700 After that war, nominations became at one time practically valueless. Several are known to have changed hands at £5 apiece After that an improvement set in, and the price rose to about £2,000, but it fell heavily during World

Strict rules govern the stockbroker in the London stock exchange, and some of the provincial stock exchanges have modelled their rules upon them. He must be a Brutish subject; he has to apply for re-election every year, he must state whether he intends to act as broker or jobber, he must not be a principal in any business other than that of stock exchange, nor must he be member of, or subscribet to, any other institution where dealings in stocks and shares are carried on. His wife, also, must not be engaged in business.

His duties bring him into contact with his clients, and with brokers and jobbers alike, and he acts as agent between the public on one side and members of the stock exchange on the other He is required to have a general knowledge of all the markets in which he is called upon to deal, and he must be prepared to give reasonable answers to the hundreds of questions with which he is plied on all sorts of subjects.

The broker's life is more arduous than that of a jobber, mvolying longer hours and the exerces of unlimited patience, for he has to make allowance for the fact that the majority of his clients do not grasp the intimate details of what is after all a very technical business. His first daily duty, after having digested the financial business. His first daily duty, after having digested the financial business. His first daily duty, after having digested the financial business. His first daily duty, after having digested the financial business. His first daily duty, after having digested the financial business. His first daily didentify a first state and the stock exchange for execution when the markets open. He, the broker, buys or sells War loam in one market, Kaffirs in another, artificial silks in another, going through various parts of the house that have no strict delimitations, one market impraging on the next. The men round the markets who deal in specialized stocks and shares are the jobbers, and to them the broker proceeds, expecting that he will be able to get a double price made to hum, at the

higher of which he can buy and at the lower of which he can sell without the jobber knowing in advance which of the two courses the broker will take in executing his client's order

In the spring of 1939, as a result of the losses sustained for many previous years by members of the public through the malpractice of what are called bucket shops, parliament passed an act to provide for regulating the business of dealing in securities. It is called the Prevention of Fraud (Investments) act, 1939 Section I lays down that no person shall, on or after the appointed day. carry on or purport to carry on the business of dealing in securities except under the authority of a principal's heence, that is to say, a licence under this act authorizing him to carry on the business of dealing in securities. The servant or agent of any such person is required to hold a representative's licence authorizing him to deal in securities as a servant or agent of the holder of a principal's licence These restrictions do not apply, the act lays down, to a member of any recognized stock exchange or recognized association of dealers in securities The Bank of England and ceitain other bodies and persons are exempted from the restrictions imposed by this act Contravention of its provisions involves liability for heavy penalties Issue of the licences, the act provides, is in the hands of the board of trade and a prescribed fee, together with a deposit of £500, is required for a principal's licence which will be valid for one year Fraudulently inducing persons to invest money is an offense that carries liability to penal servitude for a term not exceeding seven years, and restrictions are placed upon the distribution of circulars relating to investments, The restrictions do not apply to prospectuses and other documents permitted by the board of trade. The act was partly suspended after the outbreak of World War II

United States—A stockbroker is an agent who deals in stocks, bonds and other securities either on or off an organized exchange. Legally, the relationship between the broker and customer is not only that of agent and principal but becomes that of creditor and debtor and that of pielage and piedgor when the customer purchases on margin and the broker furnishes the required additional funds secured by collateral. The relationships between brokers and their customers are governed by the various and differing state statutes, customs, business policy and the constitutions and rules of the organized exchanges. The New York stock exchange does not permit a corporation to become a member, consequently brokerage houses with memberships on the exchange are partnerships.

The distinction between brokers and jobbers, which obtains in London, does not exist in the United States On the New York stock exchange all brokers are free to trade with one another and with the public as they choose provided they conform with the constitution and rules of the exchange. Brokers on the New York stock exchange may be divided, according to the special nature of their business, into five groups (1) commission brokers, those who act for the public at a commission fixed by the exchange; (2) "two-dollar" brokers, who act as agents for other member brokers on the exchange at a rate of \$2 50 per 100 shares (the old name still prevailing although the \$2 rate has been superseded); (3) floor or room traders, those who buy and sell for themselves and for their own profit; (4) specialists, who specialize in certain securities and may act as commission brokers or floor traders but who ordinarily do not come into contact with the public, and (5) the odd-lot dealers, who supply or buy from commission brokers a sufficient number of odd lots to equal the full 100 shares, which is the minimum amount that may be purchased or sold on the exchange. While very few houses deal in odd lots. they usually have several representatives on the exchange and probably one-fourth of all the business done on the exchange originates in odd lots. The odd-lot dealer enables the small investor to trade in a few stocks or shares within a small fraction above the price at which large lots are bought and sold.

to price at which large iots are brough, and solu.

Brokers who are members of the New York stock exchange are controlled rigidly by the constitution, rules and customs of the exchange in an effort to secure fair competition and the proper relationship between the broker and his customer. For example, a broker may not take the side of the market opposite his customer, his charges are regulated, he must report accurately the

status of his business to the exchange, he may not advertise securities fabely and the advertising by the firm of itself is regulated explicitly by the schange. American stock exchanges are modelled after the New York exchange. Brokets are also regulated by the laws of their respective states and by the Securities and Exchange Commission created by federal law.

STOCKER, HELENE (1869-1943), German writer, editor, educator and organizer in the pacifist movement, was born at Elberfeld in 1869 Of a strict Calvinistic family opposed to higher education for women, she eventually went to Berlin in 1892, and was one of the first women to study philosophy, economics, art and literature at the universities of Berlin, Glasgow and Berne. She received a Ph D degree from the last named institution in 1901, subsequently settling in Beilin as an adult educator 1905 she founded the League for the Protection of Motherhood and Sexual Reform, and edited its publication, New Generation To her intransigence respecting more wholesome sex relations was added her firm pacifism, induced by Bertha von Suttner's story, "Die Waffen nieder" For cuticizing the treaty of Brest-Litovsk she was forbidden by the military authorities, for the remainder of World War I, to make further public pronouncements After the war she continued her work for peace as a member of the board of the Deutsche Friedensgesellschaft and in 1921 as a member of the International Peace bureau of Geneva Some of her proposals, notably one concerning a legal status for the children of unmar-11ed mothers, were incorporated in the constitution of the Weimar republic.

In 1922 she expressed her views on love in a novel entitled Labbe, and several collections of her essays appeared in the following years. With Hitlet's rise to power she was obliged to fee Germany, going first to Caechoslovakia, then to Switzerland, England, Sweden and eventually to the United States. She was deprived of her citizenship and her property by the nazi government. She dided in New York city, Feb 24, 1943

STOCK EXCHANGE or Bourse, a market for the purchase and sale of securities, such as shares, stocks and bonds Markets for dealing in securities have existed for centuries. They had their beignings usually in the regular meetings, in a certain place, a coffeebouse or restairant, of a few men who for a commission were prepared to act as intermediaries between buyers and sellers. As their business grew, these men formed themselves into a sort of a sociation, and rules were framed to regulate the conduct of their business. With the growth and wider distribution of wealth the volume of stock exchange business has steadily expanded, and during the ooth century the growth has been more rapid than in any similar period.

The development of joint-stock enterprise could never have reached its present stage but for the facilities which the stock exchanges provide for dealing in securities. Their primary function is to liquely capital by enabling a person who has invested money in, say, a factory or a railway, to convert it into cash by disposing of his share in the enterprise to someone else. Without the stock exchange, capital would become immobilised, for once invested there would be no means of liquelymp it.

London.-London was once the greatest of the world's stock exchanges in the range and volume of its transactions; and even after New York's rise to rival importance in the 20th century the range of London's business covered every corner of the earth and every class and type of security. It was not until the latter part of the 18th century that the London stockbrokers definitely formed themselves into a stock exchange with premises of their own, They had been in the habit of meeting and doing business in the Royal exchange and neighbouring places, but in 1773 those who had hitherto met at Jonathan's (coffeehouse), in Change alley, moved to a room in Sweeting's alley to which the name of the stock exchange was formally given, the building becoming known as the Stock Exchange Coffee house or tavern. Business grew anace, and in 1801 a group of members raised \$20,000 of capital in 400 shares of £50 each for the purpose of providing an adequate building and acquired a site in Capel court, Bartholomew lane, which today is one of the entrances to the "house."

The new building of the members was opened in 1802. At that

time the members of the stock exchange numbered about 500 Rules were drawn up for the conduct of business and for regulating membership of the house It was provided that all future members should be admitted by ballot, and members were required to pay a subscription of ten guineas each for themselves and five guineas for their clerks. It was the general intention that the shares should be held by members, but there were always a large number of members who did not hold shares The first extension was made in 1823 when the floor space was nearly doubled by the addition of a second room for dealings in foreign stock. In 1854. the two rooms with some small additions were rebuilt as one in the form of a dome with two transepts Several subsequent extensions of this building were made, the principal one being in 1885 when another dome was added Then in 1953 a public gallery was constructed to help dispel some of the ignorance about the true functions of the house The stock exchange building occupies the greater portion of the triangular area formed by Throgmorton street. Bartholomew lane and Old Broad street

Organization .-- Until the end of World War II the property of the stock exchange was under the control and administration of nine trustees and managers, who were appointed by the shareholders Business transactions on the stock exchange, however, were regulated not by these trustees and managers but by the committee for general purposes, numbering 30 members elected annually by their fellow members, which was charged with the admission of members and their clerks and was generally responsible for their good order and government but had no funds of its own and could not initiate or control the expenditure of the money subscribed by the members Though this system, known as dual control, worked remarkably smoothly, it was anomalous, and various efforts were made from time to time to terminate it. But none of these efforts succeeded until World War II when a complete change took place in the management of the stock exchange. In June 1945 the two controlling bodies were amalgamated into one entity known as the council of the stock exchange. The necessary revision to the rules and regulations of the stock exchange authorizing this change laid down that the council should at first consist of: (1) foundation members, who were to be the persons acting as trustees and managers at the time of the amalgamation; and (2) ordinary members, who were to be members appointed by ballot of the members of the stock exchange generally. It was, however, provided that after June 24, 1954, there would no longer be any foundation members, all such members being compelled to retire by that date, so that after 1954 all members of the council (from 30 to 36 in number) were to be elected by stock exchange members generally.

With the adoption of a revised constitution and the abolition of dual control, the stock exchange stopped distributing profits to the proprietors. But in order that members might retain their stakes 'n the equity of the stock exchange the 20,000 shares in issue were written down from £5 to 1x. shares. The council on March 1, 1948, issued 4,0000 64 redeemable annuities as compensation for the reduction of capital and for the surrender of rights to dividends. These annuities are redeemable by purchase at any time and any price, or by drawings after March 1, 1958, at 2500 for each annuity; and they may be reissued at any of a share qualification for membership was abolished. It was, of a share qualification for membership was abolished. It was hovever, provided that each member should hold at least one share for voting purposes, which could be obtained on application to the council.

The discipline of the stock exchange is very strict, and the council deals severely with members guilty of improper conduct. It has power to suspend or expel a member. The council also settles disputes between members and between members and their clients.

Securities cannot be dealt in on the stock exchange except by permission of the council, and conditions have to be fulfilled before that permission is granted. Before World War I any security could be dealt in without the permission of the committee, and all that the latter was called upon to do was to fix a special settlement for the completion of the first transactions. Sometimes

weeks would elapse before a special settlement was applied for and granted, sometimes none was applied for or granted Grave abuses occasionally arose in connection with the marketing of new shares in this way. The abolition of this licence to deal gave the interests of the public much better protection than they had previously enjoined.

Membership.—The income of the stock exchange (for the year to March 4a, 1953, it amounted to £506,63) is derived from the annual subscriptions of members and their clerks and from entrance fees paid by new members and from rents and investments. The fees have been raised from time to time. Members admitted with three surreties after March 24, 1876, but before March 25, 1879, paid an annual subscription of only 30 guiness. In the 1950s the annual subscription was 100 guiness for a new member with three surreties, 50 guiness for a new member with three surreties, 50 guiness for a member with three surreties, 50 guiness for undustricted clerks. By this time, too, the entrance fees were: 1,000 guiness for a member with three sureties, 500 guiness for a member with two sureties, 500 guiness for member with two sureties, 500 guiness for member with two

Before 1904 it was possible to become a member of the stock exchange without the nomination of a retiring member, consequently, membership increased rapidly in periods of activity, so that in periods of mactivity competition for business became extremely keen In 1904, however, it was decided to restrict the membership. Since then, in the ordinary way the only method by which a person may become a member is to obtain a nomination (by purchase) from an existing member who must retire in his favour. Nominations may be obtained from a former member, or, if he has not disposed of his nomination, from the legal personal representative of a deceased member Nominations, which are personal and nontransferable, are usually purchased, and the cost may range between £40 and £2,000. A candidate for membership must be recommended by three members, who become sureties for him during the first four years in £500 each, or £1,500 altogether. A certain number of clerks who have completed four years' service are admitted each year without nomination; for these, only two sureties of £300 each are needed, their liability extending for four years. Membership is for 12 months only, so that everyone who wishes to remain a member must apply to the committee for re-election.

In 1953 there were 3,577 members of the stock exchange, employing 1,445 clerks (of whom 847 had the right of entry to the floor of the house).

Business -By custom, each market has a special place allotted to it; for instance, the space immediately in front of the World War memorial is the market for British government securities and other gilt-edged stocks Dealers or jobbers in these securities take up their posts in this space every day, and dealers in other classes of securities similarly occupy the floor space allotted to their particular markets In this way the locality of a market can be readily and easily found by the brokers who go to the house to buy or sell securities for their clients. There is an important distinction between brokers and dealers. Brokers are not allowed to deal on their own account, nor can dealers act as brokers-this is the vital difference (see also Stockbroker). The dealer or jobber occupies a position similar to that of the wholesale dealer in commodities. He keeps a stock of particular securities, say oil shares, and his function is to buy oil shares when they are offered to him and to sell them if they are wanted. He quotes two prices for a share, his buying price, which is the lower, and his selling price, which is the higher, and the difference represents his profit. A broker acts for the public which desires to buy or sell securities. Ordinarily, both for buying and selling securities, though under certain circumstances only for buying, a commission is charged by the broker (the minimum for such commissions was fixed first before World War I but raised in 1952) On receiving an order to deal in a certain security, a broker goes to a jobber in that market and asks for a price, mentioning the amount of stock which he desires to deal in, but he does not disclose whether he is a buyer or a seller. The jobber "makes a price": i.e., gives two prices. At one he is

prepared to buy and at the other to sell. If the broker is satisfied with the price, or if it conforms with the price lumif fixed by he client, he will tell the jobber that he sells or buys, as the case may be, at the price quoted. On the other hand, if he is disastisfied, the broker will ask for a closer price, and if the jobber is anxious to do busness he will make a closer price and the bargain is then made. A jobber's busness tequires special qualifications. If has been said that a jobber is born, not made. There is much truth been said that a jobber is born, not made. There is much truth closer in the price of the price is the price of the price of the price is the price is the price of the price of the price is the price of the price of the price of the price is the price of the pr

When a broker has bought or sold shares he enters on a printed sing the name of the shares and the price at which the business was fone, he then agas the slip and drops it into one of the boxes provided for the purpose made the house. These slips are all collected, and the prices are printed that evening in the official list. This is what is known as the marking of bargains. A broker is not now compelled by the rules to mark each bragam, although he will usually do so in order that his client may read the price at which he defall in the official list or in the financial prices.

Except in the gilt-edged market, every bargain that a broker executes for his client is "for the account," unless otherwise speci-This means that the bargain will be completed (i e, the stock led over and paid for) on the next settling day. The usual handed over and paid for) on the next settling day, period of the account is a fortnight, but there are four 21-day accounts in the course of a year Settling days are usually fixed for a Tuesday, the passing of tickets-ticket day-takes place on a Thursday, and making-up day is Wednesday, prices for the settlement of current securities being fixed in the morning. Brokers on executing an order for a client send to him a contract note which sets forth the details of the transaction, the price obtained or to be paid, the amount of brokers' commission, of stamp and transfer fee and the amount of the contract stamp. Later, as settlement day approaches, a further note is sent to a client who has bought stock, requesting him to forward the purchase money. In the case of a speculative transaction the same procedure is adopted, except that the client, if he has bought stock, is required not to pay the total purchase money but merely the difference between the price which he gave and the price fixed on making-up day if the latter is lower than the former. If, however, the security has risen in price, the client receives a cheque for the difference between the price at which he bought and the making-up price

A rate of interest, or contango (q v), as charged for the facilities of buying and holding stock without paying for it. Contangose vary in accordance with the current rate of interest. Usually they are higher on the more speculative securities than on the investment type. The rate of a contango is also affected by the state of the "open" account, as it is called, in a particular share. If there is a large bull account, t, a, b, a large number of speculative purchases for a rise (see Butt.), and dealers are annous to discourage further buying, the contango may rise to 10% or more. Rates are generally lower on the more active shares and higher on the less active, which means that there are fewer people ready to carry the latter type of share.

Shares in which the market is narrow and difficult cannot be contanged. Some speculators self for a fall (see Bear) as well as but for a rise. Facilities for technically lending shares to speculators who have sold them are also provided, and the rate of interest charged for lending stock is called backwardation ( $\sigma$ 0.). This varies with the size of the hear account. If the buil account open in a stock is larger than the bear, there will be a contango rate and no backwardation rate, and twice versa.

Since World War I the facilities for carrying over bargains from account to account have been greatly reduced, but speculation has not disappeared. The speculators have merely changed their methods. The banks, instead of lending money to members of the stock exchange as largely as formetry for releanding to their clients, now lend freely to their own customers on stock exchange collateral, provided however that they believe the loan to be for a boan fide business transaction and not for purposes of secularity.

tion This is a safer method, for a bank rarely allows its client to borrow more than he can repsy Another popular device of speculators is to gamble during one account only If mailets are rising, a speculation will buy at the beginning of an account and self toward the end and vice versus Speculation is cheaper in this form, for by completing his operation in one account, the operator pays only one commission

The hours of business on the stock exchange are nominally from 9,30 AM to 3:30 PM, after which time the streets around the house are crowded with brokers and jobbers returning to their offices. Since World War I no sessions have been held on Satur-

days

New York.—The New York Stock exchange is the principal organized securities market of the United States It came into existence in 1792 and closely parallels, in its history, almost the source course of the life of the country.

entire course of the life of that country
It was in the third year of George Washington's first administration that a few businessmen who traded in the securities of
the day decided to appoint a place and a regular time for their
meetings New York city was then a small city by later standards It had 4,0000 people and occupied 5,000.

Congress, which first met in 1789, had authorized an issue of \$80,000,000 in bonds to refund the Revolutionary War debt. Banks and insurance companies were springing up in a number of places and public improvements were being started.

To pay for the cost of the Revolutionary War and to finance these other activities, stocks and bonds had to be sold to the public But the people, then as now, were unwilling to invest in securities unless they could be easily resold. The need for a market place for securities was clearly apparent

When these pioneer brokers decided to meet every day under the wide branches of an old buttonwood tree—it was located only a few blocks away, on Wall street, from the site of the present New York Stock exchange—they fullilled one of the most vital financial needs of a young republic. These men were the 24 original members of the New York Stock exchange. They dealt only ingovernment stock and a few issues of bank, insurance and canal company shares, and for their trading floor they had a small plot of ground protected by the branches of a tree.

The New York Stock exchange is a greatly broadened, highly mechanized and efficiently organized unit, world-wide in the scope of its services. But, in essentials, the market place experienced no fundamental change by going under a roof. It is an auction market where the securities of the largest and best-known business enterprises, representing the savings of the people, are continually appraised by a world consensus and where these securities may be readily converted into cash and cash exchanged for securities.

Many millions of people—possibly half the population of the United States—have a personal interest in securities markets, either directly as part owners of the companies and as holders of government and other listed securities, or indirectly, as the holders of insurance policies and savings banks accounts. Every bank and insurance company of consequence has a substantial proportion of its assets invested in listed securities.

As a market place, the trading floor of the New York Stock exchange affords exactly the same fundamental facilities that a public market does for the housewife or the auction room for the tobacco dealer. It is solely a convenience for the conduct of trade.

The exchange does not, as is supposed by some, buy or sell securities, not does it in any manner fix the prices of them. No part of the proceeds of a transaction goes to the exchange. Commissions, however, are charged by the brokers who act as agents for the public. The New York Stock exchange is an association of brokers. As members of the exchange, their principal function is to serve as a sents for people desiring to buy or sell securities.

When the exchange lists a security it requires that the issuing company be a substantial going concern; that it be legally organized and the securities validly authorized and issued; that there be sufficient distribution of the securities to assure a national market; and that the company comply with the exchange's requirements respecting adequate periodic reports of earnings, financial position and operations for the information of security holders and the public

Fundamentally, the rules of trading are those of auction markets. The highest hid has the floor, as has the lowest offer first bid or the first offer at a price has priority at that price. Each sale ends the auction and a new market is then started. All bids and offers are made orally, in an audible voice. Secret transactions are not pennitted, and the prompit publicity given to price by means of the stock and bond ticket tapes makes deception in respect to prices of bisted securities impossible the only function the exchange has with respect to prices is to publish them on the ticket tapes.

Legally, the exchange is a voluntary association, it has never obtained a charter or assumed the form of an incorporated body. Its membership is limited to 1,375, and anyone desting to become a member must purchase a membership for seat) from a returning member or from the estate of a deceased member. A candidate for membership must also be formally elected by the board of governors after a thorough investigation of his business career, his qualifications and general fitness to be a member. The candidate must agree, without qualification, as must general partners of members, to abide by the constitution and rules of the exchange, carrying as they do powers of sweeping character over all phases of his business.

The board of governors of the exchange consists of 25 persons, including a chairman of the board, a paid president, two representatives of the public and 2r others who are chosen from among the members of the exchange and from allied members (partners in member firms).

It is required that ten of the governors shall be members of the exchange, residing and having their principal places of business within the metropolitan area of the city of New York, four shall be alled members, residing and having their principal places of business within the metropolitan area of the city of New York, who shall be general or limited partners in member firms engaged in a business involving direct contact with the public; seven shall be members or albed members of the exchange, residing and having their principal places of business outside of New York, and not less than two of these seven out-of-town governors shall be members of the exchange. The chairman of the board is elected annually from among the members of the exchange.

The board of governors of the exchange is vested with all the powers necessary for the government of the exchange, the regulation of business conduct of members and allied members and the promotion of the welfare, objects and purposes of the exchange and, in the exercise of such powers, may adopt such rules, sues such orders and directions and make such decisions as it may deem appropriate (E Low).

American, Stock Exchange.—Known until Jan 5, 1953, as the New York, Curb exchange, the American Stock exchange as a voluntary unincorporated association of regular member stock brokers. As the second largest stock exchange in the United States, it provides a free and open auction market for securities of companies engaged in every phase of industrial, commercial, utility and rafficod endeavour. (For its earlier history, see Curp Mar-EST.)

Paris.—The origin of the Paris Bourse (bourse des volence), has been traced back to the money-changers' market of the year 1138. The perpetual rente (a bond usued by the state or by a least governmental body) was first introduced in France early in the 16th century. Transactions in securities were first conducted on the Bourse at the beginning of the 18th century. There were about 1s (mainly governmental) transferable securities listed on the Bourse in 1756; the 1866 the list comprised about 36 issues.

The Bourse is open from 12.30 to 2 30 P m., except on Sundays, Saturdays and legal holidays. There are three types of market, the official market or parquet, the curb market or marché des courtiers; and the free market or marché hors-cote.

The Parquet.—The rules governing the conduct of business on the official market were firmly established by the early part of the 19th century. According to these, the official stockbroker or agent de change has a transferable monopoly (now subject to governmental sanction), must act only as an agent and must not recommend the purchase or sale of securities to his clients Members of the stockbrokers' association or Compagnie des Agents de Change (whose number was limited to 70 in 1890) enjoy great social prestige. Their appointment, or charge d'agent de change, for which they post a bond or cautionnement, is granted by the president of the republic and can be passed from father to son or, under certain regulations, sold They are sworn government officials, subject to close governmental supervision (the government, for example, reserves the right to determine the rate of commission charged by them to their clients), and, under the system of solidarité (legally instituted in 1890), they guarantee both the accounts that they accept from their clients and from lenders of money and the integrity of officially listed securities Their association publishes the daily bulletin showing official quotations for listed securities, which comprise the leading French and foreign governmental and corporate issues, in all about 2,500 stocks and bonds (including about 250 foreign) The administrative body of the association is the chambre syndicale, elected annually by the members

Methods of trading on the official market are, in the first instance, divided into cash (au comptant) transactions and transactions for the term or for future delivery and settlement (à Cash transactions are made in any officially listed security for any amount thereof Orders are commonly placed either at a fixed price (à cours fixe) or at the best market price (au mseux) or at the average price (au cours moyen) On the parquet there is one settlement day a month, at the month's end, for future or à terme contracts Included in the list of securities available for term trading are the French state rentes, securities issued by important French banks, utilities and industries, and some foreign governmental and industrial issues. Because of the breadth and better prices which often prevail in the term market, it is used by both investors and speculators. Clients trading in the term market are permitted to engage in firm of nonoption (à ferme) or in option (à prime) transactions Finally, at the end of the month, all open accounts—of chents with their agents, of agents with agents or with lenders of money (reporteurs)-are settled through the central hquidation service (hquidation centrale).

The Corb and Free Monkets—The courters, in pursuance of the law of Feb. 16, 1942, have taken the place of the former basquiers or valeurs or coulistants. They too have a transferable monopoly. Whereas that of the agents de change covers all securities quoted on the official market, theirs covers securities not the free market are handled by them. The courter, however, is not a government official but only a commission agent, being appointed by the chambre syndicale of the agents de chonge after agreement with the chambre des courters; nevertheless he is required to post a bond and to show that he has capital assets not less than a faxed minimum. In 1953 there were about 50 courters.

The free market, then, comprises all shares quoted nether on the parquet nor on the marché das courtaers. When a new the is introduced in the Bourse, it is generally quoted first of all on the free market. Upon the share's steadying its quotation, the Association des Courtiers adds it to its list of securities Eventually, when they deem that the market for its broad enough the agents de change annex it to their own list Securities may thus pass through three successive stages, from market to market. Often, however, the middle stage, in the marché des contiers, is omitted.

(G V.)

Amsterdam.—The first exchange in Amsterdam was founded in 1611. Transactions were largely concerned with commodities but also with stock of the Dutch East India company and were of a very speculative character, comprising forward bargains, purchases on margin, option and put-and-call transactions. Already in the first half of the 17th century a daily list was sused, containing, however, exclusively rates of exchange The Confusion de confusiones of Joseph de la Vega, a Spanish Jew, shows that speculation was the prevailing feature of those days.

In 1787 the Association for Trading in Bonds was founded, with its own clubhouse, henceforth stockjobbing was separated

from the trade in commodities In 1845 a new exchange, in which stockpobbing also took place, was built at the Dam In 1876 the Veieninging voor den Effectenhandel (Stock Exchange union), a private association, began to regulate the stock exchange Rules had already been evolved to protect both the public and members.

The exchange built by H P Berlage for the Amsterdam municipality at the Damaka in 1903 allotted about one-quaster of tapatry at the Damaka in 1903 allotted about one-quaster of the space to the stock exchange, but this soon proved to be too little The Stock Exchange union therefore had a new exchange of work built by J Cuypers, which came into use in 1913 and is connected with the Berlage exchange by an overhead passage

Before World War I, prehaps because of the Netherland's meccantile and seafaring tadition, pelhaps because modstry was underdeveloped at home, the Dutch investor showed a strong micination for foreign securities, patientially for US ones. After World War I capital surpluses were more and more directed to the East Indies, and there was a boom on the Amsterdam exchange until 1929, when the world economic depression began During their occupation of the Netherlands in World War II the Germans tred to disrupt business on the stock exchange as much as they could, that we prompts. After the liberation in May 1925 these amovations were somewhat mitigated but it was not until 1953 that the old articles were re-established.

The Stock Exchange union, though remaining a private association, was in 1914 subordinated to the minister of finance insofar as the latter was given the right to regulate the exchange's opening and closing and to approve the listing of new securities

The Amsterdam exchange, which in more prosperous days had had 800 members, had 500 m 1954. Transactions in a security in which no constant dealing takes place are handled by a hockman, that is, by a jobber specializing in that security and receiving a small commission from the brokers who pass orders to him. Every broker, however, has a right to bid or offer in any security listed, if circumstances would give rise to open trading. Official dealings start at 1 15 PM and terminate at 2 OP M

Since the end of the 10th century the Amsterdam banks have been members of the stock exchange, so that many transactions are effectuated not on the stock exchange itself but in the banks; such internal clearings, however, are based on the official quotations and governed by the regulations. The stock exchange has fixed minimum commission traffs, but no broker would charge a

higher commission than those minimum rates.

To speak generally, there is no forward market for stocks in Amsterdam, most dealings are for money", settlement usually takes place on the same day as the conclusion of the bargain, dolivery four days later Opton dealing is, however, possible. Upto World War II, a considerable number of transactions were done on "prolongation" (purchase on margin), whereby the security was pawned and the purchaser paid a surplus of 26%, at least on the market value, such loans could be "prolonged" at the prolongation. After World Wai II, however, all purchases have to be fully paid in cash. Bear transactions are likewise prohibited, though in practice a bear seller may borrow or line the securities that he has to deliver

Basic, Geneva and Zurich.—There are stock exchanges in a number of commercial centres in Switzerland, namely Basic, Berne, Chur (canton of Grisons), Geneva, Lausanne, Lucerna, Neuchkel, St. Gall and Zurich Of these, those situated in Basic, Geneva and Zurich are most important, and from the legal point of view it is in these cantons only that the markets come under the supervision of the cuntonal authorities In the other centres, the markets rank as private organizations. While the principal government and industrial securities are quoted in all the stock exchanges, the smaller centres generally come into use in connection with dealings in securities of a strictly local character (e.g., hotels, local or mountain railways) in which they, often specialize by writte of their geographical situation.

The stock exchange of Basle, originally founded in 1875, now functions under a cantonal law of Feb. 17, 1944; that of Zunch, originally founded in 1876, functions under one of 1883 subse-

quently modified on Dec 22, 1912, and subsequent additional legislation, that of Geneva, however, founded by the Société des Agents de Change in 1850, received legal status under a cantonal law as

early as Dec 20, 1856

While the exchanges are thus strictly individual in their organization and vary from place to place, the Vereingung Schweizerischer Effektenbersen endeavours to secure the maximum possible uniformity. This such matters as the formalities of admixion of foreign securities on the Swiss stock exchanges are regulated by this body. The admitted members each stock exchange form a committee or managing body which is responsible for the general control of the market,  $\sigma_s$ , membership, the financial sittus of members, the accounting and the presentation of accounts, the settlement of disputes and usances. It is these usances which in turn determine the manner of delange;  $t\sigma_s$ , the procedure required in the case of transactions for cash or for forward dates, delivery of stock, exercise of rights, etc.

In the three principal markets, of which Zurich, with a monthly record in 1933 of about 6,35 markings (of Geneva's 3,000 and Basle's 2,100), is the most important, only firms which have the approval of the cantenial authorities and are members of the Boersenkammer or the Effekten Boersenwerein can transact bussenses (the turnover of business in Zurich in 1932 was 6,137,1000,000 Fr. as against 1,792,000,000 Fr. in the case of Basle, Geneva did not publish corresponding figures). In Geneva the transaction of business was fournerly restricted to the agents de change, through whom all transactions had to be effected, but after 1934 consisted of three members representing the private or commercial banks, three members representing the frederal bankings organizations and two members representing the frederal bankings.

Dealing on the stock exchanges of Basie, Geneva and Zurich is restricted to banks authorized by the professional association of

dealers for the exchange in question

Only securities officially introduced can be dealt in on the stock exchange. The dealings which regularly and extensively the place in nonquoted securities (including newly issued stocks not yet officially introduced and foreign securities of all kinds) take locaentirely outside the stock exchange and are not officially marked on any record. Banks work on a commission basis and in the case operate technically as responsible principals in their own names even though they may represent third patters

Business is transacted daily in the ring or corbaile, access to which is exclusively reserved to authorized dealers. When the session opens, the clerk of the stock exchange reads out the names of the securities quoted in the order of the official price list Bonds are read out and dealt in in the first part of the session, shares in the second Once each security has been read out, dealings therein may begin between members in the ring by direct verbal negotiation (no jobbers or their equivalents are employed) and may continue so long as the session remains open In Zurich there are two rings, one for bonds and the other for shares. At the close of business, the list is read through again and dealers and ignresentatives of the Boersenkammer or association take note of all puces recorded during the session, any necessary corrections or adjustments being made. The list, which is then officially published, comprises all transactions officially recorded, markings being in each case qualified by an indication showing whether the deal is for cash, for end of the current (settlement) month or the end of the following (settlement) month (A. H. SH )

Milan.—The most important Italian stock exchange is that of Milan, which was founded in 1808. It is membrahip in 1933 comprised 104 agenti di cambio (about one-third of the total number of such agenti in Italy), who dealt in about 330 securities coof it them shares, 107 mortgage and other bonds and 23 government securities); and transactions on it constituted 60% of the total

number of such transactions in Italy in 1952.

The rules governing Italian stock exchanges are fixed by law. Stock exchanges, established by decree of the president of the republic, are administered by the local chambers of commerce and supervised by the treasury, by the deputation did borso (nominated verty year by the treasury to watch the trends of buistiness) and

by the directing committees of the agents di cambio (elected every two years by the general assembly to see that agents do not overstep the limits of their competence, to act as friendly arbitrators or in disputes efferred to them and to compile and publish the official lists); a representative of the treasury, moreover, attends the election and the subsequent sessions of the committee.

An agente di cambo is a public official appointed by presidential decree as the result of a competition, he is not allowed to deal on his own behalf or to hold interests in firms whose normal business is predominantly concerned with stock exchange transactions. His rate of commission is fixed by the treasury. Direct negotiations by word of mouth can be conducted only by these agents or their representatives, the leading banks, however, may have their observers in the stock exchanges, and persons whose normal business is concerned with the stock exchange are admitted on presentation of a succession hass.

Hours of business are the same for all Italian stock exchanges, being fixed by the treasury as from 10 15 AM to 12 45 PM every day except on Saturdays, on holidays and two weeks during the month of August.

The Italian stock exchanges deal in national, communal and provincual securities, in mortgage and other private bonds and in shares Methods of trading include transactions a content (for eash), which are of little importance, being almost entirely confined to securities of fixed value; transactions a termine (for the term) which constitute the greater part of stock exchange business, being concerned with shares, and transactions a premio of which option dealing alone is fairly widespread Shares, consolidated and redeemable government stock and a few other securities are quoted at tel qual rates, securities of fixed value usually at a price exclusive of accrued interest. Settlement takes place at the end of the month, through clearing houses. (LA R.)

STOCKHOLM, the capital of Sweden, on the east coast, not far south of the junction of the Baltic sea and the Gulf of Bothnia The population of Stockholm in 1751 was 61,040, in 1850, 93,070; in 1850, 176,875; in 1900, 300,624, in 1950, 824,850.

Origin.-Before Stockholm arose, Bjorko, Sigtuna and Uppsala were places of great importance. Bjorko ("the isle of birches"), by foreign authors called Birka, was a kind of capital where the king lived occasionally at least; history speaks of its relations with Dorestad in the Netherlands, and the extensive refuse heaps of the old city, as well as the numerous sepulchral monuments, show that the population must have been large. But though situated at a central point on Lake Malar, it was destroyed, apparently before the beginning of the 11th century (exactly when or by whom is uncertain); and it never recovered. Sigtuna. lying on the shore of a far-reaching northern arm of Lake Malar. also a royal residence and the seat of the first mint in Sweden, where English workmen were employed by King Olaf at the beginning of the 11th century, was destroyed in the 12th century. Stockholm was founded by Birger Jarl, it is said, in or about 1255, at a time when pirate fleets were less common than they had been, and the government was anxious to establish commercial relations with the towns which were now beginning to flourish on the southern coast of the Baltic. The city was originally founded as a fortress on the island of Stadholm. The castle was erected at the northeastern corner, and the city was surrounded with walls having fortified towers on the north and south It came to be called Stockholm ("the isle of the log," Latin Holmia, German Holm); the true explanation of the name is not known. During the middle ages the city developed steadily, and grew to command all the foreign commerce of the midlands and north, but it was not until modern times that Stockholm became the capital of Sweden. The mediaeval kings visited year by year different parts of the kingdom.

Situation.—Stockholm is famed for the beauty and physical

Situation.—Stockholm is famed for the beauty and physical characteristics of its situation. The coast is here thickly fringed with islands (the skörgörd), through which a main channel, the Saltsjö, penetarise from the open sea, which is nearly 40 mi. from the mainland. A short stream, with a fall normally so slight as to be sometimes reversed by the tide, drains the great lake, Millai into the Saltsjö. The city stands at the junction of the lake and the sea, occupying both shores and the small islands intervening. From the presence of these islands a fanciful appellation for this city is derived—"the Venice of the North", but actually only a small part is insular. There are five main divisions, Gamla Staden, old town, ancient nucleus of the city, properly confined to Stadholmen (the city island) which divides the stream from Malar into two arms, Norrstrom and Soderstrom, Norriman on the north shore of the channel, including the business section; of Starmann, eastern residential section, Kungsholmen, to the wei, manufacturing and municipal centre, and Sodermalm, to the south, manufacturing are

Gamla Staden.—Ancient origins are apparent in the narrow, winding streets, though the individual holess are not very old, owing to the rawages of frequent fires. A few, however, preserve antique narrow fronts with gables, as in some of the North German towns. The old market, still called Stortong (great market) is now one of the smallest in Stockholm. At the north angle of the island is the royal palace (Stott). The original building was destroyed by five in 1697, the body of Charles XI being with difficulty rescued from the flames. A new palace after designs of Nicodemus Tessin the younger (d 1728) was not completed, owing to wars and the general distress, until 1754, while a restration carried out in 1901 included many ornamental details devised by the architect and executed at the expense of King Occar III. The new town hall designed by 5 bisters combines Swedish traditional styles with Italian influences, it is one of the world's more magnificent buildings.

West of the palace are the offices of the majority of the ministries, some of them in the former buildings of the royal mint.



BY COUNTER OF SWEDISH STATE BALLWAYS
THE ENGELBREKTSKYRKAN, NORRMALM, A CHURCH NAMED AFTER
ENGELBREKT, SWEDISH PATRIOT,
WHO WAS ASSASSINATED IN 1436

Beyond these, on the west side of the island, is a square named from the palace on its northern side. the Riddarhustorg Riddarhus (house of the nobility) was the meeting place of the Council of the Nobles until 1866. and its hall is adorned with the armorial bearings of noble families. The north forecourt has a statue (1800) of Axel Oxenstierna, the chancellor, by J. Borjeson In Riddarhustorg is a statue of Gustavus Vasa, unveiled in 1773 on the 250th anniversary of his accession. Southwest of the royal palace is the Storkyrka (great church), dedicated to St Nicholas, the oldest church of Stockholm, greatly altered from its original state. The date of its foundation is 1264; but it was

practically rebuilt in 1726—43. Within it is richly adomed with paintings and wood carving. Gamla Staden is the commercial centre of the city. At the broad shipping quay (Sheppstrow) which flanks the palace on the north and east, most of the seagoing steamers lie; and the exchange, customhouse, numerous banks and merchants' offices are in the immediate vicinity, Rid-darholmen (nobles' island), lying immediately west of Stadholmen, contains the old Franciscan church (Raddarholmskyrha), no longer used for regular service, which since the time of Gustavus Adolphus has been the burial place of the royal family. It has recently been restored, and contains mediaeval pantings, and many trophies of the European wars of Sweden. On one side of it stands the old house of parliament; on the other a statue of Birger Jarl, the reputed founder of the city. On Riddarholm also are varous government offices, and most of the steamers for Malar and the inland navigation lie alongside tis quays.

Normalm.—Staden is connected with Normalm by the Normalm of the Holy Spirit), on which are situated the new houses of parlament and the Bank of Sweden. A third bridge connects with the main thoroughfare of Normalm, Drottningstann (Queen street). The Norrbor gives upon Gustaf-Adolisation (Control of the Norrbor gives upo

Torg, where a statue of that king stands between the royal thearter, royal opera house and the palace of the crown prince Normalm is the finest quarter of the city, with broad straight streets, several open spaces with gardens, and handsome buildings. East and north of the theater royal, the Karl-den-Tolites-Torg and Kungstradgård (royal garden) form the most favoured winter promenade. There are a statue of Charles XIII and a fountain with allegorical figures, by J P Molin, also a statue of Charles XIII, and in the small Berzeili park close at hand one of the chemist J. J. Berzelius Near Drottningsgatan is the Klara church, the burlial place of the poet K. M Bellman, and west of this, occupying one side of a square, is the central railway station. In the building of the academy of scence is the national museum of natural history, including mineralogical, zoological and ethnographical departments

Other Districts.-On the island of Kungsholm, S. of Vasastad, are the Caroline medical institute, several hospitals, including the Serafimer (1752), the royal mint and factories, Ostermalm, lying east, that is, on the seaward side, of Norrmalm, is a good residential quarter, containing no public buildings of note, save the barracks of the Swedish guards and the fine royal library, which is entitled to receive a copy of every work printed in Sweden The library stands in the beautiful park of Humlegård (hopgarden), in which is also a statue of Linnaeus South of Ostermalm, and east of the Kungstradgård and Staden, hes the peninsula of Blasieholm (formerly an island) and, connected by bridges, the islands of Skeppsholm and Kastellholm, the three forming the foreground in the beautiful seaward view from the Norrbro. On the first is the national museum (1866), a Renaissance building, containing historical, numismatic and art-industrial collections, with ancient and modern sculptures, picture gallery and engravings. The numismatic collection is notable for its series of Anglo-Saxon coins. About 11,000 pieces came from the island of Gotland, some dating from 901-924, but the majority are later. In front of the museum is a bronze cast of the famous group of J. P Molin (1859), the "Baltespannare" (belt-bucklers), representing an early form of duel in Scandinavia, in which the combatants were bound together by their belts.

East of Skeppsholm an inlet, Ladugårdslandsviken, so named from the proximity of the former royal farm-yard (ladugard), and bordered on the mainland by a quay with handsome houses called Strandvagen, throws off a narrow branch (Djurgårdsbrunnsviken) and separates from the mainland an island about 2 mi. in length by 4 mi. broad. This is mainly occupied by Djurgården (the deer-park), a beautiful park containing the buildings of the northern museum, a collection of Scandinavian costumes and domestic and agricultural utensils, and a biological museum housed in a wooden building imitating the early Norwegian timber churches (stavekirke). Here also is Skansen, an ingenious reproduction in miniature of the salient physical features of Sweden with its flora, fauna and characteristic dwellings inhabited by peasants in the picturesque costumes of the various districts. Both the northern museum and Skansen were founded by Dr. Arthur Hazelius (1833-1901). There is a bust of the poet K. M. Bellman, whose festival is held on the 26th of July. Sodermalm, the southern quarter, is principally residential.

The heautiful environment of sea and lake is fully appreciated by the inhabitants. To the north of the city, accessible by rail and water, are the residential suburbs of Haga and Ulriksdal, with royal chateaus, and Dyursholm. Saltsjöbaden, poin least of Stockholm, on Baggensfjord, is the nearest and most favoured seaside resort, but Dalaró (ao mi. southeast) and Nynskamm (39 mi. south) are much frequented. Vaxholm, 12 ml. northeast by water, is a pleasant fishing village where numerous villas have been built.

Institutions.—Stockholm is the centre of government and the usual residence of the king; in summer he usually occupies one of the neighbouring country palaces. The city is the seat of the high court of instite (Högsta Domstolen) and of the court of appeal for the northern and midland districts (Svosa Hofyatt) As regards local government, Stockholm is a lim (administrative district) in itself, distinct from the rural lim of the same name, under a high governor (Evertathillarer) and deputy, with departments for secretarial work, taxation and police. The city is in the ducese of Uppsala, but has a separate consistory, composed of the rectors of the city parishes, the president of which is the rector of St Nicholas (Storkyrka). Stockholm has no state university. A private university (Hogskola) as founded in 1878, and



THE CITY HALL AT STOCKHOLM, COMPLETED IN 1922

was brought under state control in 1904. The president of the governing body is appointed by the government, while the appointment of the remaining members is shared by the Swedish cademy, the Academy of Sciences and the city council. The faculties are four—philosophy and history, philology, mathematics

and natural sciences and jurispudence. The Caroline institute (Krolinka Metho-Kuruguka natisia) is a medical foundation dating from 1815, which ranks after 1814, with the state universities of Upposals and Lund in the right to hold examinations and confer degrees in its special faculty. Special and secondary education is highly developed; there are schools of agriculture, mining and forestry, technical schools, a veternary school, a school of pharmacy, etc. Among the public schools under state conting, one, the Nya Elementarskolan, was founded experimentally in 1828, after the education committee of 1825—28, among the members of which were Tegnér and Berzelius, had reported on the want of such schools. This school retains its separate governing board; whereas others of the class are under a central board The control of the primary schools in the parishes is similarly centralized; whereas in Sweden generally each parish has its school board.

Stockholm is the seat of the principal learned societies and royal academies. (See Sumes»). There are schools of painting, sculpture and architecture under the direction of the Royal Academy of Arts; a conservatory of music under that of the Royal Academy of Musics, and experimental gardens and laboratones under the Royal Society of Agraculture. Outside the city is the Thiel gallery, with a rich collection of the works of Liljefons, Carl Larsson and Anders Zorn. The Natural History museum, the observatory and meteorological office, and the botanical gardens are under the supervision of the Royal Academy of Sciences.

Minor collections deserving mention are the museums of the geological survey and the Caroline Medical institute, and the archives in the record office (Riksarkivet).

Among places of entertalment, the royal theatre is managed by a company receiving a state subsidy. The Dramatic theatre (Dramatiska Teatern), in Kungsträdgårds-Gatan, the Swedish (Svenska) theatre in Blaischom-Gatan, and the Vasa theatre in Vasa-Gatan may also be mentioned. The Djurgård is the principalese for variety entertainments in summer. Several of the leading sporting clubs have their headquarters in Stockholm. An annal regata is sheld early in August by the Royal Swedish Vacht club (Svenska Segaluālskapet). A harbour much frequented by yachts is Sandhamn in the outer skargård.

The Stockholm General Skating club (Almänna Skridskoklubb) is the leading institution for the most favoured winter sport. A characteristic spectacle in winter is the tobogganing in the Humlegård on holidays.

The principal athletic ground is the Idrottspark (sports park), on the north side of Östermalm, with tennis courts and a cycing track, which may be changed into a skating-rink in winter. There is a similar park at Djursholm.

A stadium in Swedish mediaeval style, seating 15,000, was opened for the Olympic games in 1912.

Industry and Commerce.—Stockholm's industries are varied.

Industry and Commerce.—Stockholm's industries are varied, including iron and steel, engineering, shipbuilding, and the manufacture of a great number of consumption goods such as flour, beer, tobacco, clothing, leather, etc. The nearby Gustavsberg and Rofstrand potteries produce excellent wares. Government mining, printing, etc., is done here All told, Stockholm manufactures about three times in value the product of either Malmo or

Gothenburg. Stockholm is the first port of the country for imports, but in exports about equals Malmo and falls below Gothenburg, total tonnage is about 11,000,000 annually About 50% of the shipping tonnage is Swedish The channel is 32 ft. deep, and vessels of 23 ft. draught can tue up at Skenpsbro and Blassholm.

There is an outport at Vartan on Lulla Vartan channel to the northeast. The Hammarby channel takes vessels up to 3,500 kms. There is an intreate transportation centre in and over Slussen, connecting Lake Malar with the Baltic by water and also Gambard Staden with Sodermalm by land, All trains into the city have been electrical.

See P. R. Ferlin, Stockholm, Stad. (Stockholm, 1854-185); C. Lundin, and A. Strindlers, Gamla Stockholm (Stockholm, 1889); C. Lundin, Nya Stockholm. (Stockholm), 1860); G. Nordensvan, Malarrentinsgen-lifte gueen for Malari (Stockholm, 1860); E. W. Dahligen, Stockholm, 1860); E. W. Dahligen, Stockholm, 1867; issued by the muscapal council on the octasion of the Stockholm Exhibition, 1897).

STOCKINETTE. A term strictly denoting a particular variety of knitted or hoisery fabric composed of wool, cotton, silk or artificial silk, and produced as a tubular fabric and in a continuous pecce of indefinite length on a knitting machine of the circular type. The fabric may be used in its tubular form, or may be cut lengthwise and opened out into single width, to be made up into the numerous garments for clothing and other articles for domestic use.

STOCKJOBBER: See JOBBER (STOCK EXCHANGE). STOCKMAR, CHRISTIAN FRIEDRICH, BARON VON

(1787-1863), Anglo-Belgian statesman, who came of a Swedish family, was born at Coburg on Aug. 22, 1787. He was educated as a physician, and became attached in 1816 to Prince Leopold of Saxe-Coburg-Gotha on his marriage to Princess Charlotte of England When she died next year he remained Leopold's private secretary, controller of the household and political agent, until the prince became in 1831 king of the Belgians His disinterestedness and profound acquaintance with English and European social and political questions impressed themselves on all who were associated with him. In 1831 he retired to Coburg, in order not to excite Belgian jealousies by residing at court as confidential adviser, but he continued to be Leopold's right-hand man In 1837 Leopold sent him to England as adviser to the young Queen Victoria, and in the next year he accompanied Prince Albert (afterward Prince Consort) on his tour in Italy. He won the complete confidence of the prince as well as of the queen, and on their marriage in 1840 he became their trusted though unofficial counsellor, dividing his time between England and the continent. He died at Coburg on July 0, 1863.

See the articles on Victoria, Quiers; and Albert, Prince Consort of England. Selections from Stockmar's papers were published by his son Einest in 1872, and a biography by Juste appeared at Brussels in 1873; see also The Letters of Queen Victoria (1907).

STOCKPORT, a municipal, county and parliamentary borough of Lancashire (in part) and Cheshire (in part). England, 6 mi. S.E. of Manchester. Pop. (1951) 141,660. Area 12.5 sq mi. The boundaries of Manchester and Stockport meet in Levenshulme. The ancient town stood on the slopes of a narrow gorge where the Tame and Goyt join to form the Mersey, but the modern town has extended on to the more level land above. There are river bridges and a lofty railway viaduct bestrides the gorge. Stockport is served by the L.M.S. and L.N.E. railways. Motor buses connect it with Manchester. The town is an important industrial and railway centre. Its industries include cotton and felt hat manufactures, the construction of machinery for the cotton trade, motor and electrical engineering, bleaching and dyeing, and the manufacture of leather and of foodstuffs. The public buildings include the church of St. Mary (built about 1817) with portions of earlier date and a Decorated east window; St George's church (1897); St. Mark's church (1921); the town hall (1908), designed by Sir Brunwell Thomas; the central library (1913), the grammar school (1916) and the Hall of Memory. In all there are 415 ac. of parks and grounds. The Kinder waterworks (1912) have a reservoir covering 44 acres; the Goyt valley works were opened in 1937. The old Stockport grammar school was founded in 1487 and the Stockport Sunday school (founded 1784) is one

of the largest in the kingdom Stockport returns two members to parliament It was enfianchised in 1832, incorporated 1835, and became a county borough in 1888. Richard Cobden represented Stockport in parliament from 1841 to 1847.

During the Roman occupation there was a small military station on the site of Stockport, at the junction of two Roman loads. The etymology of the name may be Saxon, but there is no evdence of a Saxon settlement, and the place is not mentioned in Domesday. A castle was in existence in the 12th century, but is not mentioned after 1327. Stockport (Stokeporte, Stopport, Stopford) was made a free borough by a charter of Robert de Stokeport about 1220. This Stockport was not a true municipal borough until formally incorporated under the Municipal Corpolations act of 1835

STOCKS, a wooden structure formerly in use both on the continent of Europe and in Great Britain as a method of punishment for petty offenses. The culprit sat on a wooden bench with his ankles, and sometimes his wrists or even neck, thrust through holes in movable boards, generally for at least several hours. That stocks were used by the Anglo-Saxons is proved by their often figuring in drawings of the time (see Harleian mss. No 65). The second Statute of Labourers (1351) ordered the punishment for unruly artisans. It further enjoined that stocks (cennes) should be made in every town between the passing of the act and the following Pentecost. The act appears to have been ill observed, for m 1376 the commons prayed Edward III that stocks should be set up in every village. Though never expressly abolished, the punishment of the stocks began to die out in England during the early part of the 10th century, though there is a recorded case of its use so late as 1865 at Rugby. In many villages may still be seen well-preserved examples of stocks, in some cases with whipping posts attached. In the United States stocks were of frequent use in the 18th century, more particularly in the New England states; while in the southern states they were employed for punishing slaves (see Pillory),

STOCKTAKING. To prepare a balance sheet it is necessary for a trader to arrive at a valuation of his stock-in-trade; this process is called stocktaking or, in the U.S. inventory taking. When proper stock records are available, they are an invaluable check upon the accuracy of the stocktaking; but in their absence it is essential that the process of stocktaking should be performed with the utmost care. If a wrong value be placed upon stock, the accounts embodying that valuation will to a corresponding extent mis-state the profits of the undertaking and its current financial position, and to a corresponding extent the accounts of the ensuing period will be affected in the opposite direction. The lower the rate of turnover the more serious will be any error in the periodical stocktaking. In many cases, the only independent check that the trader has upon the accuracy of his stocktaking is the inherent probability of the percentage of profit shown by the trading account (See also Financial Statements.)

The generally accepted basis for the correct valuation of stockin-trade, assuming the goods to be in a readily saleable condition, is either the price they actually cost or the price at which they could then be bought in the open market, whichever of the two be the lower.

But although it is unsound to take into account any rise that there may have been in market values since the goods were bought, it would be equally unwise for a trader to dispose of his stock upon a rising market at normal pruces, where he can only replace the goods sold at a greatly enhanced figure. Usually, therefore, although rising market prices are gnored for stocktaking purposes, selling prices are advanced as buying pruces in crease; and this is equalized by the fact that as buying pruces fall, it commonly becomes necessary for the trader to reduce his selling prices, though he still has stock purchased at the higher rate.

Responsibility.—In most bisinesses it is usual to make the general manager responsible for the general accuracy of the stocktaking. The managers of departments are responsible to him, and the actual work is spit up among the various employees, each of whom is held responsible for his section of the work. Those employed in counting, measuring or weighing goods are usually those familiar with the handling of these goods, and thus able to identify them as being correctly described. The cost prices are then entered on the list by clerks from actual invoices. The managers decide what (if any) percentage is to be deducted from goods that are old-fashioned, or otherwise out of condition, and the remaining calculations are then completed in the office, after which the summary is certified by the general manager

The actual process of taking stock is often rendered more difficult and uncertain because it has to go on while trading operations are in full swing, and goods are accordingly constantly coming in and going out It is very necessary to take precautions to ensure that no errors arise from this cause. For this reason some bisiness houses prefer to close their premises during stocktaking, even though it means a corresponding loss of trade. Further, it is important to see that the invoices relating to all goods which have in fact been included in stock are also included in the books are presented to the control of the control of the control of the properties of the control of the control of the control of the actual between the control of the control of the control of the actual between the control of the control of the control of the actual between the control of the control of the control of the control of the actual of the control of the

When the trade is a seasonal one, it is usual to fix a date for stocktaking that comes between the two seasons, as it is naturally more convenient to take stock when the stock is at its lowest In such cases it sometimes happens that delivenes of new season's goods have already been accepted, the invoices for which are "dated forward," \*re\*, into the new accounting period. In such cases it seems admissible to exclude the value of these goods both from the purchases of the past period and also from the stocktaking.

(I. R. D.)

STOCKTON, CHARLES HERBERT (1845-1924), US naval officer, was born in Philadelphia, Pa , Oct. 13, 1845 He saw active service with the "Macedonian" during the Civil War, graduated from the United States Naval academy in 1865 and served on the "Swatara" on a voyage around the world, 1874-75. He commanded the "Thetis" from 1889 to 1891 and served on the Asiatic station as commander of the "Yorktown" from 1895 to 1807. He was president of the Naval War college from 1808 to 1000, and after commanding the battleship "Kentucky" from 1001 to 1903, he served as naval attaché in London until 1906. He was promoted to rear admiral in 1906 and became president of the naval examining and retiring boards and the board of inspection and survey. Following his retirement in 1907 he was first delegate to the London Naval conference 1908-09 and from 1910 to 1918 was president of George Washington university where he lectured on international law. Included among his various publications in the field of international law are International Law: Recent Subreme Court Decisions and Other Opinions and Precedents and Outlines of International Law (1914). Stockton died in Washington, D.C, on May 31, 1924.

STOCKTON, FRANCIS RICHARD (1844—1902), U.S. writer, was born m Philadelphia, P.A. April 5, 1844, Upon graduating from high school Stockton studied wood engraving, but soon turned to journalism. He contributed profilically to periodicals, and was variously on the staffs of Heerls and Home, Contray Magazine and St. Nicholas Magazine, of which he was assistant editor in 1873, From 1851 he devoted himself to authorship. He

died in Washington, D.C., April 20, 1902.

Illustrative of the seven categories of "romantie" narrative within which Stockton wrote are the fairy tales in Ting-a-Ling (1870), the conventional love story of Arias Clowerdon (1893), the outdoor romance of The Adventures of Caphain Horn (1893), the science faction of The Greet Stone of Seadies (1898), the sixtical tale in Kate Bonnet (1902), the high whimay of Rudder Grange (1879) and the enignatic fantasy of "The Lady or the Tiger?" (1882). Stockton's short stories are more successful than his novels; his Tame probably rests upon the last two titles.

G. C. K.)

STOCKTON, RICHARD (1730-1781), signer of the Delaration of Independence, was born Oct. 1, 1730, in Princeton, N. J. He was the grandson of another Richard Stockton, who was one of the original settlers of the city and the owner of the land which became the centre of modern Princeton. He was educated

at the College of New Jassey at Newark which later, largely though the efforts of his father, was moved to Prunceton and became Pranceton university. After his graduation in 1748, young Stockton studed law in Newark, and his admission to the barriers, 1875, was the beginning of a long and successful career as an attack. The state of the College of New Jersey and was able to persuade John Withershoon to accept the presidency of the college, a position the later had previously declined. From 1768–76 Stockton served on the executive council of his native colony and from 1774–76 as an associate justice of the New Jersey supreme court. In 1776 he became a member of the continental congress.

Stockton's attitude on the relation of the colonies to Great Bratian underwart, a considerable change in the years before the outbreak of the Revolutionary War The first record of his opinion is dated 1764, at which time he felt that any difficulties between the colonies and England could be settled by the inclusion in parliament of some US members Ten years later, however, his letter to Lord Dartmouth entitled An Expedient for the Seltement of the American Disputes advocated that the colonies be allowed to be completely self-governing and responsible only to the king By the time of his election to congress, he was convinced of the advisability of independence for the colonies, and he not only signed the Declaration of Independence but argued in

favour of it before its passage

He was re-elected to congress in 1776 and in the same year declined the position of chief justice of the New Jersey supreme court, to which he was elected unanimously, having previously been defeated for governor In Nov 1776, he was captured by the British at the home of a friend in Monmouth, N J., and imprisnced in New York city. Before his release, which was secured several months later by Washington himself, his health had suffered so hadly that he never recovered In addition, most of his fortune was gone, his lands and buildings having been looted by the British in his absence He did not return to public life, but spent the years until his death quietly in Princeton. He died in that city, Feb 28, 1787.

STOCKTON, ROBERT FIELD (1795-1866), US mand officer, was born in Princeton, N.J., Aug. 20, 1795, the grandson of Richard Stockton (9° v), siner of the Declaration of Independence. He attended Princeton college for a time, but in 1811 joined the navy as a midshipman, shortly becoming attached to the frigate "President," under the command of Commodere John Rodgers. He served under Rodgers during the War of 1812 except for a brief period in Washington as and to the secretary of the navy, and at the conclusion of hostifities was transferred to the Mediterranean, where he remained until 1821, parturpating (1815) in the war against the Barbary pirates. In 1821 he was placed in change of the schooner "Alligator" and dispatched by the control of the society the land which later became Liberta.

From 1836–98 he lived in Princeton, devoting his attention to the foundation of the New Jersey Colonization society, of which he was first president, and to the construction of the Delaware and Raritan canal, which owed its existence to him. He was responsible for obtaining the charter for the canal, for financing it with his own fortune and for directing it as president during the last years of his life.

In 1838 he went to sea sagin, as commander of the flagship of the Moditerranean feet. John Tyler asked hun to join his cabinet as secretary of the navy, but Stockton refused, preferring to remain on active duty. With John Ericson, later designer of the "Monditor," he drew up plans for the "Princeton," the first warship to be driven with a scree propeller, designing, himself, one of its guns, the largest in the U.S. fleet. On one of the ship's first voyages, Stockton's gun was fired and exploded, killing the secretaires of state and the navy and wounding numerous other passengers, but Stockton was absolved of all blassleved of states.

In 1845 he was chosen by Tyler to sail in the "Princeton" to Texas to deliver to the state government the annexation resolution of the U.S government, and later in the same year he comwhere he had been ordered to take command of the fleet from Commodore John Sloat. War with Mexico having broken out while he was en route, Stockton immediately took command of U.S land and sea forces, capturing Los Angeles, the Mexican stronghold, on Aug 13, 1846

Stockton at once set up a civil government, naming as governor John C Frémont, who had been associated with him in the fighting He subsequently fought and defeated the Mexicans at San Diego, San Gabriel and La Mesa, after which Los Angeles, which the Mexicans had recaptured, again fell to the US forces. The entire province of California was then ceded to the United States

Stockton returned east in 1847 and resigned from the navy three years later, on May 28, 1850. He served in the U.S senate from 1851-53 and after 1853 was president of the Delaware and

Raritan Canal company. He died Oct 7, 1866

STOCKTON, a city of central California, U.S A, at the head of tidewater on the San Joaquin river, 80 mi E of San Francisco; the county seat of San Joaquin county. It is on the Pacific highway; has a municipal airport; and is served by the Santa Fe, the Southern Pacific, the Western Pacific, electric and Beltline railways, by motor coach and truck lines, population (1950) 70,853;

(1940) 54,714 by federal census.

Stockton has a level site averaging 23 ft above sea level, surrounded by the fertile lands of the San Toaquin valley, which produce potatoes, onions, beans, corn, asparagus, grain, Tokay grapes and other fruits. More than 100 crops are grown in the county, valued in 1949 at \$107,000,000. It is the site for California's only inland deepwater port completed in 1933, reaching the Pacific ocean through San Francisco via a channel 80 mi, long and 32 ft deep. The value added by manufactures in Stockton in 1947 was \$63,949,000; bank debits in 1949 totalled \$775,885,623 and the assessed valuation of property for 1949 was \$77,900,740. Stockton is the seat of the College of the Pacific, the oldest moorporated coeducational institution of the state, chartered in 1851. located in Santa Clara until 1871, and in San Jose from 1871 to 1922.

There was a small settlement there (called Tuleberg) before the discovery of gold in the Mother Lode. With the coming of the first gold seekers the importance of the site as an outfitting point for the mining country immediately became apparent. A town was laid out in the spring of 1840 by Captain Weber and named after Robert Field Stockton, who had been prominent in the events which secured California for the United States In 1850 Stockton became the county seat and was chartered as a city.

STOCKTON-ON-TEES, a municipal and parliamentary of the River Tees, 112 mi. above its mouth and opposite Thornabyon-Tees Pop. (1951) 74.024. Area 9.4 sq.mi. Stockton's first market charter was granted in 1310 and it is still a big market centre for cattle and agricultural produce Because of the presence of iron ore in the Cleveland hills to the south (which has long been mined) and the Durham coal field to the north, it grew into a big industrial centre and the leading Tees port until superseded by Middlesbrough. The port has 980 ft, of quavage, a minimum depth of 12 ft. at low water ordinary spring tide and 221 ft. at high water ordinary spring tide and trades principally with Scandinavia and the Netherlands The historic Stockton-Darlington railway (opened 1825) was the first passenger-carrying railway. Stockton is interested in the development of diesel and electric locomotives. Many light industries are located in the town and partly within the borough is the Imperial Chemical Industries establishment at Billingham,

Stockton grew up around the manor house and later castle of the bishops of Durham, to whom the town belonged. It is said that King John granted a charter in 1214, but no trace of this The borough is first mentioned in 1283. Since 1867 Stockton has sent one member to parliament,

At Norton, 1 mi. north, St. Mary's church, once collegiate, shows Saxon and Norman work and has the remains of a fine three-decker

STOCKYARDS are facilities consisting of pens or other

manded the "Congress" in its voyage from Norfolk to the Pacific, inclosures, and their appurtenances, in which livestock—cattle, swine, sheep and goats-are received, held or kept for sale, delivery or shipment in commerce Typically, they may be classified as public stockyards, private stockyards, concentration yards and auction markets Public stockvards are characteristically North American, private stockyards, South American, and auction markets. British Yet markets containing the characteristics of each are present in all large livestock-producing countries.

Public Stockwards are customarily conducted and operated as public markets and are available to all sellers and buyers of livestock who comply with established regulations. In many countries public stockyards are also publicly owned and operated by municipalities, as in Buenos Aires, or by state governments, as in Australia In the United States, they are generally privately owned and operated by a stockyard company in which corporate stock is widely owned The principal public stockyards and auction markets of the United States and Canada are posted and regulated under similar statutes, viz, the Packers and Stockyards act, TO2T, and the Layestock and Layestock Products act, 1030. In the 1050s there were about 65 primary public stockyards and 260 auction markets in the U.S., and 11 public stockyards in Canada so regulated

A considerable number of secondary public stockyards in the US, because of size or the intrastate character of their business, had not been subjected to federal regulation, but in some cases and in some respects are regulated by state agencies. A typical year of activity was 1952, in which the 65 primary public stockyards in the U.S. received for sale or delivery to packers 23,727,996 cattle and calves, 38,017,093 swine, and 15,771,683 sheep, lambs and goats In the same year, the 11 stockyards in Canada received 1,314,446 cattle and calves, 1,034,880 swine and 189,804 sheep and lambs

Public stockyard owners are required to furnish without discrimination reasonable facilities and services in connection with the receiving, handling, feeding, watering, holding, delivery, weighing and shipment of hyestock. They do not sell or buy any livestock either for their own account or as agents for sellers or buyers They are required to publish, file with the government, and observe a schedule of reasonable charges for the use of facilities and services offered. While any owner may ordinarily sell his own livestock at a public stockyard, he customarily consigns it to one of the market agencies or commission firms authorized and registered to perform selling services on an agency basis at that stockyard The market agencies doing business at a public stockyard must register with the regulatory agency, provide a surety bond to assure the prompt payment of the proceeds of sales; publish, file and observe a schedule of commission charges for the services furnished; and establish and observe just and reasonable regulations and practices in respect to such services Market agencies provide competent selling services comparable to the skill of the buyers; collect the amount of the sale from the buyer; and remit the net proceeds of the sale to the consignor, retaining their authorized commission and paying the carrier, the stockward owner. and others, the legal freight, vardage, feed and other charges.

Public markets are usually operated 5 or 6 days each week. Customarily there are present buyers representing adjacent packers, butchers, order buyers representing packers at other points. dealers who buy and sell for their own account for speculative profit, and buyers of feeder or store livestock seeking animals for further grazing, feeding or fattening. Order buyers and dealers regularly engaged in business on a public stockyard must register with the government and provide suitable surety bonds to insure the payment for all livestock purchased. Packers and other buyers may be required to provide a bond, give assurance of financial responsibility or pay for purchases before the livestock is delivered to them.

Sales at public stockyards are negotiated privately and individually between the buyers and market agents in the pens containing the livestock, which may be sorted into separate lots of comparable kind, quality or size to facilitate the sale of each consignment on its ments Livestock is weighed by the stockyard owner and held until delivered or shipped to the buyer. Prices

agreed upon by the seller and the buyer are assembled and published by the market news services of the respective departments of agriculture or by registered market agencies for the use of producers, market men and buyers generally

To control and prevent the spread of livestock diseases and protect the public health, the bureau of animal industry of the US department of agriculture maintains constant inspection at many public stockyards Other state, municipal or national agencies maintain a similar inspection service at other public stockyards

Private Stockyards are operated by packers as adjuncts to their packing plants or by dealers for the purchase of livestock for speculative profit, the only buyer present being the representative of the packer or the dealer operating the yards. In South America, price arrangements are made before the livestock goes to the packer's yard, but in the U.S. prices are usually determined on receipt at the private yard. In Canada the prices, especially of hogs, are often determined after slaughter upon carcass weight and grade Many private stockyards are located at interior points in productive livestock regions away from the public market centres

Concentration Yards, typical of the U.S., are generally only another designation for private stockyards operated as assembly points in surplus livestock producing areas by packers located some distance away, by dealers who buy for their own account and in turn sell to such packers, by order buyers who buy on order as agent for packers, or by co-operative associations Hogs and calves are principally purchased at concentration yards, although there are occasional purchases of cattle and sheep Transportation privileges, such as unloading, sorting, regrouping and reshipment at the balance of through rates, which concentration yards formerly enjoyed, are no longer of great importance since most of the shipments to, and many of the shipments from, concentration yards now move by motor truck While most operators of private stockyards and concentration yards will buy livestock from anvone who will sell to them, they may discriminate in the person from whom they buy or in the price or the conditions of any purchase They generally provide and operate the facilities used. including the scales upon which the livestock is weighed. They are not regulated as public markets.

Auction Markets are a type of public market widely distributed over the world. They are often owned or operated by the auctioneers who conduct both the selling and the general operations of the yards, although in some cases the facilities are owned and operated by an individual, firm, corporation or municipality, with the selling conducted by the auctioneer under a lease, permit

or employment arrangement.

Auction markets conduct their sales under competitive, oral or written bidding either in a central auction ring or from pen to pen in the yards, usually one or two days a week, with some private trading carried on throughout the week. In some countries, where prices and sale conditions are strictly regulated, auction markets become a type of concentration yards or collecting centres for the controlled livestock, usually livestock intended for immediate slaughter. In Canada, and in a few cases in the U.S., some kinds and classes of livestock are regularly or occasionally sold at auction in public stockyards.

Most producers and packers have a choice of one or more of all four types of markets Public stockyards are the principal mar-kets used. Following World War I, shifting production and population, changes in transportation and refrigeration, and the use of motor trucks encouraged decentralization of the packing industry. a large part of which moved nearer to producing areas. Packers adjacent to public stockyards in order to maintain their competitive position increased their purchases direct from producers. private stockyards, concentration yards, and auction markets, and decreased the proportion of livestock purchased at public stock-

Livestock is produced chiefly in the corn belt and central plains section of the U.S., while meat consumption is concentrated in the populous coastal regions. Fluctuating supplies and demands from all directions increased the importance of public stockyards, the principal function of which is to effect an equitable distribution of total production through the medium of sensitive prices determined under favourable conditions

STODDARD, AMOS (1762-1813), U S soldier, was born in Woodbury, Conn , Oct. 26, 1762. He enlisted in the colonial army in 1779, serving until the close of the Revolutionary War, when he became a clerk of the Massachusetts supreme court. He spent the years from 1793-98 as a lawyer in Hallowell, Me., serving for one year (1797) in the legislature of Massachusetts, of which Mame was at that time a district. In 1798 he rejoined the army, receiving a captain's commission on his entrance and becoming a major in 1807 and deputy quartermaster in 1812. the territory of Louisiana was purchased by the United States, Stoddard was chosen to accept the territory from Spain in the name of France and to accept it the following day from France in the name of the United States. He was then named civil and military governor of the territory, a post he held for the few months in 1804 before congress set up a government. He was assigned to Fort Meigs, Ohio, during the War of 1812 and during the siege of that post received a fatal wound. He died May II, 1812

Stoddard was the author of The Political Crisis (1701), written and published in London during a visit he made in his youth, and of Sketches, Historical and Descriptive, of Louisiana (1812).

STODDARD, JOHN LAWSON (1850-1931), U.S. writer and lecturer, was born in Brookline, Mass, on April 24, 1850. He graduated from Williams college in 1871 and attended the Yale Divinity school for the following two years. After some years of teaching and travel he began, in 1879, his successful career as a travel lecturer.

Stoddard continued to travel and lecture for almost 20 years, delivering each year the illustrated Stoddard lectures on European, American and Oriental travel. During the period he published various travel and picture books, including the well known series, John L Stoddard's Lectures which first appeared (1897-98) in ten volumes Stoddard spent his later years in retirement in Europe, devoting himself to writing and editing and after 1917 to religious study His published works include Glimpses of the World (1892); Stoddard Lectures on Travel Abroad and in America, 15 vol (1898-1909), Beautiful Scenes of America (1902), The Stoddard Library; A Thousand Hours of Entertainment with the World's Great Writers, 12 vol. (1910); Rebuilding a Lost Faith (1921); Two Arguments for Catholicism (1927). He died in Europe in June 1931.

STODDARD, RICHARD HENRY (1825-1903), U.S.

writer, was born in Hingham, Mass., July 2, 1825. As a boy Henry Stoddard read whatever he could find, and wrote and revised conscientiously and continuously. The literati of New York were kind, and soon Stoddard was contributing frequently to magazines and saving up money enough to have his first book Footprints (1848) published. Nathaniel Hawthorne helped him to secure a position in the New York customhouse (1853-70). Later he was private secretary to Gen. George B McClellan in the New ne was private serically to dean. Georgia in MacCleand in la New York York dock department (1870–73); city librarian of New York (1874–75); literary edutor of the New York World (1860–70) and the Mail and Express (1880–1903); and editor of the Aldime (1869–74). He died in New York, May 12, 1903. Stoddard's

poems are sincere, original and felicitous in form.

STODDARD, WILLIAM OSBORN (1835-1925), U.S. writer and secretary to President Lincoln, was born in Homer, N.Y., Sept. 24, 1835. He graduated from the University of Rochester in 1858 and in the same year became coeditor of the Central Illinois Gazette. He proposed Lincoln for the presidency in the columns of the Gazette and actively supported him in the presidential campaign of 1860. He served as a secretary to the president from 1861 to 1864 and in 1864 was appointed U.S. marshal of Arkansas.

Stoddard wrote more than 100 books, including: Abraham Lincoln (1884); The Lives of the Presidents, 10 vol. (1886-89); Inside The White House in War Times (1890); and The Table Talk of Lincoln (1894). He died in Madison, N.J., on Aug. 29, STODDERT, BENJAMIN (1751-1813), first US secretary of the navy, was born in Chales county, Md, in 1751 He planned to be a merchant, but at the outbreak of the Revolutionary Wat, poined the army and served for a time as a cavalty officer. From 1750-81 he was secretary of the board of war and from 1761-98 he conducted a highly successful shipping business in Georgetown, Md. He was one of the men whom George Washington commissioned to purchase tracts of land in what is now the District of Columbia, to be repurchased later by the government and used as the site of the national capital

In May 1798, Stoddert joined the cabinet of John Adams as first secretary of the new navy department, although Adams had previously offered the position to George Cabot, who refused Stoddert's experience stood him in good stead in his new post When he took office the US navy consisted of little more than three frigates. When he left office, in 1801, he had enlarged it to more than 50 ships, which were able to defeat the French in the short and undeclared naval war between the two countries (1708-1800). He also authorized the purchase of land in six locations on the eastern seaboard for the construction of navy yards and was responsible for organizing the marine corps on the basis on which it still operates. During his secretaryship of the navy, Stoddert also served as head of the war department for a brief period between incumbents. He left office with Adams and returned to his business but it never prospered again and he died in Bladensburg, Md, Dec 18, 1813, a poor man.

STOECKEL, CARL (1858-1925) U.S. music patton, was born in New Haven, Com. Dec. 7, 1858. In the late 19th century he settled in Norfolk, Conn., where he and his wife founded the Letchfield County Choral union, which eventually included the membership of five choral groups from the vicinity of Licfaeld. In 1906 he built a "Music Shed" for the annual concerts of the group which, into following year, first legan to supplement their choral music with programs of orchestral music. By 1911 there were 700 singers in the choral union and their concerts, known as the Norfolk festival, were events of international importance in the music world Some of the most noted of modern composers served as conductors of the festival and many of them, including Johan Sibelus, wrote music especially for performance there The festivals were discontinued after Stoeckel's death. on Nov. 1, 1925

STOESSEL, ALBERT (1894–1943), U.S. conductor and composer, was born in St. Louis, Mo, Oct 11, 1894. He studied in Berlin, Ger, and made his debut as a violinist there in 1914, returning afterward to the United States. He became conductor of the New York (or Oator) society in 1921 and head of the music department of New York university in 1923. He conducted the Worcester (Mass) music festivals from 1925 to 1942. His opera Garrick, on the life of the famous actor, was produced in New York city of the 24, 1937, he also composed several orchestral works He died in New York city of May 12, 1943, while conducting Wulter Damosch's symphonic poem Dunkthe. (N. N. S)

STOFFLET, JEAN NICOLAS (1751-1796), Vendéan general, was born at Lunéville, the son of a miller. Long a private soldier in a Swiss regiment in France, and afterward gamekeeper to the comte de Colbert-Maulevrier, he joined the Vendéans when they rose against the Revolution to defend their religious and royalist principles During the war in La Vendée he served first under Gigot d'Elbée, fought at Fontenay, Cholet and Saumur, and distinguished himself at the battles of Beaupréau, Laval and Antrain. He was appointed major-general of the royalist army and in 1794 succeeded La Rochejaquelein as commander-in-chief, He accepted the terms of the treaty of La Jaunale (May 2, 1795) but he soon violated them, and at the instigation of royalist agents took arms in Dec. 1795 on behalf of the count of Provence (the future Louis XVIII), from whom he had received the rank of maréchal-de-camp. This last attempt of Stofflet's failed completely. He was taken prisoner by the republicans, condemned to death by a military commission, and shot at Angers on Feb. 23,

See General d'Andigné, Mémoires, edited by E. Biré (1900-01); C. Loyer, "Cholet sous la domination de Stofflet," in L'Anjou historique, vol m (1902-03).

STOICHEIOMETRY, in chemistry, is a term which, structly, denotes the determination of the proportions in which elements or compounds react with one another, and is occasionally extended to include the determination of atomic and molecular weights (Gr \u03c4\

STOICS, a school of philosophers founded at the close of the 4th century BC by Zeno of Citium, and so called from the Stoa or painted corridor (στοὰ ποικίλη) on the north side of the marketplace at Athens, which, after its restoration by Cimon, the celebrated painter Polygnotus had adorned with frescoes representing scenes from the Trojan War But, though it arose on Hellenic soil, from lectures delivered in a public place at Athens, the school is scarcely to be considered a product of purely Greek intellect, but rather as the firstfruits of that interaction between west and east which followed the conquests of Alexander Hardly a single Stoic of eminence was a citizen of any city in the heart of Greece, unless we make Aristo of Chios, Cleanthes of Assus and Panaetius of Rhodes exceptions Such lands as Cyprus, Cilicia and Syria, such cities as Citium, Soh, Heraclea in Pontus, Sidon, Carthage, Seleucia on the Tigris, Apamea by the Orontes, furnished the school with its scholars and presidents, Tarsus, Rhodes and Alexandria became famous as its university towns. As the first founder was of Phoenician descent, so he drew most of his adherents from the countries which were the seat of Hellenistic (as distinct from Hellenic) civilization; nor did Stoicism achieve its crowning triumph until it was brought to Rome, where the grave earnestness of the national character could appreciate its doctrine, and where for two centuries or more it was the creed. if not the philosophy, of all the best Romans Properly therefore it stands in marked antithesis to that fairest growth of old Hellas, the Academy, which saw the Stoa rise and fall-the one the typical school of Greece and Greek intellect, the other of the Hellenized east, and, under the early Roman empire, of the whole civilized world The transcendent genius of its author, the vitality and romantic fortunes of his doctrine, claim our warmest sympathies for Platonism But it should not be forgotten that for more than four centuries the tide ran all the other way It was Stoicism, not Platonism, that filled men's imaginations and exerted the wider and more active influence upon the ancient world at some of the busiest and most important times in all history

The history of the Stoic school may conveniently be divided in the usual threefold manner; the old Stoa, the middle or transition period (Diogenes of Seleucia, Boethus of Sidon, Panetius, Positionius), and the later Stoicason of Roman times. By the old Stoa is meant the period (c. 304-205 R.C.) down to the death of Chrysippus, the second founder; then was laid the foundation of theory, to which hardly anything of importance was afterward added. Confined almost to Atheas, the school made its way slowly among many rivals Aristo of Chios and Herillus of Carthage, Zeno's heterodox pupils, Perseus, his favourite disciple and housemate, the poet Aratus, and Sphierus, the adviser of the Spartan king Cleomenes, are noteworthy minor names, but the chief interest centres about Zeno, Cleanthes, Chrysippus, who in succession built us the wondrous system.

Zeno.—Zeno's residence at Athens fell at a time when the great movement which Socrates originated had spen tiself in the second generation of his spiritual descendants. Neither Theophrastus at the Lyceum, nor Xenocrates and Polemo at the Academy, nor Stilpo, who was drawing crowds to hear him at Megara, could be said to have inherited much of the great reformer's intellectual vagour, to say nothing of his moral earnestness. Zeno visited all the schools in turn, but seems to have attached himself definitely to the Cynics; as a Cynic he composed at least one of his more important works, "the much admired Republic," which we know

STOICS 43I

to have been later on a stumbling-block to the school. In the sonal characteristics can be traced the hair-splitting and formal Cynic school he found the practical spirit which he divined to be the great need of that stirring troublous age. For a while his motto must have been "back to Socrates," or at least "back to Antisthenes." The Stoics always counted themselves amongst the Socratic schools, and canonized Antisthenes and Diogenes, while reverence for Socrates was the tie which united to them such an accomplished writer upon lighter ethical topics as the versatile Persaeus, who, at the capital of Antigonus Gonatas, with hardly anything of the professional philosopher about him, reminds us of Xenophon, or even Prodicus Zeno commenced, then, as a Cynic, and in the developed system we can point to a kernel of Cynic doctrine to which various philosophemes of other thinkers (more especially Heraclitus and Aristotle, but also Diogenes of Apollonia, the Pythagoreans, and the medical school of Hippocrates m a lesser degree) were added. Thus, quite apart from the general similarity of their ethical doctrine, the Cynics were materialists; they were also nominalists, and combated the Platonic ideas, in their theory of knowledge they made use of "reason" (λόγος), which was also one of their leading ethical conceptions. In all these particulars Zeno followed them, and the last is the more important, because, Chrysippus having adopted a new criterion of truth-a clear and distinct perception of sense-it is only from casual notices we learn that the elder Stoics had approximated to Cynicism in making right reason the standard At the same time, it is certain that the main outlines of the characteristic physical doctrine, which is after all the foundation of their ethics and logic, were the work of Zeno The Logos, which had been an ethical or psychological principle to the Cynics, received at his hands an extension throughout the natural world, in which Heraclitean influence is unmistakable

Cleanthes .- If the recognition of physics and logic as two studies co-ordinate with ethics is sufficient to differentiate the mature Zeno from the Cynic author of the Republic, no less than from his own heterodox disciple Aristo, the elaboration on all sides of Stoic natural philosophy belongs to Cleanthes, who certainly was not the merely docile and receptive intelligence he is sometimes represented as being. He carried on and completed the assimilation of Heraclitean doctrine; but his own contributions were more distinctive and original than those of any other Stoic He was able to transform Zeno's seeming dualism of God (or force) and formless matter into the lofty pantheism which breathes in every line of the famous hymn to Zeus. Herachtus had indeed declared all to be in flux, but we ask in vain what is the cause for the unceasing process of his ever-living fire. It was left for Cleanthes to discover this motive cause in a conception familiar to Zeno, as to the Cynics before him, but restricted to the region of ethics-the conception of tension or effort. The soul of the sage, thought the Cymics, should be strained and braced for judgment and action, his first need is firmness (ebrovia) and Socratic strength But the mind is a corporeal thing. Then followed the flash of genius this varying tension of the one substance everywhere present, a purely physical fact, accounts for the diverse destinies of all mnumerable particular things, it is the ventable cause of the flux and process of the universe. Herein lies the key to the entire system of the Stoics, as Cleanthes's epoch-making discovery continually received fresh applications to physics, ethics and epistemology.

Chrysippus.-Zeno had caught the practical spirit of his age the desire for a popular philosophy to meet individual needs. But there was another tendency in post-Aristotelian thought-to lean upon authority and substitute learning for independent researchwhich grew stronger just in proportion as the fresh interest in the problems of the universe and the zeal for discovery declined-a shadow, we may call it, of the coming Scholasticism thrown a thousand years in advance. The representative of this tendency, Chrysippus, addressed himself to the congenial task of assimulating, developing, systematizing the doctrines bequeathed to him. and, above all, securing them in their stereotyped and final form, not simply from the assaults of the past, but, as after a long and successful career of controversy and polemical authorship he

pedantry which ever afterwards marked the activity of the school, the dry repellent technical procedure of the Dialecticians par excellence, as they were called He created their formal logic and contributed much that was of value to their psychology and epistemology, but in the main his work was to new-label and newarrange in every department, and to lavish most care and attention on the least important parts-the logical terminology and the refutation of fallacies, or, as his opponents declared, the excogitation of fallacies which even he could not refute.

Stoic Conception of Philosophy.-What is philosophy? No idle gratification of curiosity, no theory divorced from practice, no pursuit of science for its own sake, but knowledge so far forth as it can be realized in virtuous action, the learning of virtue by exer cise and effort and training So absolutely is the "rare and price less wisdom" identical with virtue itself that the three main divisions of philosophy current at the time and accepted by Zeno -logic, physics and ethics-are defined as the most generic or comprehensive virtues. Accordingly Aristo rejected two of these parts of philosophy as useless and out of reach-a divergence which excluded him from the school, but strictly consistent with his view that ethics alone is scientific knowledge. Of the three divisions logic is the least important; ethics is the outcome of the whole, and historically the all-important vital element, but the foundations of the whole system are best discerned in the science of nature, which deals pre-eminently with the macrocosm and thé microcosm, the universe and man, including natural theology and anthropology or psychology, the latter forming the direct introduction to ethics

Physics.—The Stoic system is in brief: (a) materialism, (b) dynamic materialism, lastly (c) monism or pantheism (a) The first of these characters is described by anticipation in Plato's Sophist (246 C seq ), where, arguing with those "who drag everything down to the corporeal"  $(\sigma \hat{\omega} \mu a)$ , the Eleatic stranger would fain prove to them the existence of something incorporeal, as follows "They admit the existence of an animate body Is soul then something existent (ovola)? Yes And the qualities of soul, as justice and wisdom-are they visible and tangible? No Do they then exist? They are in a dilemma" Now, however effective against Plato's contemporary Cynics or Atomists, the reasoning is thrown away upon the Stoics, who take boldly the one horn of this dilemma That qualities of bodies (and therefore of the corporeal soul) exist they do not deny; but they assert most uncompromisingly that they are one and all (wisdom, justice, etc.) corporeal And they strengthen their position by taking Plato's own definition (247 D), namely "being is that which has the power to act or be acted upon," and turning it against him For this is only true of Body; action, except by contact, is inconcervable; and they reduce every form of causation to the efficient cause, which implies the communication of motion from one body to another Again and again, therefore, only Body exists. The most real realities to Plato and Aristotle had been thought and the objects of thought, νοθs and νοητά, whether abstracted from sensibles or inherent in "matter," as the incognizable basis of all concrete existence. But this was too great an effort to last long Such spiritualistic theories were nowhere really maintained after Aristotle and outside the circle of his immediate followers The reaction came and left nothing of it all; for five centuries the dominant tone of the older and the newer schools alike was frankly materialistic. "If," says Aristotle, "there is no other substance but the organic substances of nature, physics will be the highest of the sciences," a conclusion which passed for axiomatic until the rise of Neoplatonism. The analogues therefore of metaphysical problems must be sought in physics; particularly that problem of the causes of things for which the Platonic idea and the Peripatetic "constitutive form" had been, each in its turn, received solutions. (b) But the doctrine that all existence is confined within the limits of the sensible universe-that there is no being save corporeal being or body-does not suffice to characterize the Stoic system; it is no less a doctrine of the Epicureans. It is the idea of tension or tonicity as the essential attrifondly hoped, from all possible attack in the future. To his per- bute of body, in contradistinction to passive inert matter, which 432 STOICS

is distinctively Stoic. The Enjoyreans leave unexplained the primary constitution and first movements of their atoms or elemental solids, chance or declination may account for them Now, to the Stoics nothing passes unexplained, there is a reason (λόγος) for everything in nature Everything which exists is at once capable of acting and being acted upon In everything that exists, therefore, even the smallest particle, there are these two principles By virtue of the passive principle the thing is susceptible of motion and modification; it is matter which determines substance (obota). The active principle makes the matter a given determinate thing, characterizing and qualifying it, whence it is termed quality (ποιότης). For all that is or happens there is an immediate cause or antecedent; and as "cause" means "cause of motion," and only body can act upon body, it follows that this antecedent cause is itself as truly corporeal as the matter upon which it acts Thus we are led to regard the active principle "force" as everywhere coextensive with "matter," as pervading and permeating it, and together with it occupying and filling space This is that famous doctrine of universal permeation (κράσις δί όλου), by which the axiom that two bodies cannot occupy the same space is practically denied. Thus that harmony of separate doctrines which contributes to the impressive sumplicity of the Stoic physics is only attained at the cost of offending healthy common sense, for Body itself is robbed of a characteristic attribute A thing is no longer, as Plato once thought, hot or hard or bright by partaking in abstract heat or hardness or brightness, but by containing within its own substance the material of these qualities, conceived as air-currents in various degrees of tension We hear, too, of corporeal days and years, corporeal virtues, and actions (like walking) which are bodies (σώματα) Obviously, again, the Stoic quality corresponds to Aristotle's essential form; in both systems the active principle, "the cause of all that matter becomes," is that which accounts for the existence of a given concrete thing (λόγος της οὐσίας). Only here, instead of assuming something immaterial (and therefore unverifiable), we fall back upon a current of air or gas (πνεθμα), the essential reason of the thing is itself material, standing to it in the relation of a gaseous to a solid body. Here, too, the reason of thingsthat which accounts for them-is no longer some external end to which they are tending; it is something acting within them, "a spirit deeply interfused," germinating and developing as from a seed in the heart of each separate thing that exists (λόγος σπερματικός). By its prompting the thing grows, develops and decays, while this "germinal reason," the element of quality in the thing, remains constant through all its changes,

Psychology and Theory of Knowledge.-If, however, in the science of nature the Stoics can lay claim to no striking originality, the case is different when we come to the science of man. In the rational creatures-man and the gods-Pneuma is manifested in a high degree of purity and intensity as an emanation from the world-soul, itself an emanation from the primary substance of purest ether—a spark of the celestial fire, or, more accurately, fiery breath, which is a mean between fire and air, characterized by vital warmth more than by dryness The physical basis of Stoic psychology deserves the closest attention. On the one hand, soul is corporeal, else it would have no real existence, would be incapable of extension in three dimensions (and therefore of equable diffusion all over the body), incapable of holding the body together, as the Stoics contended that it does, herein presenting a sharp contrast to the Epicurean tenet that it is the body which confines and shelters the light vagrant atoms of soul. On the other hand, this corporeal thing is veritably and identically reason, mind, and ruling principle (λόγος, μους, ήγεμονικόν); in virtue of its divine origin Cleanthes can say to Zeus, "We too are thy offspring," and a Seneca can calmly insist that, if man and God are not on perfect equality, the superiority rests rather on our side. What God is for the world that the soul is for man. The Cosmos must be conceived as a single whole, its variety being referred to varying stages of condensation in Pneuma. So, too, the human soul must possess absolute sim-plicity, its varying functions being conditioned by the degrees or species of its tension. It follows that of "parts" of the soul,

as previous thinkers imagined, there can be no question; all that can consistently be maintained is that from the centre of the body—the heart—seven distinct air-currents are discharged to various organs, which are so many modes of the one soul's activity. The ethical consequences of this position will be seen at a later stage. With this psychology is unimately connected the Stote theory of knowledge. From the unity of soul it follows that all psychical processes—ensation, assent, impulse—proceed from reason, the ruling part; that is to say, there is no strife or division the one rational soul alone has sensations, assents to judgments, is impelied towards objects of desire just as much as it thinks or reasons.

Cosmopolitanism .- In their view of man's social relations the Stoics are greatly in advance of preceding schools We saw that virtue is a law which governs the universe; that which Reason and God ordain must be accepted as binding upon the particle of reason which is in each one of us. Human law comes into existence when men recognize this obligation, justice is therefore natural and not something merely conventional The opposite tendencies, to allow to the individual responsibility and freedom, and to demand of him obedience to law, are both features of the system, but in virtue even of the freedom which belongs to him qua rational, he must recognize the society of rational beings of which he is a member, and subordinate his own ends to the ends and needs of this society. Those who own one law are citizens of one state, the city of Zeus, in which men and gods have their dwelling In that city all is ordained by reason working intelligently, and the members exist for the sake of one another; there is an intimate connection (συμπάθεια) between them which makes all the wise and virtuous friends, even if personally unknown, and leads them to contribute to one another's Their intercourse should find expression in justice, in friendship, in family and political life. But practically the Stoic philosopher always had some good excuse for withdrawing from the narrow political life of the city in which he found himself. The circumstances of the time, such as the decay of Greek citylife, the foundation of large territorial states under absolute Greek rulers which followed upon Alexander's conquests, and afterwards the rise of the world-empire of Rome, aided to develop the lead-ing idea of Zeno's Republic. There he had anticipated a state without family life, without law courts or coms, without schools or temples, in which all differences of nationality would be merged in the common brotherhood of man. This cosmopolitan citizenship remained all through a distinctive Stoic dogma; when first announced it must have had a powerful influence upon the minds of men, diverting them from the distractions of almost parochial politics to a boundless vista. There was, then, no longer any difference between Greek and barbarian, between male and female, bond and free

Religion—The religious problem had peculiar interest for the school which discerned God everywhere as the ruler and upholder, and at the same time the law, of the world that He had evolved from Himself. The physical ground-work lends a religious sancton to all moral duties, and Cleanthes's noble hymn is evidence how far a system of natural religion could go in providing satisfaction for the cravings of the religious temper;—

iaction for the cravings of the religious temper:—
"Most glorious of mumortals, Jo Zeus of many names, almighty and everlasting, sovereign of nature, directing all in accordance with universe, as it rolls circling round the earth, obey wheresoever thou dost guade, and gladly owns thy sway. Such a mumster thus holdest in thy invincible hands—the two-edged, fiery, everliving thunderbolt, under whose stroke all nature shudders. No work upon earth is wrought apart from the, lord, nor through the drone etherest sphere, own foolshiness. Nay, thou knowest how to make even the rough smooth, and to bring order out of disorder; and things not friendly are friendly in thy sight. For so hast thou fitted all things together, the good with the evil, that there might be one ternal law over all. . . . Deliver men from tell genorance. Banish if, father, from the tool, and the with gustness of the such parts of the s

To the orthodox theology of Greece and Rome the system stood in a twofold relation, as criticism and rationalism. That the popular religion contained gross errors hardly needed to be

STOICS 433

images, shrines, temples, sacrifices, prayers and worship to be of no avail A really acceptable prayer, he taught, can only have reference to a virtuous and devout mind. God is best worshipped in the shrine of the heart by the desire to know and obey Him At the same time the Stoics felt at liberty to defend and uphold the truth in polytheism Not only is the primitive substance God, the one supreme being, but divinity must be ascribed to His manifestations—to the heavenly bodies, which are conceived, like Plato's created gods, as the highest of rational beings, to the forces of nature, even to deified men; and thus the world was peopled with divine agencies. Moreover, the myths were rationalized and allegorized, which was not in either case an original procedure The search for a deeper hidden meaning beside the literal one had been begun by Democritus, Empedocles, the Sonhists and the Cynics It remained for Zeno to carry this to a much greater extent and to seek out or invent "natural principles" (λόγοι φυσικοί) and moral ideas in all the legends and in the poetry of Homer and Hesiod In this sense he was the pat-

tern if not the "father" of all such as allegorize and reconcile.

Stoicism in Rome.—The introduction of Stoicism at Rome was the most momentous of the many changes that it saw After the first sharp collision with the jealousy of the national authorities it found a ready acceptance, and made rapid progress amongst the noblest families. It has been well said that the old heroes of the republic were unconscious Stoics, fitted by their narrowness, their stern simplicity and devotion to duty for the almost Semitic earnestness of the new doctrine In Greece its insensibility to art and the cultivation of life was a fatal defect; not so with the shrewd men of the world, desirous of qualifying as advocates or jurists. It supplied them with an incentive to scientific research in archaeology and grammar; it penetrated jurisprudence until the belief in the ultimate identity of the jus gentium with the law of nature modified the practor's edicts for centuries Even to the prosaic religion of old Rome, with its narrow original conception and multitude of burdensome rites, it became in some sort a support. Scaevola, following Panaetius, explained that the prudence of statesmen had established this public institution in the service of order midway between the errors of popular superstition and the barren truths of enlightened philosophy. Soon the influence of the pupils reacted upon the doctrines taught. Of speculative interest the ordinary Roman had as little as may be; for abstract discussion and controversy he cared nothing Indifferent to the scientific basis or logical development of doctrines. he selected from various writers and from different schools what he found most serviceable All had to be simplified and disengaged from technical subtleties. To attract his Roman pupils Panaetius would naturally choose simple topics susceptible of rhetorical treatment or of application to individual details. He was the representative, not merely of Stoicism, but of Greece and Greek literature, and would feel pride in introducing its greatest masterpieces, amongst all that he studied, he valued most the writings of Plato. He admired the classic style, the exquisite purity of language, the flights of imagination, but he admired above all the philosophy. He marks a reaction of the genuine Hellenic spirit against the austerity of the first Stoirs.

The Later Stoics,-The writings of the later Stoics have come down to us, if not entire, in great part, so that Seneca, Cornutus, Persius, Lucan, Epictetus, Marcus Aurelius are known at first hand. They do not profess to give a scientific exposition of doctrine, and may therefore be dismissed somewhat briefly (see EPICTETUS and MARCUS AURELIUS). We learn much more about the Stoic system from the scanty fragments of the first founders, or even from the epitomes of Diogenes Laërtius and Stobaeus. than from these writers. They testify to the restriction of philosophy to the practical side, and to the increasing tendency, ever since Panaetius, towards a relaxation of the rigorous ethical doctrine and its approximation to the form of religious conviction. This finds most marked expression in the doctrines of submission to Providence and universal philanthropy. Only in this way could they hold their ground, however insecurely, in face of the re-

pointed out The forms of worship were known to be trivial or ligious reaction of the 1st century. In passing to Rome, Stoicism mischievous, the myths unworthy or immoial. But Zeno declared quitted the school for actual life. The fall of the republic was a gam, for it released so much intellectual activity from civic duties. The life and death of Cato fired the imagination of a degenerate age in which he stood out both as a Roman and a Stoic To a long line of illustrious successors, men like Thrasea Paetus and Helvidius Priscus, Cato bequeathed his resolute opposition to the dominant power of the times, unsympathetic, impracticable, but fearless in demeanour, they were a standing reproach to the corruption and tyianny of their age But when at first, under Augustus, the empire restored order, philosophy became bolder and addressed every class in society, public lectures and spiritual direction being the two forms in which it mainly showed activity. Books of direction were written by Sextius in Greek (as afterwards by Seneca in Latin), almost the only Roman who had the ambition to found a sect, though in ethics he mainly followed Stoicism His cor emporary Papirius Fabianus was the popular lecturer of that day, producing a powerful effect by his denunciations of the mamers of the time Under Tiberius, Sotion and Attalus were at ended by crowds of hearers.

Seneca .- Seneca is the most prominent leader in the direction which Roman Stoicism now took. His penetrating intellect had mastered the subtleties of the system of Chrysippus, but they seldom appear in his works, at least without, apology. Incidentally we meet there with the doctrines of Pneuma and of tension, of the corporeal nature of the virtues and the affections, and much more to the same effect. But his attention is claimed for physics chiefly as a means of elevating the mind, and as making known the wisdom of Providence and the moral government of the world. To reconcile the ways of God to man had been the ambition of Chrysippus, as we know from Plutarch's criticisms. He argued plausibly that natural evil was a thing indifferent-that even moral evil was required in the divine economy as a foil to set off good The really difficult problem why the prosperity of the wicked and the calamity of the just were permitted under the divine government he met in various ways, sometimes he alleged the forgetfulness of higher powers; sometimes he fell back upon the necessity of these contrasts and grotesque passages in the comedy of human life Seneca gives the true Stoic answer in his treatise On Providence: the wise man cannot really meet with misfortune; all outward calamity is a divine instrument of training, designed to exercise his powers and teach the world the indifference of external conditions In the soul Seneca recognizes an effluence of the divine spirit, a god in the human frame; in virtue of this he maintains the essential dignity and internal freedom of man in every human being. Yet, in striking contrast to this orthodox tenet is his vivid conception of the weakness and misery of men, the hopelessness of the struggle with evil, whether in society or m the individual Thus he describes the body (which, after Epicurus, he calls the flesh) as a mere husk or fetter or prison of the soul; with its departure begins the soul's true life. Sometimes, too, he writes as if he accepted an irrational as well as a rational part of the soul. In ethics, if there is no novelty of doctrine, there is a surprising change in the mode of its application The ideal sage has receded, philosophy comes as a physician, not to the whole but to the sick We learn that there are various classes of patients in "progress" (προκοπή), i.e., on their way to virtue, making painful efforts towards it. The first stage is the eradication of vicious habits: evil tendencies are to be corrected, and a guard kept, on the corrupt propensities of the reason. Suppose this achieved, we have yet to struggle with single attacks of the passions; irascibility may be cured, but we may succumb to a fit of rage. To achieve this second stage the impulses must be trained in such a way that the fitness of things indifferent may be the guide of conduct. Even then it remains to give the will that property of rigid infallibility without which we are always liable to err, and this must be effected by the training of the judgment. Other peculiarities of the later Stoic ethics are due to the condition of the times. In a time of moral corruption and oppressive rule, as the early empire repeatedly became to the privileged classes of Roman society, a general feeling of insecurity led the student of philosophy to seek in it a refuge against the vicusitudes of fortune which he daily beheld

Musonius—From Seneca we turn, not without satisfaction, to men of sterner mould, such as Musonius Ruffus, who certainly deserves a place beside his more illustrious disciple, Epictetus As a teacher he commanded universal respect, and wherever we catch a glimpse of his activity he appears to advantage His philosophy, however, is yet more concentrated upon practice than Seneca's, and in ethics he is almost at the position of Arlisto. Epictus testifies to the powerful hold he acquired upon his pupils, each of whom felt that Musonius songe to his heart.

Epictetus.-In the life and teaching of Epictetus this thought bore abundant fruit. The beautiful character which rose superior to weakness, poverty and slave's estate is also presented to us in the Discourses of his disciple Airian as a model of religious resignation, of forbearance and love towards our brethren, that is, towards all men, since God is our common father. With him even the "physical basis" of ethics takes the form of a religious dogma—the providence of God and the perfection of the world We learn that he regards the  $\delta a l \mu \omega \nu$  or "guardian angel" as the divine part in each man; sometimes it is more nearly conscience, at other times reason. His ethics, too, have a religious character. He begins with human weakness and man's need of God: whoso would become good must first be convinced that he is evil Submission is enforced by an argument which almost amounts to a retractation of the difference between things natural and things contrary to nature, as understood by Zeno. Would you be cut off from the universe? he asks Go to, grow healthy and rich, But if not, if you are a part of it, then be resigned to your lot.

Aurelius.- Epictetus is marked out amongst Stoics by his renunciation of the world. He is followed by a Stoic emperor, M. Aurelius Antoninus, who, though in the world, was not of it. The Meditations give no systematic exposition of belief, but there are many indications of the religious spirit we have already observed. together with an almost Platonic psychology. Following Epictetus. he speaks of man as a corpse bearing about a soul; at another time he has a threefold division—(1) body, (2) soul, the seat of impulse (πνευματίον), and (3) νοῦs or intelligence, the proper ego. In all he writes there is a vein of sadness, the flux of all things, the vanity of life, are thoughts which perpetually recur, along with resignation to the will of God and forbearance towards others, and the religious longing to be rid of the burden and to depart to God. These peculiarities in M. Antoninus may perhaps be explained in harmony with the older Stoic teaching; but, when taken in connection with the rise of Neoplatonism and the revival of superstition, they are certainly significant. None of the ancient systems fell so rapidly as the Stoa. It had just touched the highest point of practical morality, and in a generation after M. Antoninus there is hardly a professor to be named. Its most valuable lessons to the world were preserved in Christianity; but the grand simplicity of its monism slumbered for fifteen centuries before it was revived by Spinoza.

before it was revived by Spinoza.

BERLIGORAFUT.—Zeller, Påkt. G. Gricke, iii, pt. 1. (3rd ed., 1880)—
Eng. trans. Stones, by Reichel (1870), and Eclectics, by S. F. Alleyne
Eng. trans. Stones, by Reichel (1870), and Eclectics, by S. F. Alleyne
Die Leire vom Logos (Oklonburg, 1870). H. Sebeck, Disternous particular
Cicklan, 1880, J. R. Hirtel, "Die Benivaching effect stones, Phil." in
Untersuchungen zu Ciccoro Schriten, in. 2-560 (Leipme, 1880); Ogereau, Eras zur Es zysthen des Stonesse (Paras, 1885); I. S. Stone
una, Eras zur Estythen des Stonesse (Paras, 1885); I. S. Chen,
Phillosphie der Stone, i. p. ii. (Bertin, 1880); A. C., Pearson, The
Proceedings of the Stonesse (Paras, 1885); I. S. Stone
philosphie der mitthress Stone (Bertin, 1890); A. Bonchiffer, Estele
und die Ston (Stuttgurt, 1890); Die Elbnis des Stokers Expetes (Stuttsurt, 1891); A. Dyrof, Die Elbnis der allen Stone (Bertin, 1890); R. D.
Hicks, Stoler and Experiencess (1910); E. V. Arnold, Roman Stotcian
(J. von Artum, Stotcian westerum fragmentia), Lin, Lickpie, 1900-190.
See also Errates, Hirsver or, and Loone, Hirsver or, R. D. H.).

STOKE DEWINGTON. a metropolitan brough of London.

STOKE NEWINGTON, a metropolitan borough of London, England, Pop. (1951) 49, 137; area 1.3 sq.mi. In Church street is the restored ancient parish church of St Mary. The borough returns one member to parliament. A new town hall was opened in 1937.

STOKE-ON-TRENT, a city in Staffordshire, England, in the heart of the Potteries. Pop. (1951) 275,095. Area 33.1 sq mi Stoke-upon-Trent, Burslem, Fenton, Hanley, Longton and Tun-

stall were amalgamated on March 31, 1910. In 1928 the borough became a city, with a lord mayor, and in 1920 was further extended. The principal public buildings are the town hall (enlarged 1910-19), the county court offices, the market hall, the Minton memorial building, and the North Staffordshire Technical college (1914, enlarged 1921), containing the Solon bibary ocramics, one of the finest in existence. There are several large pulss, In addition to the potteries, there are coal mines, as well as deposits of coarse clay, but the finer china-clay comes from Cornwall and elsewhere. Other industries are electrical accessories, rubber tire manufacture, dyeing, etc. The district is well served by railways and also by the Grand Trunk (Trent and Mersey) canal. There is a statue to Josiah Wedgwood (b. 1730) in Burslem. Other names made famous by the pottery industry here are Josiah Spode (b. 1754), Herbert Minton (b. 1793) and W. T. Coolead.

In the Domesday Survey of 1086 half the church of Stoke and lands in Stoca are said to have belonged to Robert of Stafford Market rights were not acquired until 1845 By the Reform Bill (1832) Stoke sent two members to parhament, and after 1918 sent three members

It was first incorporated in 1874

STOKE POGES, parish and village in Buckinghamshire, Eng, about z mi N of Slough. Pop. (1921 st) 15,500. Area 4 sq mi It is a residential area. Humbert de Pugeis held the manor in 1255. St. Giles's chunch is of mixed architectural styles, Thomas Gray is burned in the churchyard, held to be the original of his Elegy. William Penn (q v) built the manor house, later a golf cheb.

STOKES, ADRIAN (1887-1927), English bacteriologist, was born at Lausanne, and educated at Trinity college, Dublin, becoming demonstrator in anatomy, and assistant professor of pathology. During the World War, he established a mobile laboratory for the prevention of epidemic outbreaks, including typhoid. His inoculation of the Belgian civil population helped to suppress enteric. He was awarded the Belgian order of the Crown, and in 1918 received the DSO After the war (1919) he became professor at Dublin and in 1922 he was appointed to the Sir William Dunn chair of pathology. In 1920 the Rockefeller Commission on Yellow Fever in West Africa included Stokes among its members, and in 1927 asked him to go out to West Africa. He collaborated with Hideyo Noguchi (q.v) and William Young, and their discovery of a monkey susceptible to the disease enabled them to prepare a preventive vaccine. Stokes became infected with the disease, and died on Sept. 19, 1927. He published papers, particularly on infectious jaundice, typhoid carners and dysentery.

and opsentery.

STOKES, SIR (FREDERICK) WILFRID SCOTT
K.B.E. (1860-1937), engineer and mventor, son of Scott Nasmyth Stokes, was born in 1860 at Liverpool After some years
in ratiway work he joined Rausomes and Rapier of I pswich, becoming managing director and charman He was distinguished
in many branches of engineering. His inventions, for which some
fity patients were granted, included imprements in sluce gates,
making machinery, ordanace and projectiles. He, had a share in
many notable engineering achievements at home and abroad,
including the Manchester ship canal and the irrigation works in
India, Egypt and the Sudan. He was responsible for the design
of the sluice and lock gates, and he was present both at the openmo of the Assum dam 1907 and of the Senard dam 1926.

From 1915 until 1918 Stokes served on Ministry of Munitions inventions committees, and he was also chairman of the East Anglan and other munitions committees. In 1915 he acquired fame by the timely invention of the Stokes trench mortar and ammunition.

At great personal risk, without previous technical knowledge of explosives he perfected the shells of which more than trenspy million rounds were used with deadly effect in the trenches and at Zeebrugge and elsewhere. He also promoted the invention of effect enti-directaft shells. For his public services he was created K B.E. in 1917. Stokes was president of the British Engineers' Association 1916–1918.

See Handbook of Stokes' Trench Mortar Equipment (1920); History of the Ministry of Munitions (1922); T. E. Lawrence, Revolt in the

Desert (1927), W. Slokes, "Sluces and Lock Gates of the Nile Reservoir, Assuan," Proc. Inst Crul Engineers (1902–03), "The Stokes Gun and Shell and their development," Engineering, June 28, 1918, "The Senant Dam," Engineering, Jan 22, 7956, "The late Str W. Stokes," Engineering, Feb. 11, 1927, "The Stokes Gun," Whitchall 1918, "The Senhat Dain, Engineering, Jan 22, 1920, "The late Si Stokes," Engineering, Feb 11, 1927, "The Stokes Gun," Whit Gazette, Oct 1919, "Sir W. Stokes," The Engineer, Feb 11, 1927

STOKES, SIR GEORGE GABRIEL, BARF (1819-1903). British mathematician and physicist, son of the rector of Skreen. Co Sigo, Ireland, was born on Aug 13, 1819 In 1837 he entered Pembroke college, Cambridge, where he became a fellow in 1841 He lost his fellowship when he married in 1857, but twelve years later, under new statutes, he was re-elected In 1902, he was elected Master. As Lucasian professor, secretary and president of the Royal Society, he held three offices, which had only once before been held by one man, Sir Isaac Newton He was member of parliament for the University from 1887 to 1802. was created baronet in 1889 and died on Feb 1, 1903.

Stokes was the oldest of the trio of physicists, Clerk Maxwell and Lord Kelvin being the other two, who especially contributed to the fame of the Cambridge school of mathematical physics in the middle of the 19th century The Royal Society's catalogue of scientific papers gives the titles of over a hundred memoirs by him published down to 1883. The greater part of his work was concerned with waves and the transformations imposed on them during their passage through various media. His first published papers, which appeared in 1842 and 1843, were on the steady motion of incompressible fluids and some cases of fluid motion, these were followed in 1845 by one on the friction of fluids in motion and the equilibrium and motion of elastic solids, and in 1850 by another on the effects of the internal friction of fluids on the motion of pendulums To the theory of sound he made several contributions, including a discussion of the effect of wind on the intensity of sound and an explanation of how the intensity is influenced by the nature of the gas in which the sound is produced These inquiries together put the science of hydrodynamics on a new footing, and provided a key not only to the explanation of many natural phenomena, such as the suspension of clouds in air, and the subsidence of ripples and waves in water, but also to the solution of practical problems, such as the flow of water m rivers and channels, and the skin resistance of ships

His best-known researches are perhaps those on the undulatory theory of light His first papers on the aberration of light appeared in 1845 and 1846, and were followed in 1848 by one on the theory of certain bands seen in the spectrum. In 1849 his paper on the dynamical theory of diffraction showed that the plane of polarization must be perpendicular to the direction of Two years later he discussed the colours of thick plates, and in 1852, in his famous paper on the change of refrangibility of light, he described the phenomenon of fluorescence, as exhibited by fluorspar and uranium glass, materials which he viewed as having the power to convert invisible ultra-violet rays into rays of wave lengths which are visible. A mechanical model, illustrating the dynamical principle of Stokes's explanation was shown in 1883, during a lecture at the Royal Institution, by Lord Kelvin, who said he had heard an account of it from Stokes many years before, and had repeatedly but vainly begged him to publish it. In the same year, 1852, there appeared the paper on the composition and resolution of streams of polarized light from different sources, and in 1853 an investigation of the metallic reflection exhibited by certain non-metallic substances About 1860 he was engaged in an inquiry on the intensity of light reflected from, or transmitted through, a pile of plates; and in 1862 he prepared for the British Association a valuable report on double refraction, which marks a period in the history of the subject in England. A paper on the long spectrum of the electric light bears the same date, and was followed by an inquiry into the absorption spectrum of blood

The discrimination of organic bodies by their optical properties was treated in 1864; and later, in conjunction with the Rev. W. Vernon Harcourt, he investigated the relation between the chemical constitution and the optical properties of various glasses, with reference to the conditions of transparency and the improvement of achromatic telescopes. A still later paper connected with the

construction of optical instruments discussed the theoretical limits to the aperture of microscopical objectives. In other departments of physics may be mentioned his paper on the conduction of heat in crystals (1851) and his inquiries in connection with the radiometer, his explanation of the light border frequently noticed in photographs just outside the outline of a dark body seen against the sky (1883); and, still later, his theory of the Rontgen rays, which he suggested might be transverse waves travelling as innumetable solitary waves, not in regular trains Two long papers published in 1849-one on attractions and Clairaut's theorem, and the other on the variation of gravity at the surface of the earthalso demand notice, as do his mathematical memoirs on the critical values of the sums of periodic series (1847) and on the numerical calculation of a class of definite integrals and infinite series (1850) and his valuable discussion of a differential equation relating to the strains, stresses and other factors involved in the breaking of railway bridges (1849)

Many of his discoveries were only touched upon in lectures An instance is his work in the theory of spectrum analysis Some of Stokes's friends and punils claimed that he had anticipated Kirchhoff but Stokes maintained that he had failed to see an essential step in the argument and disclaimed priority. As Lucasian professor. Stokes announced that he wished to help any member of the university in his mathematical studies, and pupils were glad to consult him, even after they had become colleagues During the thirty years of his secretaryship to the Royal Society he advanced the cause of mathematical and physical science, not only by his own investigations, but by suggesting problems for

inquiry and inciting men to attack them.

He received the Rumford medal in 1852 and in 1893, the Copley medal His numerous other honours included the Prussian Ordie pour le Mérite. In 1869 he presided over the Exeter meeting of the British Association

or George Stokes's mathematical and physical papers were pub-ed in a collected form in five volumes, the first three (Cambridge, Sir George Noxes's mathematical and physical papers were puriabled in a collected form in the volumes, the first three (Cambridge, Indied in the Cambridge, 1998) and 1998 and 1998 under that of Sir Joseph Laumor, who also selected and arranged the Henom and Scientific Correspondence of Stokes published at Cambridge in 1997. Stokes was the author of Light (1884–197) and Natural Theology (1891).

STOKES, WHITLEY (1830-1909), British lawyer and Celtic scholar, was a son of William Stokes (1804-1878), and a grandson of Whitley Stokes (1763-1845), each of whom was regius professor of physic in the university of Dublin Educated at Trinity college, Dublin, young Stokes became a barrister and in 1862 went out to India In 1877 he became legal member of the viceroy's council, and he drafted the codes of civil and criminal procedure. After his return to England in 1882 he devoted himself to the Celtic studies which made him famous. He studied Irish, Breton and Cornish texts, and among his numerous works may be mentioned editions of Three Irish Glossaries (1862): Three Middle-Irish Homsles (1877); and Old Irish Glosses at Wurzburg and Carlsruhe (1887) He was one of the editors of the Irische Texte published at Leipzig (1880-1900); and he edited and translated Lives of Samts from the Book of Lismore (1890) With Professor A. Bezzenberger he wrote Urkeltischer Sprachschatz (1894) His principal legal work was The Anglo-Indian Codes (1887). He died in London, April 13, 1909.

STOKESAY, a fortified manor house in Shtopshire, Eng., 61 mi. N.W. of Ludlow. Stokesay castle is one of the most remarkable moated manor houses surviving in England. It was built in 1240 by John de Verdon with banqueting hall, north tower and solar (panelled in the 17th century). The south tower was added in 1291 when the Ludlows bought Stokesay and fortified it The 16th-century half-timbered gatehouse replaces the old entrance tower From 1620 to 1869 (when it was thoroughly repaired) Stokesay belonged to the lords Craven,

STOLBERG, FRIEDRICH LEOPOLD, GRAF ZU (1750-1819), German poet, the younger son of Count Christian Stolberg, was born at Bramstedt in Holstein on Nov. 7, 1750 He studied in Göttingen and was a member of the famous Göttinger Hum or Dichterbund. After leaving the university he made a journey to Switzerland with his brother Christian, in company with Goethe In 1777 he was appointed envoy of the prince bishop of Lubeck at the court of Copenhagen, but often stayed at Eutin, where he was the intimate associate of J H Voss In 1782 he married Agnes you Witzleben, whom he celebrated in his peams After her early death in 1788, he became Danish envoy at the court of Berlin, and contracted a second marriage with the countes Sophie von Redern in 1780, In 1791 he was appointed president of the Lubeck episcopal court at Eutin, he resigned this office in 1800, and returning to Munster in Westphalia, there jouned, with his whole family, the eldest daughter only excepted, the Roman Catholic Church For this set ple was severely attacked 1810.

After Iving for a while (from 1812) in the neighbourhood of Bildefeld, Stoberg removed to bus estate of Sondermublen near Onabruck, where he ched on Dec 5, 1819. He wrote many odes, ballads, satires and dramas—among the last the tragedy Timoleon (1784), translations of the Hiad (1778), of Plato (1706–1797), Asschylus (1802), and Ossian (1806), he published in 1815, a Leben Alfredd des Grossen, and a voluminous Geschichte der

Religion Jesu Christi (17 vol , 1806-1818).

Stölberg's brother, Christian, Gara zu Stoleerg's hether, Eristian, Gara zu Stoleerg's Hazil, was also apect. Born at Hamburg on Oct 15, 1748, he became a magustrate at Tremsbuttel in Holstem in 1777, and died on Jan 18, 1821. Of the two brothers Frendrich was undeubtedly the more talented, but Christian, though not a poet of high originality, excelled in the utterance of gentle sentiment. They published together a volume of poems, Gedichte (edited by the contract of the co

Christian von Stolberg was the sole author of Gedichte aus dem Griechtschen (1782), a translation of the works of Sophocles (1787), and of a poem in seven ballads, Die wesse Frau (1814), which last attained considerable popularity.

The Collected Works of Christian and Friedrich Leopold zu Stolerg were published in zo vol 1820-25, rade di 827). Friedrich's correspondence with F. H. Jacobi will be tound in Jacobis Breigneschen Steller and Steller Steller and Steller S

STOLBERG, a town of Germany formerly in the Prussian Rhine province and after 1945 in N. Rhine-Westphalia, about 6 mi E of Aachen.

The population of Stolberg in 1039 was 20,498. Its prosperity began in the ryth century, when French refugees introduced brass founding. A castle was built on the site of a church said to have been used by Charlemagne Leading industries developed there include metal-working in zinc, brass and iron.

STOLE, a liturgical vestiment of the Catholic Church, peculiar to the higher orders, i.e., descons, priests and hisbops. It is a strip of material, usually silk, some 2½ vd. long by 4 in wide; in the middle and at the ends, which are commonly broadened out, it is ornamented with a cross. Its colour varies with the liturgical colour of the day, or of the function at which it is worn. The stole is worn immediately over the abl or surplice; by deacons, scartifwise over the let shoulder, across the breast and back to the right side; by peters and bishops, dependent from the neck, the two ends failing over the breast; In the case of bishops the stole always hangs straight down; while priests ware it crossed over the breast when vested in the alb. According to the Roman Catholic usage the stole is worn only while performing religious functions.

The origin of the stole is very obscure. It has been variously derived from the ancient stole, which was, however, a tunic, from the Jewish prayer blanket (tallith), from the ancient oration (neck (olth) and, as regards the diaconal stole, from a napkin used in the litturgy. Father Braun, however, in his Liturgache Gesend-

ung, gives good reasons for rejecting all these derivations and suggests that the stole was originally introduced as that which first appears in the 22nd canon of Laodicea, viz, a special mark of distinction for deacons, which was later extended to higher orders

The stole was not one of the vestments prescribed by the rubures of the first Prayer book of Edward VI (see VESTMENTS) It was replaced in the Church of England from the Reformation onward by the scarf, a broad band of black silk, formerly part of the outdoor dress of the dignified clergy and without hturgical significance. This vestment has some resemblance to the stole, in that its sworn round the neck, hanging straight down in front over each shoulder. This resemblance facilitated the reintroduction of the stole by the "Ritualists" during the 19th century. The revised Prayer book, adopted by convocation and the church assembly in 1027, authorized the use of the "stole or scarf."

STOLEN GOODS: See LARCENY

\$TOLP or Stupsex, a town formerly in Pomerania, Germany, and after 1943 in Kossalin province, Pol Pop (1946) 33,948
Stolp received town rights in 1273 From the 14th to the 16th century it was a member of the Hainseatic league Until 1627, when it passed to Brandenburg, the town usually belonged to the dukes of Pomerania The large church of St Mary, with a 14th century tower, the 16th century Renaissance castle which became a prison, one of the ancient town-gates restored in 1872 and the church of St 16th f 12th century are the 10dest buildings.

church of St. John (13th century) are the oldest buildings STOLYPIN, PETER ARCADIEVICH (1863—1911), Russan statesman, was born at Baden-Baden in 1863. He was educated at St Petersburg (Leningrad), and n 1902 he became governor of Grodno, and in 1903 of Saratov, where he was a firm administrator.

In 1906 Stolypin was minister of internal affairs, and in July succeeded Goremykin as minister-president (See Russia.) His relentless policy led to attempts upon his life. In Aug 1906 a bomb was exploded at his summer residence, injuring a daughter, and on Sept 14, 1911, he was shot in a theatre at Kiev before the eyes of the Imperial family, by a Jew, Mordka Bogrov He died on Seot. 18, 1911

STOMACH, the bagiske digestive organ which in man is in the upper left part of the abdomen lying between the oesophasgus and the duodenum For anatomical details see ALIMENTARY CANAL For the diseases of the stomach in general see ALIMENTARY SYSTEM, DISEASES OF THE, and for special forms, DYSPEPSIA, GASTRIC AND DUODENAL ULGER, GASTRICTS; etc.

STONE, EDWARD JAMES (1831-1897), British astronomer, was born in London on Feb. 28, 1831. He was educated at the City of London school, King's college, London, and Queen's college, Cambridge.

In 1966. Stone succeeded Main as chief assistant at the Royal observations, Greenwich He deduced the solar parallax, first from observations of Mars, obtaming 8 937' (Mon Not R A S, xxxii. 128), and 8.945' (Mem of R A S, vx). xxxiii), and secondly from the transit of Venus in 1769 which yielded 8 91'' (Mon Not R.A.S., xxviii, 25) From the Greenwich transit circle observations between 1851 and 1865 he found for the constant of lunar nutation the value p.134''. He received the Royal Astronomical society's gold medal in 1869, and in 1870 became astronomer at the

He produced a catalogue of 12,441 stars to the 7th magnitude between the south pole and 25°. S. declination, published as the Cope Catalogue for 1880. In 1878, he was appointed Radchife observer at Oxford. At Oxford he extended the Cape observations of stars to the 7th magnitude from 25° S declination to the equator, and collected the results in the Radchife Catalogue for 1899, which contains the places of 6,424 stars. Stone observed the transit of Venus of 1874 at the Cape, and organized similar expeditions in 1882. He was presented to the Royal Astronomical society (1838–1884), and drew attention to the old observations at the Radcliffe observatory by Hornsby, Robertson and Rigado (Mon. Not. R.A.S., vol. iv). He died at Oxford on May 9, 1899.

BIBLIOGRAPHY -Proc. Roy Society, lxn 10, Month Not Roy. Ast. Soc lvili 143; The Times (May 10, 1897), Observatory, xx. 234; Astr. Nach. no. 3426, Roy. Soc. Cat. Scient. Papers.

STONE 437

STONE, GEORGE (1708-1761), archibishop of Armagh, es and a London banker, was educated at Westmaster school d Christ Church, Oxford He took holy orders and advanced only in the church, mainly through the influence of his brother drew (1703-73), who was undersecretary of state (1734) un-re George II and treasurer to Queen Charlotte under George I. When the duke of Dorset became lord leutenant of Ireland 731, George Stone went to Ireland as the chaplaim After Iding various preferments in Ireland as deen and histop, he came archibishop of Armagh in 1747. As archibishop he proved ire a politician than an ecclessastic In 1758 Stone wrote a letter, seeved in the Bedjord Correspondence (it, 387), in which he asks despondently of the distress of the people. He was one of 3 "undertakers" who controlled the Irish house of commons, d took a prominent share in the administration of Ireland until ideath in London on Der 10, 1764.

death in London on Dec 19, 1764.
Although this "much-abused prelate," as Lecky calls him, was firm supporter of the English government in Ireland, he was t intolerant. It was due to him that the antitithe disturbances Ulster in 1765 were suppressed with little bloodshed, he faured conculation toward the Roman Catholics, whose loyalty he lended

STONE, LUCY (1815-1893), US reformer and women's that leader, was born in West Brookfield, Mass, Aug 13, 1818. a child, indignant at the way in which women were treated, she termined to go to college, study Greek and Hebrew and try to demine whether the Scripture tests regarding subjection for men were correctly translated. She enrolled at Oberlin, O, the by college admitting women at that time. She was graduated in 47, and in 1848 was engaged as lecturer for the Anti-Slavery liety

It was agreed that she should lecture for the Anti-Slavery society Saturday evenings and Sundays—times regarded as too sacred a women's rights meeting. The rest of the week she might ask for women's rights on her own responsibility. In time she n wide popularity. She headed the call for the first National name's Rights convention, held at Worcester, Mass, in 1850—all signed by many distinguished men and women. A report of so convention reached England and attracted the attention of urriet. Taylor, afterward the wife of John Stuart Mill. Mrs. ylor worde an article about it for the Westmuster Reviews, which is the beginning of the modern movement for women's rights in eland.

In 1853 Miss Stone married Henry B Blackwell (1824-1900), antislavery worker. They issued a joint protest against the in-audities in the marriage laws, and with full approval she kept cown name. In Boston, in 1870, she founded the Woman's urval From 1872 until 1839, she served on its cidical staff led by her husband and later by her daughter. She died Oct. 18,

STONE, MELVILLE ELIJAH (1848-1929) U.S. jourlist, was born in Hudson, III, Aug. 22, 1848. In 1866 his father s made pastor of a Methodist church in Chicago, and it was ret that he got his schooling. In 1864 he began as a reporter the Chicago Tribine, but he became proprietor in 1869 of an in foundry and machine shop. In the great Chicago fire of 71 this was destroyed, and Stone then engaged in the administive work of municipal rehef and reconstruction. In 1872 he name one of the editors of the Chicago Republican (subsequently 18-r-Ocean), and later of the Post and Mail, becoming for several yra a political correspondent at Washington, D.

At the end of 1875, having returned to Chicago, Stone with a league, started the evening Dayl News, and two years later itor F. Lawson became a partner. The venture was very prosous He and Lawson bought out the Post and Mail, and in 37 they established the Morning News (later Record and cord-Herald). In 1888 he retired, and later founded the Globe tional bank, of which he became president in 1892. In 1893 became general manager of the Associated Press, which reved a new stimulus. He held this position until April 1921, tring that 28 years the budget of the Associated Press had wan from \$50,000 to \$6,000,000,000 and it had come to furnish wan from \$50,000 to \$6,000,000,000 and it had come to furnish

more than half the news printed in U.S. papers. He died in New York city on Feb. 15, 1929

See his autobiography, Fifty Years a Journalist (1921)

STONE, NICHOLAS (1587-1647). English sculptor and architect, was the son of a quarryman of Woodbury, near Exeter, and as a boy was apprenticed to Isaac James, a London mason About 1603 he went to Holland and worked under the sculptor Hendrick de Keyser (1552-161) and his son Pieter, and married his master's daughter. Stone is said to have made the portico to the Westerkerk at Amsterdam Returning to London about 1613 with Bernard Janssens (F 1610-20), a Fellow pupil, he settled in Southwark and obtained a large practice, in 1610 he supponted master than 101 he set 1610 he sone of the size 
See an article by A E Bullock in the Architectural Review (1907), and the same author's illustrated monograph, Some Sculptural Works of Nicholas Stone (London, 1908)

STONE, market town and urban district of Staffrordshire, Eng., on the Treat raver, 7 ml. N. of Stafford and 9 ml. S of Stoken. Treat Pop (1951), 8,299. Area 2 5 sqm. It is in the Stafford and Stone parliamentary division Shoemaking and brewing are the chief industries. There are earthworks at Bury Bank and Saxon Low, and remans of a 7th-century abboy. In St. Michael's (1750) churchyard is the tomb of Admiral St. Vincent.

STONE, a detached piece or fragment of rock. The word is thus applied to the small fragments scattered in the ground or on roads, to the waterwom pebbles of the seashore or river beds and to rock used as building material. A descriptive word generally accompanies "stone" when referring to pieces of rock cut to a particular size and shape for a specific purpose, e g., millstone, hearthstone, gravestone, etc. The term precious stone is applied to those minerals which, because of their beauty, colour, etc., their rarity and usually their hardness, are valued for ornaments (see GEM). The word is applied to many objects resembling a stone or pebble -the hard pit of certain fruits, as peach stone or the calculi or concretions sometimes formed in the gall or urinary bladder or the kidneys. (See Bladder and Prostate Diseases; Kidney, Diseases of). The stone has been a common measure of weight in northwestern Europe. In Germany the Stein was of 20 to 22 lb. In the British system of weights the legal stone or horseman's weight is of 14 lb avoirdupois; in weighing wool it was also of 14 lb., but is now usually 16 lb. The customary stone for fish or butcher's meat is of eight pounds

Building stone is a term somewhat loosely used to describe stone which is sawed, cut or broken, but ordinarily not crushed, in preparation for use in various types of structures. The term is roughly synonymous with dimension stone, which includes also curbing, flagging, paving stones and monumental stone.

Various terms without very exact defautions are applied to building stone. Stone which is shaped for use inhis blocks or slabs of specified dimensions is often referred to as cut stone. This includes stone used primarily as a structual material as well as that used for decoration and having an exterior surface finished by polishing, planing, honing or other means. Some of it is carved. The term shalts is applied to blocks of stone, usually of relatively small size, rectangular in shape but of various dimensions and commonly prepared by swaing, planing or hand splitting and trimming. Rough building stone and rubble are ordinarily irregular pieces of stone of various shapes and size.

Among other terms in use for stone for specific purposes are: eneering stone for relatively thun, usually natural stone slabs that are set on edge as a veneer for the exterior of structures; fingstone or flagging for flat slabs of stone used for walks, for paving courtyards and the like; curbstone for slabs used for curbing; pavings stone for rectangular blocks of stone used for streets, highways or other traffic areas, and for cobblestones which are rounded stones used for the same purposes; and boulders, field stone and creek stone for stone picked up loose from fields, creeks or other sources.

#### VARIETIES OF BUILDING STONE

Many kinds and varieties of stone, ranging in geological age from very old to recent, have been used for building Genetically they may be divided into three groups (1) sedimentary rocks, as limestone, dolomite, sandstone and some marble; (2) igneous rocks as granite, syenite and traprock, and (3) metamorphic rocks as marble, most slate and quartzite

Limestones (sedimentary) are composed principally of calcium carbonate as crystalline particles of the mineral calcite, with varying amounts of impurities such as sand and clay The textures of limestones vary greatly. Some are very fine grained and uniform in colour, others are coarser grained, mottled or streaked and some are granular and consist of fossils or pieces of fossils cemented together Oolite, a variety of limestone composed of cemented small rounded grains, many of which have a concentric structure, has been considerably used as a building stone, especially that from the Bedford, Ind, district in the United States, the Portland and Bath oolites of England and the Caen oolite of France. Many limestones occur in deposits comprised of relatively thin strata, a character which favours their use as sources of rough building stone, rubble, veneering stone and the like Thicker bedded deposits are usually favoured for the production of cut stone Coquina, a variety of recently formed limestone composed of loosely cemented shells and shell fragments, is used as a building stone in Florida, Cuba, the West Indies and elsewhere

Dolomites (sedimentary) consist principally of the mineral dolomite, a double carbonate of calcium and magnesium, and have many of the same characters as limestones, from which they are sometimes not differentiated. They have the same crystalline nature, occur in thin to massive bedded deposits and contain fossils Some dolomites are gray when freshly quarried but weather in time to a yellow or buff colour-in some cases a desuable phenomenon -as a result of the change of small amounts of ferrous carbonate in the fresh stone to ferric hydroxide. Magnesian limestone or dolomitic limestone has a chemical composition intermediate between that of limestone and dolomite

Travertine (sedimentary) is a variety of limestone deposited by waters of springs and when sufficiently hard it is locally used as a building or decorative stone. That quarried near Rome and sometimes referred to as Italian or Roman travertine has been used for many years because of its pleasing variegated gray and white or buff colour and texture of irregularly shaped pores distributed through the groundmass of the stone. Recently the buff travertine has been considerably used for interior decoration. In some places porous buff dolomite, used as building stone and resembling the Italian travertine, is referred to commercially as travertine.

Marble (metamorphic) is, geologically speaking, a limestone or dolomite which has been recrystallized by heat, pressure and solution that accompanied earth disturbances. In this process some of the structural and textural features of the original limestone are eliminated and others substituted, especially those relating to the deformation of the beds by earth forces, and often new minerals are formed. Many commercial marbles are of this sort. but limestones and dolomites are also called marble commercially if they take a good polish, have an attractive appearance and are used for decoration, trim, flooring and the like

Onyx marble (sedimentary), sometimes called cave onyx or oriental marble, is also calcum carbonate, usually deposited in caves and often exhibiting colour banding caused by the presence of metallic

and other exhibiting colour banding cajased by the presence of metanic compounds or other impurities in the various layers of the stone, Mexican only is a well-known example of colour-banded only that has been particularly used for staturary and novellers in colour but often handler group of marbles, dominantly green in colour but often handler group of marbles, dominantly green in colour but often handler group of marbles, dominantly green in colour but often handler group of marbles, dominantly green in colour but often handler group of marbles are repeated and the colour but of the state of th

are composed mostly of serpentine, a hydrous magnesium silicate There are a great many sources and varieties of marble which have been used commercially, among them Italian Carrara and Greek Parian and Pentelic mariles, much used for situary as well as building stone; Italian Seina and Bretic mariles, much used for situary as well as building stone; Italian Seina and Bottidino, Greek Skyros, French Hauteville and Circite, English Purbeck and Devonshire, Swiss Cippolino, Belgian black and Numidian marile of northern Africa In the United States, Vermont, Georgia, Tennessee, Missouri and Alabama, among others, are important producers of marble and furnish stone in a variety of colours and textures. Egypt and northern Algeria in addition to Mexico are well known as sources of onyx marble, as are Ireland, Italy, Greece

and the United States for serpentine marble
Sandstone (sedimentary) is a compacted sand more or less indurated as a result of cementation by silica, calcium (arbonate, clay or iron oxide Generally the giains of sandstone are principally the mineral quartz, SiO<sub>2</sub> Sandstones are commonly shades of white, gray, yellow, brown or red, the last three colours usually being due to oxides of non They are widely used as building stone for rough construction, as rough architectural stone, rubble, curbing and flagging and in the sawed or dressed form both for construction and decoration England, Scotland, Germany and Australia have produced a variety of sandstones for building, in the United States, Ohio, Pennsylvania, Tennessee and New York are the principal producing states

Quartzite (metamorphic or sedimentary) is a sandstone which has been altered into a hard compact tock composed mainly of the mineral quartz. It is used in some places as a building stone, for example, the Stoux Falls quartzite of South Dakota, also known as Sioux Falls granite or jasper, and the Crab Orchard quartzite of Ten-

Slates (metamorphic), as the term is used commercially, are rocks, mostly very fine grained, with more or less well-developed cleavage and other characteristics suiting them for use as relatively thin slabs for building and other purposes. Most slates are the result of the alteration of the sedimentary rocks, clay or shale, particularly by pressures that have accompanied deformation within the earth, so that some of the original minerals are flattened or elongated and others, especially the clay minerals, are changed to flaky or fibrous micaceous minerals, thus producing a rock which, because its mineral components are parallel, cleaves along the flat surfaces of the mineral grains and independently of the original bedding of the rock Such slates sometimes are called mica slates in distinction to clay slates, which are partly metamorphosed clays or shales or clays hardened by cementing materials, and ash and dike slates of igneous origin

The most common colours of slate are gray, black, red, green, purple and brown or mottled combinations of these colours Among minerals and hower or metiled combinations of these colours. The green purposes and hower or metiled combinations of these colours are nematite for responsible for these colours are hemanite for red, hemmitte and chlorite for purples, chlorite and sencite for greens, sencite for gaves and calon for grays and black. When exposed to waster some lates and calon for grays and black. When exposed to waster some lates mineral components of the slate, especially minerals that contain ron, the phenomenon does not necessarily undicate failure of the slate.

ate finds its principal use as a building stone as 100fing but is also used as Hagging, flooring and for various lesser interior construction purposes. In the United States, Pennsylvania, Vermont, Maine, New York and Virginia are important producers of slate for building; it is also quarried near Quebec, Que, and in many other countries of the also quarized near Quebec, Que, and in many other countries of the world, especially in Europe, with well-known sources in England, France, Italy and, particularly, Wales

Granite (igneous) is the term applied commercially to a number of crystalline building stones which have resulted from the solidification of molten tocks (thus called igneous tocks) although the term strictly applies to mostly coarse-grained igneous rocks consisting principally of the minerals quartz, feldspar and hornblende or mice or both Many of the commercial granites are of the latter type Gianites find par-ticular use as monumental stone because of their durability, but they are also used as building stone and sometimes for paying and curbing They usually occur in massive deposits which are not bedded, as are limestone and sandstone deposits, although granites do split in cerinnestone and sangasone deposits and gram) more readily than in others and some deposits show a sheety structure. Granites are of tain directions (referred to as rift and gram) more readily than in others and some deposits show a sheety structure. Granties are of many different predominant colours and shades including white, gray, punk, red, blue, brown and green, they range from fine to coarse shades to the coarse of the the larger producers. I nere are many widerly known granites. Among them are those from the vicinity of Barre, Vt, Quincy, Mass, Stone Mountain, Ga, Wausau and Montello, Wis, St. Cloud, Minn, Mount Airy, N.C., Stanstead, Que, the Scotch granites from Aberdeen and Peterhead, Scot., the Norwegian peal gray, the Swedish rose, the Finnish rapakity, the Egyptian Syene and the English Cornwall and on granites

Other Types.—Besides the above mentioned varieties of building stone, a considerable number of others find more limited use, including basalt and related traprocks (incous) for construction and in the monumental field where they are known as black granites, soapstone (metamorphic), a talcose rock used as tile, wainscoting and the like, greenstone (igneous), a greenst stone related to scapstone employed for structural and decorative purposes, volcanic tuffs (igneous), atgilite (metamorphic) and coral (sedimentary), used principally for constructure) (metamorphic), a talcose rock used as tile, wainscoting and the like

## PROPERTIES OF BUILDING STONE

The desirable properties in building stone, aside from those related to workability, as well as the tests made to measure these properties, differ according to whether the stone is to be used in the intensor or exterior of structures. In the first case, desirable properties include attractive colour and texture, reasonable strength and resistance to

abrasion and cleaning solutions of other liquids with which the stone may come into frequent contact However, if building stone is to give satisfactory service when it is used on the exterior of structures and is thus exposed to the weather, it must possess not only an attractive appearance, adequate strength and in some cases resistance to abiasion, but also resistance to freezing water, to the stresses set up by heating but are restrained to Irelating water, to the stresses set up by heating and cooling, to the action of chemical compounds naturally present or introduced into the atmosphere (especially cubonic and sulphuric acids) and in some instances to the effects of growing plants, as algae, and to salt-water spray or sand- and guit-laden winds. Changes in the immedia Comprising a building stone also may cause deterioration, for example, hydiation of clay minerals or ordization of iron pyrite.

These various potentially destructive agencies are not of equal importance in different parts of the world, and for this reason some building stones that prove sound in waim diy chmates may prove unsound in cold moist climates

The soundness or durability of exterior stones, especially those occurring in bedded deposits such as sandstone and limestone, is often much influenced by the relation of the stone's natural bedding or statisfication to the way it is set in a wall. Thus, stone set with a bedding surface exposed is likely to be less ieusiant to weathering than is a stone with its bedding surface flat in a wall. Other causes of failure of building stone are construction practices which permit water to seep into the stone from roofs or gutters or cause concentra-

tion of drin water

Without doubt the best test of the durability of a stone either for exterior or interior use is its actual performance under various condi-tions. Lacking such information, an examination of weathered outcrops sometimes gives light on durability However, in order to forecast the sometimes gives light on dutability. However, in order to forecast the probable behaviour of stone, certain laboratory tests were devised. Usually consideration of data from a group of tests, rather than from one test alone, as required to evaluate the probable performance of a stone for a specific purpose. Soundness tests include actual repeated freezing and thawing of water-socked pieces to detenime resistance to the spalling and splitting effects of matural freezing and thawing Accelerated soundness tests, havoling use of solutions of vanious sails of the splitting of the splitting of vanious sails. (especially sodium sulphate), attempt to duplicate and augment the stresses produced by the free/ing of water, so that the effects of such stresses are more quickly determinable. Water absorption is also measured in view of the possibility that rocks with a high absorption may be more affected by freezing, thawing and other degenerative processes than are those that absorb little water. This observation cannot be made as a generalization with respect to freezing, however, because other factors are also involved, such as whether or not the poies in a stone are more or less connected and serve as a system which absorbs and cushions the stresses of freezing water, so that some highly porous stones have greater soundness than other stones of less

porosity. Abrupt changes in temperature cause differential expansion and con-traction of the exterior portions of building stones Also, the minerals comprising building stones do not all expand and contract equally. comprising funding stones of not an expand and contact equally.

As a result spalling or other types of failure may occur; or the mortar used with the stone may be adversely affected. Resistance of stone to such stresses may be more or less anticipated by laboratory measure-

ments of thermal expansion

The strength of building stone was formerly of great significance because the walls, partitions and foundations of many structures carried the weight of the entire structure. In most large modern buildings, ine weignt of the entire structure. In most large modern buildings, however, a structural sted framework carries the structural load Nevertheless, in some instances crushing strength tenains a matter of concern, as in the case of bridge pilers and monuments, thus, strength tests are still commonly made. D. W. Kessler and W. H. Sigh give the following ranges in compressive strength, evpressed in Djunda per pounds per compressive strength, evpressed in pounds per compressive strength. ne tonowing ranges in compressive strength, expressed in Doulday Ber square inch, for some of the more common structural stones grantic, square inch, for some of the more common structural stones, grantic, stones, (2000–10,000 Most building stones which are otherwise sound probably have adequate strength to withstand pressures in the more common types of structures. Resistance to abrasion, sire, atmosphesic ands and to the solvent action of water, toughanse, elasticity, density and weight per cubic foot are other properties determined by testing.

The preservation of deteriorating building stones is a matter of incern in old structures that have utilitarian or historical value. Usually it is possible to treat only the outer portion of the stone. methods employed attempt to seal the pores partly or entirely, or to seal the pores and bond together the grains of the surficial portion with a weather-resistant material. Various oils, waxes, fats, insoluble sosps, stheates, silicofluorides, silicones and other materials have been used

for these numbers.

for thesic pulposes.

Binimonaparty—Oliver Bowles, The Stone Industries (New York, London, 1924); Charles H. Richardson, Building, Stones and Clays London, 1924); Charles H. Richardson, Building, Stones and Clays (New York, 1921); American Institute of Minning and Metallurgical Engineers, Industrial Minerals and Rocks (New York, 1927); F. J. North, Limestone Clandon, 1930; D. W. Ressler and W. H. Sigh, "Physical Properties of Principal Commercial Limestones Used for Building Construction in the United States," United States Bureau of States Survey of States Bureau of States States (States States States). Standards Technologic Papers, vol. 21, no 349 (Washington, D.C., 1927); D. W. Kessler, H. Insley and W. H. Shgh, "Physical Mineralogical and Durability Studies of Building and Monumental Granites of the Umted States," Research Paper 1320 (Washington, D.C., Aug 1940)

STONE AGE: see Archaeology.

STONE CARVING. Many as are the kinds, there is a character that properly belongs to all good stone carving, whether in relief (high relief or low) or in the round. The first constituent of this character is the quality called plasticity; it is the quality of solidity, of being in three dimensions. The beauty of stone carving is dependent upon this quality. Modelling in clay is a business wherein one staits from nothing, or perhaps a wire only (the armature) and builds up a thing in three dimensions stone carving one does not start from nothing and build up, one starts from a solid thing and proceeds by subtraction instead of addition and, apart from the sensuous enjoyment which some people have in using tools and materials, the natural tendency in stone carving is to subtract as little as possible, as in modelling it is to add as little as possible. The result is that whereas a certain spareness and tensity of form is characteristic of modelling. the character most noticeable in stone carving is fullness and roundness of form-solidity, mass, weight Moreover, by the use of wire or iron armatures it is possible to give a clay model any required freedom and detachment of parts-if it be an image of a man, the arms and legs may stand out freely from the body, fingers may be separate and hair may even stand on end. In stone, on the other hand, freedom or detachment of parts is unnatural and difficult. The custom of many sculptors, ancient and modern, to work exclusively in clay and to leave the business of carving to hired mechanicians is responsible for the lack of the proper character of stone carving in their works Trained mechances are clever enough to do anything; whether the thing done be worth doing is not their affair.

In a stone carving done according to the natural character of stone, there is no detachment of paris; everything is solidly joined to every-thing else. If there be any separation between one thing and another the space between is in the nature of a hole—a piering—as in the characteristic Byzantine foliage carving or in mediaeval window tracery Stone is a brittle and very heavy material, it will stand enormous crushing strains but will hardly bend These differing characters of materials render them suitable for different services—in on or wood for a girder subjected to a bending stiam, stone for a pier or pillar, bronze for a gate, stone for a gatepost And as each material renders its characteristic service, so each has its characteristic beauty To imitate the characteristic beauty of flesh and blood in a material so different as stone is absurd in proportion to the success with which it is achieved, and it is as wasteful as it is ridiculous. The stickbeetle has excellent and it is as wasteful as it is indiculous. The stuckbeetle has excellent reasons for wishing to remain anonymous, that a stone carrow should deare to produce flusions is folly. Moreover, it cannot be done, and the dust and duit which collect in the rome sand dimples of a realistic sculpture very soon belay it. The militation of one material in an-other is wasteful because it is throwing away the special beauty of the

material used. There is great beauty in the sculpture of Michelangelo, but it is not the beauty of stone. The movement of the human mind which is called the Renaissance ushered in an entirely new attitude on the part of artists. Men who had formerly been part of the ordinary gang of builders, who made buildings or sculptures in stone or bronze as one makes boots or books in leather or claim, now caused to be makers and thecame critics. Thus caused to be, as they formerly were, men imitating nature by working as she works (Ars minteur naturem in sua operatione, St. Thomas Aquina, Surmar Theol. 1, 6, 117, a, 1), they became men ministing and the control of th in leather or skins, now ceased to be makers and became critics product of unconscious natural causes whereas the stone carving was the product of a conscious and deliberating mind Neither in the one case nor the other was there any more criticism or imitation of nature than is displayed in an electrical switchboard. It is only in the paucity of language that a sculptor would speak of carving a man or a flower The likeness to nature is an accident of such works, not the substance A crucifix of the 12th century, for instance, or a Buddha of the same

date in India is not substantively a lifelike imitation of a man as seen in flesh and blood The substance of such things is their philosophical or religious significance. That being so, the artist was free to use or exploit the aesthetic possibilities of the material used to the fullest extent Thus it is that for the study of stone carvings as works of art we are compelled to look to the past or to foreign and distant countries compelled to look to the past or to loreign and custant countries. There is no question whether modern European stone or marble carvings are good or bad things. The statue of Gladstone in Westmister abbey is probably an excellent portrait, it would simply be wrong to judge it as stone curving. On the other hand, the sculpriess of Egypt, India and China, like those of early mediaveal Europe, are primarily stone curvings, it would be wrong to judge them as portraits or as militations of nature. After about 1350 the desire for versimilitated became the ruling motive

Generally, a good stone carving is one which will not break (Michelangelo is said to have enunciated, but perhaps not followed, the dictum that the test of a good sculpture was to roll it down hill without breaking it); that stands firmly and well balanced; that is free from of Maurice Dens, "What we ask of stone carring is that it shall look

of Maurice Denis, "What we ass to assert the first the stone the stone the stone the stone the stone of the s

STONECHAT, a small thrush, Saxicola torquata, ranging over Europe, Asia and Africa The male is black, white and rufous in colour. It is an active, restless bird, of open brushlands where it sits on tops of bushes flicking its wings and tail, and flying down to the ground to pick up its insect food. Other related species are the wheatear and the whinchat (qq.v) (A. L. RD.)

STONE FLY, a member of the insect order Plecoptera (q.v.), a group of wide distribution and containing about 800 The immature stages are aquatic, confined chiefly to species. cfreeme

STONEHAM, a town of Middlesex county, Massachusetts, U.S.A. Pop. (1950) 13,229. Within its area of 6.6 sq mi, is Spot pond, a large lake which serves as a storage basin for the metropolitan water district; and 730 ac. of the Middlesex Fells reservation.

The manufactures include shoes, shoe stock, furniture, chemicals and druggists' supplies Steam power was first applied to the manufacture of shoes there, by John Hill and company who introduced many laboursaving devices, notably the heeling machine (1862). Stoneham was settled about 1668. It was incorporated as a town in 1725.

STONEHAVEN, small burgh, seaport and county town (since 1607) of Kincardineshire, Scotland, 15 mi. S.S W. of Aberdeen by road

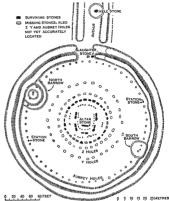
The population in 1951 was 4,438. There the rivers Cowie and Carron enter the sea. The old town with a 17th-century tolbooth hes behind the harbour, used mainly by fishing boats; northward is the newer quarter with the beach and an open-air swimming pool. Fishing nets are made at Stonehaven. Dunnottar castle, built by Sir William Keith (see KEITH) in the 14th century, is 11 mi. contheast

STONEHENGE, a circular setting of large standing stones surrounded by an earthwork, situated about 8 mi. N of Salisbury. Wiltshire, England. Among the earliest references to it is that of Geoffrey of Monmouth, who relates in his Historia Regum Britanmae (c. 1136) the legend that the stones were magically transported from Ireland by Merlin. This legend perhaps enshrines a folk memory of the bringing from Pembrokeshire of the "bluestones" which form part of the monument. The supposed connection of Stonehenge with the Druids, which, though without foundation, has held the public imagination since the 17th century, originated with John Aubrey (1626-97), and was more particularly elaborated by William Stukeley in 1740. The modern interpretation of the monument is based chiefly on excavations carried out by the Society of Antiquaries of London since 1919.

The monument consists of a number of structural elements, mostly circular in plan. On the outside is a circular ditch, broken by an entrance gap on the northeast, with a bank immediately

Inside the bank is a ring of 56 pits, known after their discoverer as the Aubrey holes Between these and the stones in the centre are two further rings of pits, now invisible on the surface, known as the Z and Y holes The stone setting consisted of two circles and two horseshoes of uprights, the first and third being capped by stone lintels. Additional stones include the Altar stone, lying on the axis southwest of the centre; the Slaughter stone inside the entrance of the earthwork; two Station stones just within the bank on the northwest and southeast, and the Heel stone, standing on the Avenue outside the entrance and surrounded by a narrow circular ditch

Similar ditches enclose two flat areas on the inner edge of the



ADAPTED, BY PERMISSION, FROM MINISTRY OF WORKS PLAN STONEHENGE PLAN SHOWING STONES AND PROGRESS OF EXCAVATIONS

THE AUBREY. Z AND Y HOLES ACTUALLY FORM COMPLETE CIRCLES BUT ONLY THOSE EXCAVATED ARE SHOWN ON THE PLAN

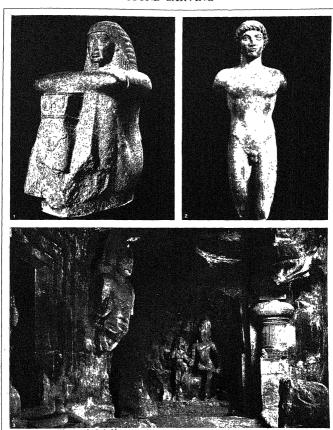
bank, known as the North and South barrows, with empty stoneholes at their centres.

These structures can be divided into four groups, each representing a separate phase of building. To the first belong the bank, ditch and Aubrey holes, and the Hele (Heel) stone with its ditch.

This earliest monument is thought to have incorporated at least one block of rhyolite, one of the varieties of bluestone imported from southern Wales which figure prominently in a later stage of the history of Stonehenge.

The ditch is very irregular in outline and was dug in a series of interconnected pits; it averages 13 ft, in width, 5 ft, in depth, and 350 ft. in diameter. The sides are steep and the bottom flat bank stands on its inner edge, and is of only moderate height. It is made of chalk rubble, laid directly on the underlying chalk rock after removal of the ancient turf.

The Aubrey holes form a circle about 290 ft. in diameter and are spaced 16 ft. apart. They are circular holes varying in diameter from 30 in. to 70 in and in depth from 24 in. to 48 in, and were deliberately filled with burned chalk and chalk rubble, soil and ashes; many of them show signs of subsequent disturbance in early times. Although two-thirds of those excavated contained cremated human bones, their purpose is not necessarily sepulchral, nor is there any evidence that they ever held uprights of stone or wood. With them should be associated a number of other cre-

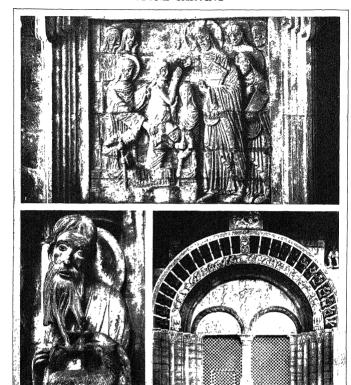


BY COUNTEST OF (1, 2) THE TRUSTEES OF THE BRITISH MUSEUM, (3) THE INDIA OFFICE

#### EXAMPLES OF ANCIENT CARVING

- 1. Seated granits figure of Rui, High Priest of Amen (about 2000 B C.),
  3 Rt. high New in British Museum
  2. The Strangford Apollo. 5th century B.C. New in the British Museum

  of the Strangford Apollo. 5th century B.C. New in the British Museum



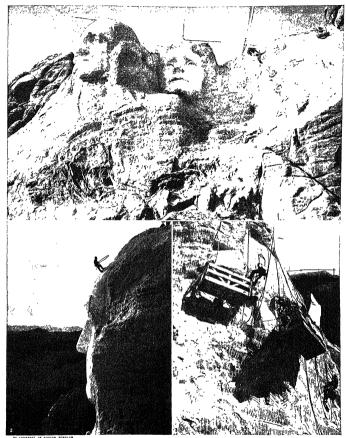
RAFSS, (1) VALENTINS AND BONS, LTD., (2) E HOUVET, (3) E N A

# STONE CARVING OF THE MIDDLE AGES

- 1. The Raising of Lazarus, an example of Romanasque soulpture in Chi-chester Cathedral, Sussex
- 13th century cheater Cathedral, Sussex

  2. Head of John the Baplist, in north perch of Chartres Cathedral, France:

  3. "The Deposition," a low relief carving on the western perch of the Church of St Mary at Oloron, southern France; about 12th century



PRESENT-DAY STONE CARVING

- Profile of Washington, showing how the stone carver, in the protective oradle, can move to all parts of the head to work
   Blocking out the head of Lincoln. Note the plaster model to guide the soulptors

mated burnals in the bank and the silting of the ditch

These structures together form an open-air sanctuary of the kind known as a Henge monument, belonging to the late Nothing period. This date is confirmed at Stonehenge not only by pottery and by objects associated with the cremations, but also by a node-active carbon determination made on charcoal from the Aubrey holes (1848 B SC  $\pm$  215 years).

To the second phase belong the outer ring and horseshee of uprophic, the Station stones and harrows, and the Shaphter stone. The stones are all sarsens, a form of sandstone whose nearest probale source is the surface of the downs near Avelvry, about 5 mil to the notitivest. The centre of these structures differs slightly from the earlier centre, and less at the intersection of lines drawn between the Station stones and between the centres of the harrows, which thus appear to represent perlumnary markers exceed to find the centre of the earthwork. The barrows are known to be later than the hank and the Aubret who

The outer sarsen ring consisted originally of 30 uprights, set on a circle 98 ft in diameter, supporting a continuous ring of 30 lintels. The average length of these uprights is 18 ft, of which about 4 ft. is below ground

In the outer horseshoe the five sarsen trillihous (each of two uprights capped by a lintel) increase in height from 16. It at the outside to 22 ft at the centre. The upraghts were erected by means of ramps entering their sockets from the inade, and must have been raised before those of the outer ring. Both upraghts and hintels, here and in the outer ring, have been carefully dressed to shape by pounding with stone mauls, many of which were used as packing-stones round their bases.

The lintels are fixed to the uprights by mortice-and-tenon joints, and those of the outer ring are also fixed to each other by toggle or tongue-and-groove joints. This technique is copied from a wooden prototype, probably not directly but through the intermediary of an earlier local monument built of bluestone as suggested below.

The sarsen structure exhibits a number of architectural refinements Great care was taken with the alignment of the stones and the levelling of the lintels

The inner and outer faces of the intels are worked to the appropriate curve, and on the trilliuons their upper faces are broader than the lower, so that when viewed from below their sides do not appear to recede. Such refinements are unknown elsewhere in prehistoric northern Europe, and imply influence from the contemporary Mycenaean and Munoan architecture of the Mediterranean. The probability of such influence was startlingly confirmed in 1933 by the discovery of carripas of Bronze Age weapons on three of the saren stones. These comprise over 30 representations of bronze ascheades, of a pattern current in Britain (and of Irish manufacture) between 160 and 1400 a C., and a single carring of a higher discovery of the content of the

The order and absolute date of the two remaining phases, represented by the Z and Y holes and by the bluestones, is not known, though both are certainly later than the sarsen stones. The Z and Y holes average 4 ft. by 6 ft. in diameter and 40 in in depth, and though roughly concentric with the sarsens are irregularly slinned.

After the original excavation of these holes they appear to have sited up naturally over a period of many conturns, during which pottery of the pre-Roman Iron Age found its way into their filling. There is, however, no reason for supposing that the hotes are of this dist, or for associating them with the Druids. Though their date and purpose is unknown, it is perhaps significant that they are of a suitable size and shape to serve as emplacements for the bluestones, and that their number is the same as the best estimate of the original number of the bluestones in their present setting. It may be, therefore, that the Z and Y holes represent an unfinished project for the erection of the bluestones at Stonebenge, which for some reason unknown was abandoned in favour of the present setting of these stones.

The bluestone setting, consisting of the inner circle and horse-

shoe and the Altar stone, is made up of at least four varieties of igneous rock foreign to the region. The inner horseshoe is of spotted dolenie, and the inner circle manily of the same rock with four specimens each of rhydite and volcanic ash, the Altar stone alone is of micaceous sandstone. The first three of these rocks are found in association only in the Prescelly mountains in Permbrokeshite, whence they were brought to Wittshire.

The occurrence of micaceous sandstone near Milford Haven suggests transport of the stones at least in part by seagoing boats

The bluestones are all carefully diessed to shape, and taper gradually from the ground to fist tops. They vary in high from 6 fit to 8 ft. It is clear that they were erected after the sarsons, since some of them stand in the filling of the ramps of the sarsons' sockets. Three of them, all of dolente, retain the remains of a tenon and two pairs of mortices respectively. This suggests that they, and probably the remainder of the dolerate, originally stood elsewhere as a separate monument incorporating at least two trilithous, and it is doubtless from this that the mortice-and-tenon joints of the sarsens stones were derived.

Recent work suggests that another structure, of bluestones other than dolerate, stood about a mile northwest of Stonehenge, and that the bluestones were brought to Wiltshire in the late Neolithuc period, some centuries before their erection in their present position at Stonehenge

Stonehenge is approached from the northeast by an avenue, 7g ft. in width, bounded by a slight bank and ditch on each side, which runs by three successive alignments to the bank of the River Avon 14 m to the southeast. In date at appears to be intermediate between the first and second phases. The section adjoining Stonehenge, and the aws of symmetry of Stonehenge itself, is aligned approximately on the point of midsummer sunits (though not, as is often stated, on the file is stone). This fact has occasioned much fruttless conjecture

frutless conjecture

Billindonary—For a bibligraphy complete to 1900 see Willishire

Archaeological and Natural History Magazane, xxxxx (Devires, 1901). A

later book a E H Stone, The Stone of Simochaege (Landon, 1924).

Crawford in Antquisty, I, ill, xxvxi (Gloucester, 1927-9), Newbury,

1954). S Piggolt, Aspets of Archeeology in Britan and Beyond, ed

W F Grames (London, 1952); R J C Atlinson in Proceedings of the

W F Grames (London, 1952); R J C Atlinson in Proceedings of the

W F Grames (London, 1952); R J C Atlinson, S Piggott and J F S. Stone

in Antiquaties Journal, t-vi, vin, xxxxx (London, 1950 ft.); W Gowland

in Archaeologica, I wil (London, 1902); J F S S tone in Archaeological

Journal, etv (London, 1947); and R. J. C Atlinson in Mature, dxxxx

(R. J. C. A.)

STONE MONUMENTS, PRIMITIVE. The term primitive stone monuments implies an ancent or rudimentary memorial or mark. Some represent men or things. Others are tabernacles, provided, either with pious or magical intent, that a power or a soul may be induced to dwell therein.

At first, they were memorial—to keep in memory the site of a certain event, or definite spot—perhaps to mark a route, perhaps to delimit the bourn of forbidden ground. They would be signosts, of a welcoming, funereal or warming character. Not ural existing marks were doubtless first used; later, wooden posts where trees were plentiful.

Stone heaps or boulders where available, would replace wood aless subject to decay and more difficult to remove treacherously. Such marks become sacred by natural evolution, so that men fear to remove them. This process varies according to the people's standard of magic or religion.

Retribution is to be feared should a memorial be defaced or a boundary stone moved. During Woolley's excavation at Ur in 1944 there was found, in what appeared to be a museum or records department attached to a convent of the Kassite period (£. 1600 a C.), such a boum (now in the Baghdad museum), photographs of which were exhibited in 1945 in the basement of the Assyrian department at the British Museum. On this stone were graven the boundaries of the property it had presumably once marked, the names of the owner and of the witnesses to the gods whose emblems were carved upon the stone should this testinonly to destroyed. The stage from the bourn to the ideal a witness-stone is almost imperceptible. The stone becomes something on which solemm ouths can be sworn, as is exemplified by pillar-stones and their folk-dore, especially such as have a hole through which may be passed the clasped hands of two persons making a contract. The Law Fail at Tan and other stones on which irish kings and chiefs took their oaths at their imaguration, and the Bocac della Versta in Rome, display the persistence of such an idea into historic times. Similar traditions have clung for longer periods to witness-stones or pierse the justice among the primitive stone monuments of Brittany, Cornwall, Wales, Scotland and Teland, dating from about 400 E.C. to An 300.

Once a memorial pillar or a witnessestone became finvested with such a sacral character it would easily uself become the object of propitatory rites, especially if marked with sacred emblems. Thus the drivers travelling the lonely desort routes uniting India, China, Tibet, Russia and Persia pour hibations of wheel oil on the anthropomorphic stone wasyide caims and sacred wooden pillars set up at certain stages of their road. (See also Genesis xwixii, 16-22)

As to the representation of the human form or of its lifegiving organs, the more primitive idea is not the symbology associated with fertility cults, but the intention to represent a particular man or a supernatural being in the likeness of man however crude. This is demonstrable, because although standingstones or menhirs rudely hewn into effigies, recognizably female by their indications of femininity (and almost certainly intended to represent or symbolize a Mother Goddess), are compatible with a very primitive knowledge of physiology, and call for no esoteric or philosophical explanation, the case with phallic (see PHALLICISM) representations is rather different. A religion calling for the recognition of that symbol as representative of fertility (as distinct from fecundity) presupposes a society cognizant of the respective parts played by the male and female functions in nature in the production of offspring, and long familiar with husbandry and cattle-raising, whereas in very primitive societies the physical association of the sexes, though regulated by custom, is often unrelated to paternity. The child is known to be physiologically produced by its mother. Socially it may belong to its maternal uncle (see Avunculate), uterine relationship between brothers and sisters being easily demonstrable. Even when the observed association of maternal fecundity with post-initiate sexual connection brings about recognition of cause and effect in specific cases, there is still some way to go intellectually before the symbol of male fertility can take the natural place in the ideology of magic or religion that is taken by the crude representa-tion of a human form with female breasts. The stone pillar that is recognizably a phallus is not on the same primitive plane with the menhir having indications of eyes, nose, mouth and breasts, but rather with the esoteric symbology of the holed stone.

Mystery dramas, in which the initiate actually passes through the circular gate of exit from "91s mother's womb'r to that new life, and domestic altars on which phalius and holed stone are not the accessories of indocent rites but the emblems of an exalled interpretation of the twin principles of life, must have been sufficiently common to perpetuate, as appears to have been the case, the esoteric significance of these symbols through long ages. We see the origin of the doubly solemn nature of an asseveration or contract made by passing the hand through a holed stone, and of the idea of passing sick children boddly through such stones. The clut of the lingum stone in India to-day illustrates this point.

Thus, no doubt, many of the rude stone monuments characteristic of Britany, Conwall, Wales, Socialand, Ireland, etc., came to have their connection in folk-lore and folk memory with fertility cuts, the furtive practice of whose associated ries might well be condemned by the unthinking as fundamentally indecent, and by the early Christian Church as subversively pagan. Such monuments, therefore, are not so much primitive in themselves as relices of a highly elaborate order of ideas,

The ideas connected with pillar and holed-stone cults probably go back to 2500 or 3000 B.C., although not introduced into Western Europe till somewhere about 600 to 200 B.C. Long before that, however, men probably put up small rude bourns and memory stones (where stone was available) as more permanent than marked trees or wooden posts or carris of loose stones. It is difficult to disentangle, from among a welter of stone monuments (such, eg, as those at Carnac which range from small unhewn pillars 2 feet high to elaborately chambered barrows), primitive commemorative menhirs that may have survived from an earlier day The more pumitive-seeming stone monuments-menhirs in 1solation—are almost invariably found in districts where the elaborate chambered barrow, the cromlech and the stone avenue are equally characteristic. In the Naga Hills, lying between Assam and Burma, we can observe a rather primitive society electing just such menhirs as we see in the megalithic districts of Western Europe, to mark social occasions and events of their lives Such primitive monuments as standing-stones are erected by men according to a prescribed efiquette to commemorate contemporary events of their own lives and need not necessarily be either funereal or in the nature of witness-stones or boundary-marks It is arguable that the stone-raising Nagas, like the peasants of Ireland or Brittany with their cults of the stones, are merely keeping alive customs which originated in a more complex society, and certain other Naga customs connected with the use of stone and the symbolism of horns bear this out.

When, therefore, we come to deal with such stone monuments as are really rude human efficies, we are far away from the symbolical ideas already discussed Primitive folk to-day provide the disembodied spirit with an effigy, preferably near his grave, thus preventing him from taking up his abode in an already

occupied body.

Alignments, cromlechs and denuded dolmens are not strictly primitive, as has been demonstrated by excavation in Brittany (see Carrac, Megalithic Monuments).

(see Carnac, Megalithic Monuments),
Binazooanny — W., G. Wood-Martin, Pagan Ireland, paragraphs on
Pillar-Stones" and "Haled-Stones" pp. 302–33 (1865, Bibliography),
ship" (tops Bibliography), Sin Arthur J. Ewan, The Mycenesa design of the Montanger of the Mont

STONE MOUNTAIN MEMORIAL. Stone mountain, about 15 mi. N E. of Atlanta, Ga, 18 a gray monadnock, shaped like a half parabola, 650 ft. high, covered with growths of mosses and briens and various plants, including rare varieties.

and lichens and various plants, including rare varieties.

In 1916 the sculptor, Gutzon Bouglum (1834—1941) (7 v.), conceived the plan of carying upon the side a huge memoral to the valour and loyalty of the south to the lost Confederate cause.

The design, 200 ft. high and 1,300 ft long, was to represent the amy of the Confederacy with Robert E. Lee and other souther leaders at its head. Work was begun by Borglum in 1917, interrupted by World War I, and continued in 1923—25 when a dispute with the Stone Mountain Monumential association, which raised the funds, resulted in his dismissal.

In 1926 Augustus Lukeman was employed as Borglum's successor. Borglum's head of Lee was unveiled m 1924 and a section of Lukeman's work was unveiled in 1928, but the total then accomplished represented but a corner of one section of the complete design.

STONE RIVER, BATTLE OF, a battle of the American Civil War, called the battle of Murfreesboro by the Conselectates, fought on Dec. 31, 1863, and Jan. 2, 1863. After his appointment in October to command the Army of the Cumberland, Gen W. S. Rosecrans, with Chattanooga as his objective, moved from Nashulle upon Gen. Braxton Bragg, who left the winter quarters he had established at Murfreesboro and met the Union army on Stone river immediately north of Murfreesboro, on the last day of December. The plan of attack on each sade was to crush the enemy's right. Bragg's left, commanded by Leeut, Gen. W. J.

Hardee, overlapped and bore back the Union right under Maj gen A McD McCook, and May-gen T L Crittenden, commanding the Union lett, was hurriedly called back from his attack on the Confederate right to support McCook The Union right was crumpled up on the centre, where Maj -gen G. H Thomas's corps checked the Confederate attack There was practically no fighting on Jan 1, but on the 2nd the Confederates renewed the attack, Maj -gen. J C Breckinridge with Bragg's right attempting in vain to displace one of Crittenden's divisions which had established itself during the 1st on high ground across the river. On the night of the 3rd Bragg withdrew and the Union army occupied Murfreesboro Tactically a drawn battle, Stone River was strategically a Union victory. The losses on both sides were heavy of 37,712 Confederates present for duty, 1,294 were killed, 7,945 were wounded, and about 2,500 were missing; and of 44,800 Union soldiers present for duty, 1,677 were killed, 7,543 were wounded, and 3,686 were missing

See A F Stevenson, The Battle of Stone's River (Boston, 1884), and W. J Vance, Stone's River, the Turning-Point of the Civil War

STONEWORT, the common name for Algae (q v.) of the class Charophyceae, so called from the deposit of lime in their cells They grow in fresh and brackish water
STONINGTON, a borough of Connecticut, USA Pop

(1950), 1,739 There is a good harbour In the 18th and 19th centuries whaling and sealing were important industries Nathaniel B. Palmer, who discovered Palmer Land in the Antarctic early in the 19th century, was a whaling captain of Stonington The village was a military depot during the Revolution, and in Aug 1775, was bombarded by a British frigate. In 1801 it was incorporated as a borough, the first in the state. An attack by a British squadron in Aug 1814 was repulsed

STONY POINT, a township in Rockland county, NY U.S.A. Pop (1950) 5,485 Area, about 30 sq. miles. It was named from a rocky promontory which juts into the Hudson During the Revolutionary War it was of considerable strategic importance. The Americans occupied it in Nov. 1776, and about two years later erected a blockhouse upon it The garrison, however, was very small, and on May 31, 1779, it was taken by the British, who immediately erected much stronger fortifications. On the night of July 15-16, it was recovered by Gen Anthony Wayne, in command of about 1,350 picked American troops, the garrison (under Lieut Col. Henry Johnson) losing 63 killed, 70 wounded and 543 taken prisoner. The American loss was only 15 killed and 83 wounded The Americans, however, had no thought from the first of holding the place and evacuated it on July 18, whereupon it was reoccupied by the British, but late in October they, too, abandoned it In the "old Treason house" (no longer standing) Gen Benedict Arnold and Major John Andre met in the area before daylight on Sept. 22, 1780, to settle plans for the surrender of West Point by Arnold to the British

STOOLBALL. Of the ancient game of stoolball very little indeed is known, and it has nothing whatever in common with the modern game which, since 1916, has made astonishing progress. During the war a simple but not strenuous outdoor game was very badly needed for wounded officers, soldiers and sailors; and the idea occurred to Maj. W W Grantham, who was stationed at Brighton, that the old game of stoolball adapted to modern requirements, would be suitable for the purpose. The game was soon played in scores of hospitals and convalescent homes, in England and France. He made a few simple rules adapted from cricket, and the first public match took place on the County cricket ground of Hove in 1917

In 1924 a Stoolball Association was formed at Lord's, and by the end of 1927 it was estimated that nearly 3,000 clubs had become members. In Sussex alone the game is played in hundreds of villages, and by large numbers of schools of all kinds, women's institutions and girl guides associations It has been intro-duced into Iceland, Japan, Siberia, Switzerland and Finland.

The materials required for the game are very few and very simple, and although with the exception of the ball they can be easily and quickly made by any carpenter they may now be obtained from most of the outfitters Two bats, a ball, and two wickets comprise the materials. The bats are wooden, made like a racket, the diameter of the round part being not more than  $7\frac{1}{2}$ in , and, including the handle, the bat must be not more than 18in in length. The ball is usually known as "best tennis No 3," but a hard lawn tennis ball will serve the purpose Each of the two wickets consists of a board ift square fastened to a stout post which must be firmly fixed in the ground in such a way that the top of the board is 4ft 8m above the ground; a tripod is often substituted for the post

The wickets must be fixed at a distance of 16yds from each other, and a bowing crease not more than 1vd in length must be marked at a spot royds from each wicket, for this is where the bowler stands. The bowling is underhand, and the number of balls to an over, originally ten, has been reduced to eight. A batsman may be bowled, caught, or run out (the ball hitting the face of the board), or may be given out "body before", runs are made just as in cricket In order that the batsman shall be out, "bowled," the ball must hit the face or edge of the wicket (but not the stump), without having previously touched the groundin other words the ball must be a full pitch. On all points for which there are no special rules, the laws of cricket, as far as possible, hold good for stoolball The game can be played on any piece of ground which is fairly level and not so rough as to be dangerous, the minimum space required would be about half the size of an ordinary cricket ground

The ancient form of the game was once very popular in England, and was commonly considered to be the ancestor of cricket. Writing in 1801, Joseph Strutt gives a description of it

See W. W Grantham, Stoolball Illustrated and How to Play it. (W. A. BE)

STORACE, STEPHEN (1763-1796), English composer, was born in London but studied (under his father, Stefano Storace, an Italian contrabassist) at the Conservatorio di Sant' Onofrio, at Naples His first opera, Gli Sposi malcontenti, was produced at Vienna, in 1785 Here he made the acquaintance of Mozart, in whose Nozze di Figaro his sister, Anna Sehna Storace, first sang the part of Susanna. Here also he produced a second opera, Gli Equivocs, founded on Shakespeare's Comedy of Errors, and a Singspiel entitled Der Doctor und der Apotheker. In England. after creating a favourable impression by bringing out his Singspiel at Drury Lane, under the title of The Doctor and the Apothecary, Storace attained his first great success m 1789, in The Haunted Tower, an opera which ran for fifty nights in succession. The music of The Pirates (1792) affords one of the earliest instances of the introduction of a grand finale into an English opera.

Storace's music is pre-eminently English He doubtless learned See H P. Johnston. The Stormag of Story Pount (1900); E. H. something from his silect Anna (1706-1877), a brilliant: single Hall and F. W. Halsoy, Story Pount Battle-Field (1900); and D. Cole who died leaving £50,000. Storace himself died on March 19, 1796.

\*\*TORAGE, COLD: see Refricement on the Hallow Story of Resident County (1864).

## STORAGE BATTERY: SEE BATTERY.

STORK, the name for various large to very large long-legged, long-necked, large-billed birds related to the herons and this and placed with them in the order Ciconnformes. The 17 species of typical storks form the family Ciconiidae They frequent open fields and shallow water, where they stalk about looking for their food of insects, fish, frogs or almost any other small animal. Some storks, such as the adjutant, Leptoptilos dubius, of India, and the marabou, L. crumeniferus, of Africa feed on carrion.

During the nonbreeding season they are often in flocks, and at times soar majestically high in the air. Their voices are little more than grunts or peeps, but storks commonly make a rattling noise by snapping their great mandibles together. While stately, or impressively grotesque in everyday activity, at mating time storks perform grotesque dances, hopping about with spread wings and clattering mandibles The nests are bulky affairs, usually placed in trees, sometimes in colonies. The eggs are white and unmarked, the young are down-covered and are cared for in the nest by the parents. In plumage storks may be mostly glossy black, or black and white, the head feathered or naked and with brightly coloured lapets on the bill, depending on the species

Most storks live in the old world where the group is widespread, only three occurring in tropical America, including the jabiru, Jabiru mycteria, and wood ibis, Mycteria americana.

The white stork, Cicoma cicoma, of Europe is one of the bestknown birds. It stands more than three feet high and is white with black in the wings. It nests on houses where platforms are sometimes put up for it, and it is thought to bring good luck. The hammerkop (q v ) stork, Scopus umbretta, of Africa is the only species in the related family Scopidae and the whale-headed stork, Balaensceps rex, of Africa is the only species in another related family, Balaenicipitudae. (A, L, RD.)

STORM, THEODOR WOLDSEN (1817-1888), German poet and novelist, was born at Husum, Schleswig, on Sept 14, 1817, and studied jurisprudence at Kiel and Berlin, where he formed a close friendship with the brothers Theodor and Tycho Mommsen. Storm is hardly less remarkable as a lyric poet than as a novelist. As the former, he made his debut, with the two Mommsens, with As the former, he made no sebus, with the two Mommsens, with Lederbuck drew Freunde (1843); but his Gedichie (1852), in the wake of Exchendorff and Morine, first dutained for him general received the second of th

tovo).

STORM. This term is sometimes applied to any disturbed atmospheric condition, but more often only to the violent disturbances. Windstorm, thunderstorm, snowstorm, sandstorm, duststorm, etc., are more specific terms Ordinary cyclones  $(q\ v)$  are frequently referred to as storms. In hydrology, the name is applied to an area of rapidly accumulated rainfall whether caused by one meteorological storm, a series of them or only a portion of one. In the Beaufort scale (q.v.) a wind of force II (64 to 75 m.p.h.) is called a storm wind. (For magnetic storms see TERRESTRIAL MAGNETISM.) (HRB)

STORMBERG, ACTION OF (Dec. 10, 1899): see South

AFRICAN WAR, 1899-1902 STORNOWAY (Norse, Stjarna vogr, "Stjarna's bay"), a small burgh, the principal town of Ross and Cromarty, Scot. Pop. (1951), 4,954. It is situated on the east coast of Lewis, at the head of a harbour accessible for steamers of 3,000 tons. Stornoway, which was made a burgh of barony by James VI. is the centre of the Outer Hebrides fishery district and during the herring season the population is very largely increased. Steamers run daily in summer to Mallaig and weekly to Glasgow. Belfast, Leith and Liverpool.

STORY, JOHN (c. 1510-1571), English martyr, was educated at Oxford, where he became lecturer on civil law in 1535. being made later principal of Broadgates hall, afterward Pembroke college. He appears to have disayowed his Roman Catholic opinions just after the accession of Edward VI, but having been chosen a member of parliament in 1547 he gained notoriety by his opposition to the Act of Uniformity in 1548. For crying out "Woe unto thee, O land, when thy king is a child," he was imprisoned by the house of commons, but he was soon released and went into exile. Returning to England in 1553, he resigned his position at Oxford, which was now that of regius professor of civil law, and was made chancellor of the dioceses of London and of Oxford and dean of arches. Story was one of Queen Mary's most active agents in prosecuting heretics, and was one of her proctors at the trial of Cranmer at Oxford in 1555. Under Elizabeth I he was again returned to parliament, but in 1560 he under-

went a short imprisonment for boasting about his work in the former reign. In 1563 he was again arrested, but managed to escape to Flanders, where he became a pensioner of Philip II of Spain. The duke of Alva authorized him to exclude certain classes of books from the Netherlands and, in 1570, while engaged in this work, he was decoyed onto a ship at Antwerp and conveyed to Yarmouth In spite of his claim that he was a Spanish subject, he was tried for high treason and executed at Tyburn on June 1. 1571. In 1886 Story was beatified by papal decree

STORY, JOSEPH (1779-1845), US jurist, was born at Marblehead, Mass, on Sept 18, 1779 He graduated from Hárvard in 1708 and was admitted to the bar at Salem. Mass., in 1801. a Democrat. In Nov 1811, at the age of 32, he became, by Pres James Madison's appointment, an associate justice of the US supreme court This position he retained until his death. Soon after Story's appointment, the supreme court began to bring out into plain view the powers which the constitution had given it over state courts and state legislation

The leading place in this work belongs to Chief Justice John Marshall, but Story has a very large share in that remarkable series of decisions and opinions, from 1812 until 1832, by which the work was accomplished. In addition to this he built up the department of admiralty law in the US courts, he devoted much attention to equity jurisprudence and rendered invaluable services to the department of patent law. In 1819 he attracted much attention by his vigorous charges to grand juries, denouncing the slave trade, and in 1820 he was a prominent member of the Massachusetts convention called to revise the state constitution In 1829 he became the first Dane professor of law at Harvard university, and continued until his death to hold this position. He died at Cambridge, Mass, on Sept. 10, 1845.

He died at Cambridge, Mass, on Sept. 10, 1845.

Among his publications are Commentaries on the Law of Bailments (1832), a work of profound learning which is still the standard (1833), a work of profound learning which is still the standard by many regarded as his ablest work; Commentaries on Equity Iuri-produces (1835-50), Equity Pleadings (1838), Law of Agency (1830), Law of Partnership (1841), Law of Balls of Evchange (1843), and Law of Frentheyn Notes (1845) ones for the Life and Latters of Joseph Story (Boston and London, See The Life and Latters of Joseph Story (Boston and London, See The Life and Latters of Joseph Story (Boston and London, See The Life and Latters of Joseph Story (Boston and London, See The Life and Latters of Joseph Story (Boston and London, See The Life and Latters of Joseph Story (Boston and London, See The Life and Latters of Joseph Story (Boston and London, See The Life and Latters of Joseph Story (Boston and London, See The Life and Latters of Joseph Story (Boston and London, See The Life and Latters of Joseph Story (Boston and London, See The Life and Latters of Joseph Story (Boston and London, See The Life and Latters of Joseph Story (Boston and London, See The Life and Latters of Joseph Story (Boston and London, See The Life and Latters of Joseph Story (Boston and London, See The Life and Latters of Joseph Story (Boston and London, See The Life and Latters of Joseph Story (Boston and London, See The Life and Latters of Joseph Story (Boston and London, See The Life and Latters of Latt

STORY, WILLIAM WETMORE (1819-1895), US sculptor and poet, was born at Salem, Mass., Feb 12, 1819 A graduate of Harvard college (1838), he studied law under his father, Justice Joseph Story, and for six years he only wrote poetry and criticism, modelled and painted to amuse himself. A request that he make the public monument to his father resulted in a journey abroad, which caused him to find that his "heart had gone over from the Law to Art." Thereafter he spent his life in Italy, where he died, Oct 7, 1895 What Nathaniel Hawthorne called "his perplexing variety of talents and accom-plishments" prevented his high contemporary reputation from becoming permanent. His statue of Cleopatra is most famous because of the enthusiastic description in Hawthorne's Marble Faun; typical of the majority of his sombre feminine figures are "Semiramis" and "Medea" in the Metropolitan museum, New York city His Poems (1885), He and She; or, A Poet's Portfolio (1884) and A Poet's Portfolio: Later Readings (1894) show his love of beauty, but, like his statues, they lack vitality, as do his other books.

See Henry James, William Wetmore Story and His Friends (1903); Lorado Tait, History of American Sculpture (1924).

STORY: see Shorr Story.
STOSS, VEIT (1438 or 1440-1533), German sculptor and wood carver, was born in Nuremberg. In 1477 he went to Cracow, where he was actively engaged until 1499. It was there that he carved the high altar for the Marienkirche, between 1477 and 1484. On the death of King Casimir IV in 1492 Stoss carved his tomb in red marble for the cathedral in Cracow. He also executed the marble tombstone of the archbishop Zbigniew Ollsnicki in the cathedral at Gnesen and the Stanislaus altax for the Marienkirche at Cracow. In 1406 he returned to Nuremberg where he did a great deal of work in completing altars His main works are: a relief with the Coronation of the Blessed Virgin in the Germanic museum at Nuremberg, a statue of the Blessed Virgin in the Frauenkirche, the Annunciation in the Lorenzkirche, and the cir- and large ironworks, nails and other iron goods being made, cular rosary in the Germanic museum

STÖSSEL, ANATOLI MIKHAILOVICH (1848-1915), Russian general, boin at St Petersburg (Leningrad), on July 10, 1848, entered the Russian aimy in 1864. He served in the Russo-Turkish War of 1877-78 and in the Boxer campaign of 1900 At the outbreak of the Russo-Japanese War (1904) he was placed in command at Port Arthur. After a prolonged defence (see Russo-JAPANESE WAR) he surrendered the city to the Japanese (Jan 2, 1005). He was tried by court-martial and imprisoned Stossel was released in May 1909 He died in January 1915.

STOTHARD, THOMAS (1755-1834), English subject painter, was boin in London on Aug 17, 1755 After a delicate childhood, he was apprenticed in Spitalfields to a draughtsman of patterns for brocaded silks In 1778 he became a student of the Royal academy, of which he was elected associate in 1792 and full academician in 1794. In 1812 he was appointed librarian. He

died in London on April 27, 1834

In 1780 he became a contributor to the Novelist's Magazine, for which he executed 148 designs, including his 11 admirable illustrations to Peregrine Pickle and his graceful subjects from Clarissa and Sir Charles Grandison He contentedly designed plates for pocketbooks, tickets for concerts, illustrations to almanacs, portraits of popular players-and into even the slightest sketches he infused grace and distinction. He is at his best in domestic or ideal subjects, the heroic and the tragic were beyond his powers. His oil pictures are usually small in size, and rather sketchy in handling; but their colouring is often rich and glowing, Stothard having been a great admirer of Rubens. The "Vintage," perhaps his most important oil painting, is in the National gallery. His best-known painting is the "Procession of the Canterbury Pilgrims," also in the National gallery, the engraving from which attained an immense popularity.

Among his illustrations are the two sets to Robinson Crusse, one for the New Megazame and one for Stockdale's edition, and the plates to The Pilgran's Proyects (1983), to Hardnag's edition of Goldston to the works of Gesner (1803), to Cowper's Pootons (1883), to The Decemeron, the editions of Roger's Haby (1830) and Proms (1834), to The Decemeron, the editions of Roger's Haby (1830) and Proms (1834) to The Stockmar also defeorated the grand starcase of Bunghley house, (1810) and the cupola of the upper hall of the Advocates' history, Cathoburgh London eccupied by the Signet History), with Apollo and the Muses, and figures of poets, oration, etc. (1837). His designs for executed, owing to the death of Ceorge IV, He also designed the magnificent shield presented to the dule of Wellington by the mechanist of London, and executed with his your hand as series of eight Among his illustrations are the two sets to Robinson Crusoe, one

chants of London, and executed with his own inhol a series of eight etchings from the various subjects which adonned it.

An interesting but most indiscriminately eulogistic biography of Stothard, by his daughter-in-law, Mrs. Bray, was jublished in 1855. A. C. Coxhead's Fibonas Stothard, R. A., an Illustrated Mongraph (1964), contains a short biographical chapter, and an accurately dated summary of the various books and periodrals illustrated by Stothard; see also Austin Dobons, lighteent Century Vignattes.

STOUR, the name of several English rivers, an ancient word of doubtful etymology. (1) The East-Anglian Stour rises in southeast Cambridgeshire and flows 47 mi. to the North sea at Harwich. (2) The Kentish or Great Stour rises on the south of the North Downs, one branch, the East Stour, rising N.W. of Hythe but flowing away from the sea, while the western branch rises near Lenham and the two unite at Ashford. Passing Canterbury, the Stour again divides: the Great Stour, joined by the Little Stour, flows east to Pegwell bay; the small branch enters the North sea near Reculver. It is navigable to Fordwich. Its length is about 40 mi. Other rivers named Stour are: (3) a tributary of the Hampshire Avon: (4) a left-bank tributary of the Severn, which it joins at Stourport; and (5) a small tributary of the Warwickshire Avon, rising west of Banbury,

STOURBRIDGE, a municipal borough in the Stourbridge parliamentary division of Worcestershire, England, 143 mi. W.N.W. from London by the G.W.R. Pop. (1951) 37,247. Area, 6.6 sq.mi. The grammar school, in modern buildings, was founded in 1430 and the Hospital school in 1670. The Vine inn is a 16th century half-timbered building. There are coal mines

21-Q

though the chief trade is in fire bricks. The glass manufactory was established in 1556.

STOURPORT-ON-SEVERN, an urban district of Worcestershire, England, 4 mi SW of Kidderminster. (1951) 10,140 Area, 5 sq mi. An electrical generating station serving Shropshire, Worcestershire and Staffordshire is there The town is more industrial than formerly, though the river traffic is less extensive. At Redstone is a hermitage excavated out of

the red sandstone bank of the Severn.

STOUT, SIR ROBERT (1844-1930), New Zealand judge and statesman, was born on Sept. 28, 1844 at Lerwick, Shetland Isles, where he became a pupil teacher at the parish school in 1857 In 1863 he went to New Zealand, where he taught until he began to study law in 1867, being admitted as barrister and solicitor of the supreme court of New Zealand on July 4, 1871 He served in the Otago provincial council from 1872-76, acting concurrently (1874-75) as provincial solicitor and as Liberal M.P. for Caversham (1875). As a member of parliament, he was an important force in the formation of the Liberal party in New Zealand. In Feb. 1878 he became attorney general and minister of lands and immigration in Sir George Grey's ministry. He resigned in 1870 but returned to public life in 1884 as member for Dunedin East. On the defeat of Sir Harry Atkinson's government he joined Sir Jules Vogel in forming a ministry (Aug. 16-28, 1884), but after another Atkinson government had held office for a few days (Aug. 28-Sept. 3) a second Stout-Vogel government was formed which lasted three years. In both the Stout-Vogel governments Stout was premier, attorney-general and minister of education. At the general election in 1887 he lost his seat. In 1893 he was elected as an independent Liberal for Inangahua, at a by-election, and at the general elections of 1803 and 1896 he was elected for Wellington city. In 1898 he resigned his seat and from 1899-1926 served as chief justice of New Zealand. From 1926-30 he was a member of the country's legislative council. In 1886 he was made K C M G.

Stout's principal measures were the Land act of 1877; the first Land Tax act (which he drafted in co-operation with John Ballance and which became law in 1878); the Hospitals and Charitable Institutions act of 1885; and the Civil Service Reform act of 1886. As a member of a royal commission appointed in 1881 he helped Allen Holmes to form the code of civil procedure, which was enacted in 1882 and which made the supreme court procedure of New Zealand one of the simplest in the world Stout was chancellor of New Zealand university from 1903-23 and a member of that institution's senate from 1884-1930, as well as being associated with Otago university and Victoria college as member of their respective councils He died in Wellington, July 19, 1930.

BIBLIOGRAPHY —Stout's works include Leasing State Lands (1875); State Louis (1875).

State Louise The Property of New Zealand, 1869-48 (1885); and The Notice on the Property of New Zealand, 1869-48 (1885); and The Views (1891). See also The Trines, 1919 x, 1919. New Zealand Parliamentary Record (1869-295); T. M. Hocken, Contributions to the Early History of New Zealand, 1898; J. B. Condilific, New Zealand, 1898.

STOUT: see BEER; BREWING.

STOVES: see Household Appliances; Gas Stoves; Elec-TRIC FURNACES: HEATING AND VENTILATION.

STOW, JOHN (c. 1525-1605), English historian and anti-quary, was born about 1525 in London. He learned the trade of his father, a tailor, but possibly did not practise it much after he grew up. In 1561 he published his first work, The Woorkes of Geffrey Chaucer, Newly Printed With Divers Addicions Whiche Were Never in Printe Before. This was followed in 1565 by his Summarie of Englyshe Chronicles, which was frequently reprinted, with slight variations, during his lifetime. In 1580 Stow published his Annales, or a Generale Chronicle of England from Brute Until the Present Years of Christ 1580.

The work by which Stow is best known is his Survey of London, published in 1598, not only interesting from the quaint simplicity of its style and its amusing descriptions and anecdotes, but of unique value from its minute account of the buildings, social condition and customs of London in the time of Elizabeth, Through the patronage of Archbishop Patker, Stow was enabled to print the \*Plores instornarum\* of Matthew of Westmuster in 150°, the Chromole of Matthew Paris in 1571°, and the \*Historna breuss of Thomas Walsingham in 1574. At the request of Parker he had himself compiled a "farre larger volume," An history of this silond, but the manuscript is lost Stow remained poor all his fie, and was authorized by James I to appeal for alms in 1604. He died on April 6, 1605, and was buried in the church of St Andrew Undetshaft, where is, his monument.

A number of Stow's manuscripts are in the Harleian collection in the Bitish Museum Some are in the Lambeth library (No 306), and from the volume which includes them were published by the Camden Society, edited by James Gardner, Three Fifteenth-Century Chronicles, with Historical Memoranda by John Stowe the Antiquary, and Contemporary Notes of Occurrences written by Jam (1880).

of the many editions of Stow's Survey of London, see that with notes by C L Kingsford (Oxford, 1908).

STOWE, HARRIET ELIZABETH (BEECHER) (1811-1896), American writer and philanthropist, seventh child of Lyman and Roxana (Foote) Beecher, was born at Litchfield (Conn ), June 14, 1811 Her parents were descended from founders of New Haven, and the community in which she spent her childhood was one of the most intellectual in New England. At her mother's death, in 1815, she came most directly under the influence of her eldest sister, Catherine, a woman of keen intellect, who a few years later set up a school in Hartford, to which Harriet went, first as a pupil, afterwards as teacher. In 1832 her father, who had for six years been the pastor of a church in Boston, accepted the presidency of the newly-founded Lane Theological seminary at Cincmnati Catherine Beecher, who was eager to establish what should be in effect a pioneer college for women, accompanied him; and with her went Harriet as an assistant, taking an active part in the literary and school life, contributing stories and sketches to local journals, and com-piling a school geography She was married Jan 6, 1836, to one of the professors in the seminary, Calvin Ellis Stowe. In the midst of privation and anxiety, due largely to her husband's precarious health, she wrote continually, and in 1843 published The Mayflower, or Sketches of Scenes and Characters among the Descendants of the Pilgrims She hved 18 years in Cincinnati, separated only by the Ohio river from a slave-holding community, coming in contact with fugitive slaves, and learning from friends and her own visits the life of the South. When, therefore, in 1850, Mr Stowe was elected to a professorship in Bowdoin college, Brunswick (Me.), and removed his family thither, Mrs. Stowe was prepared for the great work which came to her, bit by bit, as a religious message which she must deliver. There she wrote, for serial publication in the National Era, an anti-slavery paper of Washington (D C), the story of Uncle Tom's Cabin; or, Life Among the Lowly. The publication in book form (March 20, 1852) was a factor which must be reckoned in summing up the moving causes of the Civil War. The book sprang into unexampled popularity, and was translated into at least 23 languages. Mrs. Stowe reinforced her story with A Key to Uncle Tom's Cabin, in which she accumulated a large number of documents and testimonies against the great evil; and in 1853 she made a journey to Europe, devoting herself especially to creating an entente cordiale between English and American women on the question. In 1856 she published Dred: a Tale of the Dismal Swamp, in which she threw the weight of her argument on the deterioration of a society resting on a slave basis. The establishment of the Atlantic Monthly, in 1857, gave her a constant vehicle for her writings; also the Independent of New York, and later the Christian Union, of which papers successively her brother, Henry Ward Beecher, was one of the editors.

From this time she led the life of a woman of letters, writing novels, of which The Minister's Wooing (1859) is best known, and many studies of social life in the form both of faction and easay. Her Pear of or's Jained (1863), Sarah Orne Jewett credited with having revealed to her the literary value of the country folk. Miss. Stowe polished also a small volume of re-

lagious poems, and towards the end of her career gave some public readings from her writings. In 1832 FOr Stowa excepted a professorship in the Theological semmary at Andover (Mass.), and the family made its home there till 1863, when he redde wholly from professional life and removed to Hartford After the close of the war for the Union, Mrs Stowe bought an establishment of the stop of the store of the constant of the war for the Union, Mrs Stowe bought and estate in Flouda, chiefly in hope of restoring the health of her son, Capt. Frederick Beecher Stowe, who had been wounded in the war, and there she spent many winters. After the death of her hushand in 1886, she lived in the sections of her Hartford how, where she chied on July 1, 1806. She is buried by the side of her hushand in 1880 and Andover.

See the Life and Letters of Harrest Beecher Stome (1807) which were edited by Anne Pields Recent lives are C E and L B Stove, Harrest Beecher Stowe. the Story of Her Life (1911), and a biography for grik (1913) by Martin F Crow See also "Harrest Beecher Stowe" in John Enslune's Leading American Hovelsis' (1910) The Riverside in John Enslune's Leading American Hovelsis' (1910) The Riverside vivolinesses (with an advistroal volume of biography)) (H E S) in

16 volumes (with an additional volume of biography) (H E S) STOWELL, WILLIAM SCOTT, BARON (1745-1836), English judge and jurist, was born at Heworth, near Newcastle, on Oct 17, 1745. His younger brother John became the famous Lord Chancellor Eldon Scott was educated at the Newcastle grammar school and Corpus Christi college, Oxford In 1779 he graduated as doctor of civil law and, after the customary "year of silence," commenced practice in the ecclesiastical courts. In 1783 he became registrar of the court of faculties; in 1788 judge of the consistory court and advocate general, and in 1708 he was made judge of the high court of admiralty. Sir William Scott twice contested Oxford university-in 1780 without success, but successfully in 1801. He also sat for Downton in 1700 Upon the coronation of George IV (1821) he was raised to the peerage as Baron Stowell. Lord Stowell retired from the bench-from the consistory court in Aug 1821, and from the high court of admiralty in Dec 1827. He died on Jan. 28, 1836. The doctrines of international law with the assertion and illustration of which the name of Lord Stowell is identified are these the perfect equality and entire independence of all states ("Le Louis," 2 Dod 243)-a logical deduction from the Austinian philosophy and still one of the fundamental principles of English jurisprudence; that the elementary rules of international law bind even semibarbarous the elementary ruse of international and non-zero seminosconstates (the "Hurtige Hane," 2 Rob 325," that blockade to be binding must be effectual (the "Betsey," 1 Rob, 33); and that contraband of war as to be determined by "probled elestimation" (the "longe Margaretha," 1 Rob, 189). In the famous Swedish convoy case (the "Man," 1 Rob, 325; see, too, the "Recovery," 6 C. Rob. 348-9) Lord Stowell asserted that "a prize court is a court not merely of the country in which it sits but of the law of nations."

See W. C. Townsend, Lines of Twelve Emment Judge, 2 vol., vol. II (1245) W. Townsend, Lines of Twelve Emment Judge, 2 vol., vol. II (1245) W. E. Surtees, Sheekel of the Lives of Lords Slewell and the Lines of Lords Slewell and the Lines of Lords Slewell and the Lines of Lines Slewell with the Lines of Lines Slewell and Lines of Lines Slewell and Lines of Lines Slewell and Lines Slewell S

STOWMARKET, a town in Suffolk, Eng. Pop (1951)
7,335. Area 2.6 sq.mi. The church of SS. Peter and Mary is Decorated and Early English, with a tower and wooden spire. The vicarrage has associations with Milton through his tutor, Young.

STRABANE, urban district and principal town of County Tyrone, Northern Ireland. Pop. (1951) 6,620. Area, 2,9 sq.mi. The Mourne and Finin rivers join there and thenceforward form the Foyle. The trade in corn is considerable. Shirt and collar making is the chief industry

STRABO (Strakovs) (horn 6.65 n.c.), Greek geographer, was born at Amasis in Pontus, a city which had been much Hellemzed. He studied at Nysa under the grammarian Aristodemus, under the grammarian Tyrannio at Rome, under the philosopher Xenarchus, and he studied Aristotle with Boethus. He also states that he saw P. Servillus Issurrus, who died at Rome in advanced years in 44 n.c., from which it has been inferred that he visited Rome early in life. He also tells us that he was at Gyaros (one of the Cyclades) when Augustus was at Corinth on his return to Rome from the east in 29 n.c., and that he accompanied the prefect of Egypt, Achius Gallus, on his expedition to upper Egypt, which seems to have taken place in 25-a8 xc. These are the only dates in his life

which can be accurately fixed The latest event mentioned in his work is the death of Juba, king of Mauretania, in AD 27 Although he had seen a comparatively small portion of the regions which he describes, he had travelled much As he states "Westward I have journeyed to the parts of Etruria opposite Sardinia. towards the south from the Euxine to the borders of Ethionia." His Geography was finally revised between A.D. 17 and 23

Works .- His earliest writing was a historical work now lost, which he himself describes as his Historical Memoirs He tells us (x1, q, 3) that the sixth book of the Memours was identical with the second of the Continuation of Polybius, probably, therefore, hooks 1-1v formed an introduction to the main work Plutarch. who calls him "the Philosopher," quotes Strabo's Memours (Luc 28), and cites him as a historian (Sulla, 26) Josephus calls him "the Cappadocian," and often quotes from him

The Geography is the most important work on that science which antiquity has left us It follows Eratosthenes, who had first laid down a scientific basis for geography The earlier book was too small to contain the description of separate countries which Strabo included The historical notices are all his own. He regarded Homer as the source of all wisdom and knowledge-indeed. his description of Greece is largely drawn from Apollodorus' commentary on the Homeric "Catalogue of Ships"-and treated Herodotus with undeserved contempt, classing him with Ctesias and other "marvelmongers,"

Strabo chiefly employed Greek authorities (the Alexandrian writers Polybius, Poseidonius and Theophanes of Mytilene, the companion of Pompey) and made comparatively little use of Roman authorities He probably amassed his material in the library of Alexandria, so that Greek authorities would naturally furnish the great bulk of his collections, and then returned to Rome. where he perhaps used the chorography of Agrippa, a map of the

Roman empire set up in the Porticus Vipsaniae.

The Geography consists of 17 books, of which the 7th is imperfect The first two are introductory, the next eight deal with Europe, two being devoted to Spain and Gaul, two to Italy and Sicily, one to the north and east of Europe and three to Greek lands The 11th book treats of the main divisions of Asia and the more easterly districts, the next three of Asia Minor. Book xv deals with India and Persia, book xvi with Assyria, Babylonia, Syria and Arabia and the closing book with Egypt and Africa

Syris and Arabia and the assung book with Egypt and Artica Binanous arms.—The Adme echoic Vience, critô was unfortunately based on a very corrupt manuscript. The first substantial improvements were made by I Casaubon (Genew, 153; Paris, 1520), whose text remained the basis of subsequent editions till that of A. Coraes (Paris, 152-19), which removed many corruptors. The manuscripts were first schemidically of the control of the correct of

was born at Aberdeen, Scot., on April 12, 1778. After taking his degree at Aberdeen he emigrated in 1799 to Canada. There he was ordained (1803) and appointed to the parish of Cornwall, and in 1812 to York.

Strachan was appointed to the executive council of Upper Canada in 1815. He was soon the leading spirit in that dominant group known in Upper Canadian history as the "family compact." In 1820 he was appointed by Sir Peregrine Maitland a member of the legislative council in order that the governor might have a confidential medium through whom to make communication to the council. At the instance of the lieutenant governor he went to England in 1824 to discuss various colonial questions with the colonial secretary. He paid a second visit to England in 1826-27 to obtain a royal charter for King's college. In 1827

Strachan became archdeacon of York. The breakup of the Liverpool ministry in 1827 interrupted Strachan's plans for placing the government endowments for religion and education under the Episcopal Church Adverse criticism and a suggestion from the colonial office led to his resignation from the executive council, but he declined to resign from the legislative council

On the death of Bishon Stewart of Quebec the Canadian see was divided, and Strachan was made bishop of Toronto in Aug 1839. He energetically opposed the act of 1840, which sought to settle the clergy reserves question by dividing the proceeds among the different religious denominations, the larger share still

remaining with the Church of England.

The university of King's college was finally established, with certain modifications of its charter, in 1843, Bishop Strachan being the first president. The renewed agitation finally resulted in the elimination of all religious tests by the act of 1849, which also changed the name to that of the University of Toronto Strachan at once took steps to found another university which should be completely under the control of the Episcopal Church, hence the establishment of Trinity university, which was opened in 1852 Bishop Strachan also raised once more the question of the disposal of the clergy reserves, which were completely secularized in 1854 He died in November 1867.

STRACHEY, GILES LYTTON (1880-1932), British critic and biographer, son of Sir Richard Strachey, the Indian administrator, was born on March 1, 1880, and educated at Trinity college. Cambridge. He was a leading figure in the remarkable "Bloomsbury" circle which included his Cambridge friends I M Keynes, Desmond MacCarthy, Leonard Woolf and Clive Bell and also the two daughters of Sir Leslie Stephen, Vanessa Bell and Virginia Woolf. In 1912 he published Landmarks in French Laterature and throughout his life did much by his articles to make his countrymen appreciate the precision and delicacy of French poetry and prose. His greatest achievement, however, was in biography. He made his reputation with Emment Victorians (1018) and Queen Victoria (1921) and added to it with Elizabeth and Essex (1928) and Portraits in Miniature (1931) Strachev made a revolution in the writing of biography. Treating his subjects from a highly idiosyncratic point of view, he determined to create a work of art rather than to record activities and events fascinated by personality and motive and delighted in pricking the pretensions of the great and reducing them to life-size in a prose style that was at once elegant, sinuous and singularly ironical.

His aim was to paint a portrait, and though this led to caricature and sometimes, through tendentious selection of material, to inaccuracy, he taught biographers a sense of form and of background as well as sharpening their critical acumen. His many imitators also hastened to "debunk" the past, but they lacked Strachev's detachment, taste and Voltairean assurance; nor could they rival his best work, Queen Victoria, in which Strachey combined his gift for narrative with a power of analyzing characters with whom he had nothing in common. His defects as a biographer arose mainly from his clear but limited vision of life. He did not love the past for its own sake; and he saw politics largely as intrigue, religion as a ludicrous anachronism and personal relations as the supremely important facet of life. Though bitterly attacked during and after his lifetime, Strachey remains a phenomenon in English letters and a pre-eminent English humorist and wit.

Two collections of essays, Books and Characters (1922) and Characters and Commentaries (posthumously in 1933) were also published. Strachey died unmarried on Jan. 21, 1932,

(N. G. A.) STRACHEY, JOHN ST. LOE (1860-1927), British journalist, was born at Sutton Court, Somerset, on Feb. 9, 1860, the second son of Sir Edward Strachey, 3rd bart., and Mary Isabella, daughter of John Addington Symonds He studied at Balliol college, Oxford, and was called to the bar, but adopted journalism as his profession. After writing for some time for the Saturday Review, the Economist and other papers, he became in 1886, with Charles Graves, editor of the Liberal Unionist, and in the same year assistant editor of the Spectator. After the death of R. H. Hutton and the retirement of Meredith Townsend (1897)

he became proprietor of the Spectator, which, under his editorship not only maintained but increased its great influence upon English opinion St Loe Strachey also edited (1896-97) The Cornhill Magazine He resigned from the editorship of the Spectator in 1025, but continued to contribute to its columns

His publications melude The Manufacture of Paupers (1907), The Problems and Perils of Socialium (1908), The Practical Wisdom of the Bible (1908), A New Way of Life (1906), The Madonia of the Barricades (a novel, 1925), American Soundings (1926)

STRACHWITZ, MORITZ KARL WILHELM AN-TON, GRAF VON (1822-1847), German poet, was born on March 13, 1822, at Peterwitz near Flankenstein in Silesia After studying in Breslau and Berlin he settled on his estate in Moravia. where he devoted himself to literary pursuits He died on Dec 11, 1847, at Vienna in his 25th year He had already revealed a lyric genius of remarkable force and originality His heroic ballads are notable and had much influence upon Theodor Fontane and Detley von Liliencron His first collection of poems. Lieder eines Erwachenden, appeared in 1842 and went through several editions Neue Gedichte were published in 1848

BIBLIOGRAPHY -Strachwitz's collected Gedichte appeared first in 1850 (8th ed , Breslau, 1891), a convenient reprint will be found in Reclaim Universalbibliothek (Leipzig) H M Elster (ed ), Samtliche Lieder und Balladen (Berlin, 1912) has a biography See also T Baumstark, Die Dichtung des Grafen Moritz von Strachwitz (Munster, 1935)

STRADELLA, ALESSANDRO (?1645-1682), Italian composer, one of the most accomplished musicians of the 17th century, was probably boin at Naples The generally accepted story of his life was first circumstantially narrated in Bonnet-Bourdelot's Histoire de la musique et de ses effets (1715) According to this account, Stradella was engaged by a Venetian nobleman to instruct his mistress, Ortensia, in singing Stradella eloped with Ortensia to Rome, where the outraged Venetian sent two paid brave to put him to death On their arrival in Rome the assassins learned that Stradella had just completed a new oratorio, over the performance of which he was to preside on the following day at S. Giovanni in Laterano They determined to kill him as he left the church, but the beauty of the music conquered them, and they warned the composer of his danger. Thereupon Stradella fled with Ortensia to Turin, where, notwithstanding the favour shown to him by the regent of Savoy, he was attacked one night by another band of assassins, who, headed by Ortensia's father, left him on the ramparts for dead. Through the connivance of the French ambassador the ruffians escaped, and Stradella, recovering from his wounds, married Ortensia, by consent of the regent, and removed with her to Genoa There he believed himself safe, but a year later he and Ortensia were murdered in their house by a third party of assassins in the pay of the implacable Venetian Research has, however, driven several holes in this picturesque story

The first certain date in Stradella's life in 1672, in which year he composed a prologue for the performance of Cesti's opera La Dori at Rome; he probably spent a considerable time at Rome about this period, since his cantatas and other compositions contain frequent allusions to Rome and noble Roman families. There is, however, no proof that he ever performed the oration S Giovanni Batissta in the Lateran Documents in the archives at Turin relate that in 1677 he arrived there with the mistress of Alvise Contarini, with that in 1077 he arrived there with the mistress of Alvise Contarin, with whom he had deped from Venice. We hear of Stradella last at Genoa. An opera by him, Le Forma dell' amor paterno, was given there in 1678, and his last composition, It Barcheggio (r.g. a "Water-Music"), was performed on June 16, 1681 in honour of the marriage of Carlo Spinola and Paola Brignole 'That he died at Genoa in Fch. 1682 is established

and Paola Brignole. That he died at Genoa in Feb, 1882 is established by documents in the archives at Modena. Stradella's best operas are It Floridoro, also known as It Mora per amore, and It Trespolo tutore, a comic opera in three acts which worthly carned on the best traditions of Florentine and Roman, comic opera in the 17th century. The oratorio S. Giovanni Battista displays open in the 17th century. The oratorio S. Givenent Bottitis displays from some still in construction and corclestration (or far as the limited in the same still in construction and corclestration (or far as the instruction of the construction of Stradella.

Structura, "J. The finest collection of Stradella's works extant is that at the Biblioteca Esteries at Modena, which contains 148 manuscripts, includ-

ing four operas, six oratorios and several other compositions of a semidramatic character

BIBLIOGRAPHY—Heinz Hess, Die Opern Alessandro Stradellas (Leipzig, 1905), which includes the most complete catalogue vet made of Stradella's extant works, Catelani, Delle Opere di A Stradella instenti nell' archivio musicale della r biblioteca palatina di Modena (Modena, 1865); and Sedley Tayloi, The Indebtedness of Handel to other Composers (Cambridge, 1906)

STRADIVARI, ANTONIO (1644-1737), Italian violinmaker, was associated throughout his life with Cremona, where he brought the craft of violin-making to its highest pitch of perfec-The obscure details of his life were thoroughly worked out in the monograph on him by W H Hill, A F Hill and Alfred Hill (1902) He was still a pupil of Nicolas Amati in 1666, when he had begun to insert his own label on violins of his making, which at first follow the smaller Amati model, solidly constructed, with a thick yellow varnish. It was not till 1684, that he began to produce larger models, using a deeper coloured varnish, and beautifying them in various details, his "long" patterns (from 1690) representing a complete innovation in the proportions of the instrument, while from 1700, plete innovation in the proportions of the materiment, while iron 1760, and otherwise improved his model He also made some beautiful violencellos and violes. The most famous instruments by him are Tolonis the "Halher" (1970), the "Schlier" (dorso, 1680), the "Nucean Yorkota" (1770), the "Holonis (1770), the "Quarke" (1771), the "Violentia" (1770), the "Parke" (1771), the "Wood of "Gillot" (1773), the "Gillot" (1773), the "Gillot" (1773), the "Messia" (1770), the "Banta" (1773), the "Messia" (1770), the "Mess after for a few years returning to an earlier style, he again broadened to the possession of Antomo's stock-in-trade The Stradwan method of voilin-making created a standard for subsequent times, but the secret of his varnish, soft in texture, and shading from orange to red, though much debated, has never been discovered See E. N. Doring, How Many Strads? (Chicago, 1945)

STRAFFORD, THOMAS WENTWORTH, EARL OF (1593-1641), English statesman, son of Sir William Wentworth, of Wentworth Woodhouse, near Rotherham and of Anne Atkins, was born on April 13, 1593, in London. He was educated at St John's College, Cambridge, was admitted a student of the Innei Temple in 1607. In 1614 he represented Yorkshire in the Addled Parliament, but, so far as is now known, it was not till the parliament of 1621, in which he sat for the same constituency, that he took part in the debates.

Wentworth was returned for Pontefract to the parliament of 1624, but appears to have taken no part in the proceedings. In the first parliament of Charles I, June 1625, he again represented Yorkshire, and opposed the demand made under the influence of Buckingham for subsidies for a war with Spain, and was consequently, after the dissolution in November, made sheriff of Yorkshire, in order to exclude him from the parliament which met opposition He was annous to serve the grown, but he disapproved of opposition He was annois to serve the crown, but he disapproved or the king's polecy. After the dissolution of the parhament he was dis-missed from the justiceship of the peace and the office of custor rotulorum of Yorkshire, to which he had been appointed in 1613 He refused in 1627 to contribute to the forced loan, and was imprisoned in

In the parliament of 1628 Wentworth joined the popular leaders in resistance to arbitrary taxation and imprisonment, but he was jealous for the prerogative of the crown, to which he looked as a teserve force in times of criss. A moderate bill supported by Wentworth for securing the liberties of the subject was wiccked between the uncompromising to morries of the subject was whereas between the uncompromising demands of the parliamentary path, who would give nothing to the and the leadership was thus snatched from Wentworth's hands by Eloit and Coke Later in the session he fell into conflict with Eloi, as he desared to modify the Petition of Right.

On July 22, 1658, Wentworth, was created Baron Wentworth, and

received a promise of the presidentship of the Council of the North at the next vacancy He was now at variance with the parliamentary party both on the constitutional and on the religious question. In December he became Viscount Wentworth and president of the Council December he became viscount wentworth and president of the Council of the North In the speech delivered at Yolk on his taking office he said, almost in the words of Bacon "Whoever," he said, "ravels forth into questions the right of a king and of a people shall never be able to wrap them up again into the comeliness and order he found them?"

wrap them up again into the comeanness and order he found them."
The session of 1629 ended in a breach between the king and the
paliament which made the task of a moderator hopeless. He stood
definitely for the maintenance of the king's prerogative
The Policy of Thorough.—In January 1633 Wentwoith was

amed lord deputy of Iteland, and he arrived in Dublin in July 1633 named lord deputy of I teland, and he arrived in Dublin in July 1633. He reformed the administration, getting fit osmanuity of the melicinal control of the property of the control of the country of the cou from a little over £25,000 in 1633-1634 to £57,000 in 1637-1638 Hè raised an army. He swept the pirates from the seas. He reformed and instilled life into the church and rescued church property His etrone and even administration broke down the tyranny of the great men over the poor Such was the government of "Thorough," as Strafford and two poor "Modelman the coverage of "Thopout its great fine of the poor "Modelman the coverage of the poor "Modelman the poo and Lord Mountnorns, the last of whom Strafford caused to be sen-tenced to death no notice to obtain the resignation of his office, and then the control of the control of the control of the control of the be forced into Connaught, and, raking up an absolute tile—found in the 14th century of Connaught to Lionel, dute of Charence, whose her Charles was—he missted upon the grand junes in all the countse faming verdents for the king! High-handed as Wentworth was by get he had never consulted on English alfairs, and it was only in February 15g4 that Charles saked his opinion on a proposed interference in the affairs of the Continent. In reply, he assured Charles that it would be unwassed to undertake even haved open and the proposed interference would be unwassed to undertake even haved open for the continent. absolute power at home. He wished that Hampden and his followers "were well whipped into their right senses." When the Scottish Puri-tans tebelled he advocated the most decided measures of repression. in February 1639 sending the king £2,000 as his contribution to the expenses of the coming war, but he deprecated action before the English army was trained, and advised concessions in religion

army was trained, and advised concessions in religion
Wentworth arrived in England in September 1639, after Charles's
failure in the first Bishops' War, and from that moment he became
Charles's principal adviser In January 1640 he was created earl of
Straiford, and in March he went to Ireland to hold a parliament, where the Catholic vote secured a grant of subsidies to be used against the the Cathonic vote secured a grant of subsidies to be used against the Presbyteran Socia An Irash army was to be leved to assist in the coming war. When a April Strafford returned to England he found the commons holding back from a grant of supply, and Iratl to en-list the peers on the side of the king. On the other hand he induced Charles to be content with a smaller guant than he had organally asked for The commons, however, insisted on peace with the Scoia Charles, on the advice of Vang, returned to his larger defaund of 12 in Charles, on the advice of vane, redulated to in larger demand of its subsidies, and on May 9, at the privy council, Stafford, though reluctantly, voted for a dissolution The same morning the Committee of Eight of the privy council met again. Vane and others were for a mere defence against invasion. Strafford's advice was for a vigorous

osecution of war
Bill of Attainder,—The Long Parliament assembled on Nov. 1640, and Charles immediately summoned Strafford to London Under safe conduct from Charles, he arrived on the 9th and on the 10th pro-posed to the king to forestall his impeachment, now being prepared by posed to the kingt to forestall this impeachment, now being propared by the parliament, by accusing the leaders of the popular party of trea-sonable communications with the Scots. But Pym immediately took up the impeachment to the lords on the rith. Straffed came to the house to control his accusers, but was ordered to withdraw and committed whereapon he was sent to the Tower, and, on Jin 3, 7464, the ac-cusations in detail were piecented. These were, in sum, that Strafford had endeavoured to subvert the forward and on Jin 3, 7464, the ac-lant of the responsibility to the nation of the leader of its satisfiant of of the responsibility to the nation of the leader of its satisfiants of of the responsibility to the nation of the leader of its satisfiants of of the responsibility to the natuon of the leader of its administration. The commons, convinced that the destruction of Strafford was essential to the histories of the singdom, dropped the imprachment, and brought to the histories of the singdom, dropped the imprachment, and brought the library of the procedure of an impactment was practically adhered to. Strafford might still have been saved but for the kings ill-advised conduct. The administration of the strafford was practically adhered to. Strafford religious to the strafford was also been saved but for the kings ill-advised conduct. The statistical religious to the strafford was also been saved but for the kings is advised conduct. The statistical religious transfer in the straff of the strafford was also been supported by the supported by the strafford was also been supported by the suppor

Thus passed into history "the great person," as Clarendon well calls him, without doubt one of the most striking figures in the annals of England. Strafford's patriotism and ideas were fully as noble as those

of his antagomsts Like Pym, a student of Bacon's wisdom, he believed in the progress of England along the lines of natural development, but that development, in opposition to Pym, he was convinced could only proceed with the mecesse of the power of the executive, not of the paliament, with a government controlled by the lang and not by the

peopie Sträfford was martied three times (1) in 1611 to Lady Margaret Chifford, daughter of Francis, 4th earl of Cumberhand, (2) in 1625 to Lady Arabella folles, daughter of John, 1st eanl of Claret, (3) in 1631 to Elizabeth, daughter of Sir Godfery Rhodes He left three daughters and one son, Whilman, 2nd earl of Strafford

and one son, William, and earl of Strafford in the Det. No. Bose by BRILLOGARPY—The article on Strafford in the Det. No. Bose to S. R. Gardiner, Strafford's Letters, ed by W. Knowledt (1991); R. R. Gardiner, Strafford's Letters, ed by W. Knowledt (1991); R. R. Gardiner, Strafford's Letters, and the Letters of the Computer Strafford on Letters of the Letters of the Computer Strafford to the titerd Wije, Philobholto Sco. Blog & Hest Miss vol 1 (1864), Lincu by H. D. Traill (1889) in "Brailish Men of Action Sense," and by Elizabeth Cooper (1889), Lift, M. M. S. Comm. Action Series," and by Edizabeth Coope (1885), Cel. of Nate Papers, Domestic and Inst., esp. of 33-deq Introduction, Hast MSS. Comm. MSS of East Comper, Strafford's Correspondence, of which the volumes published by Knowler represent probably only a small selection, temains still in ms in the collection of East Fitzwilliam with the Wentworth Woodhouse, also HO Grady, Simiford and Inland, 2 vol. (Dublin, 1923)

STRAITS QUESTION. The Straits Question concerns the international status of the Black Sea straits, i e, the Bosporus and the Dardanelles, which form the only existing passage from the Black sea into the Mediterranean and vice versa. In 1453 these straits became a part of Turkey and thus entered into the Eastern Ouestion (a v.) until the end of the Ottoman empire in 1920. It is not identical with the problem of Constantinople as the former capital of the Byzantine empire, although the two problems might have been connected in the past. Whatever the political aspirations of the antagonists of the Ottoman empire, including Peter the Great, there was no Straits Ouestion before 1774, for until then the Black sea was an inland Turkish sea From 1774 on, with Catherine the Great acquiring the northern shore of the Black sea, the Straits Question appeared involving the interests of Russia, Turkey and the non-Black-sea naval powers These interests do not coincide. Russia's aim has been to secure free passage for its warships through the straits but to close them to warships of non-Black-sea powers, the latter, and especially Great Britain with its imperial life line, aimed at keeping the Russian navy from entering the Aegean sea or at least at opening the straits to the war-ships of all nations. The Ottoman empire resisting both pressures saw in the control of the straits a guarantee of its independence and security, and this point of view remained that of the Turkish republic From 1947, the control of the straits by Turkey was also considered as a major guarantee of their own security by the non-Black-sea powers,

The history of the Straits Question can be divided into three

periods. (1) 1774-1840, (2) 1841-1920 and (3) after 1921. 1774-1840 .- This period begins with the Treaty of Kuchuk-Kamardji between Russia and Turkey, which maugurated an epoch of bilateral Russian-Turkish agreements as to the straits. The treaty opened the Black sea and the strats to Russian commercial anxigation, and this privilege was extended to the commercial navigation of other states by the Peace Treaty of Adrianople in 1820. Therefore the Peace Treaty of Adrianople in 1820. The Peace Treaty of South Russia, it did not conflict with the economic development of south Russia, it did not conflict with the economic interests of the non-Black-sea, powers, while Russia present of the Peace Treaty of Treaty treaty opened the Black sea and the straits to Russian commercial Britain in Turkey, the Treaty of 1833 was cancelled by the London convention of 1840 which established a rule that no non Turkish navy

might cross the straits in peacetime, the Russian navy included 1840-1920.—The London convention was the first general international convention concerning the straits, and it inaugurated a period in which they became the common concern of all Great Powers. In water they became are common concern or all treat rowers. In without modification until World War I. The prohibition of passage for warships of all nations was confirmed in 1856 (Treaty of Paris), in styr (Treaty of London) and in 1852 (Treaty of Berlin). During in styr (Treaty of London) and in 1852 (Treaty of Berlin). During regime more favourable to the passage of its winkips, but in spite of Russafa political alignment with France and England in European

affans at that time the attempt ended in a failure During World Wa: I, Turkey having fought on the side of the Central Powers, the Allied Powers agreed to the inclusion of the straits, after the war, in the Russian empire (Treaty of London, 1915) However, the leaders of the October Revolution having cancelled all the impenial leaders of the October Kevolution having cancelled all the impelial seciet freates and renounced all annexations, the problem of the strait was solved after the war differently and without the participation of Russia. The Peace Treaty of Sevices (1920) which never went into force, would have imposed on Tutkey the disarmament of the straits and their opening to all foreign warships, while the zone of the straits would have passed under the administration of an international com-

massion 2921.—The proposed segme of the Treaty of Swives was durapted by the opposition of the national Turkas government formed by Mustafa Kennal Thereafter, a forceful Turkish factor was increasingly influencing the Strats Question. In the Deginning, since the strategies of the Company of warsings should be decided by a conference of the functivesses states only (treaty of March 16, 1921). However, no such conference was held, and the regime of the straits was finally decided with the participation of the western powers at Laussane (convention of July 24, 1921). The convention of Laussane maintained the demilitarization of the straits and the freedom of passage for warships "under any banner", also the International Commission of the Straits was maintained under the chairmanship of Turkey—a concession among others, to Turkey The convention included a clause that no naval force larger than the largest Black sea fleet (se that of Soviet Russia) might be sent in peacetime into the Black sea by a non-Black-sea state

Because this arrangement satisfied neither Turkey nor Soviet Russia, it was revised at Montreux in 1936, when a new international situation resulting from a more aggressive German and Italian policy made it appear dangerous also to Great Britain and France The Montreux conference re-established the full right of Turkey to fortify the strauts and disbanded the International commission Reaffirming the already traditional freedom of navigation for commercial ships of all nations, the Montreux convention agreed to differentiate between the warships of Black-sea states and those of non-Black-sea states, giving to the former privileges the latter did not receive. With the exception of air-craft carriers and submarines all warships of Black-sea states were alcrait carriers and summarines an warsings of Black-sea states were allowed to close the statist unrestrictedly in peacetime, only light warsings of non-Black-sea states had this right under limitation of tonange, number of units simultaneously present and duration of cruising time. In time of war, the struts would be closed to all participants in the conflict, if Turkey was neutral

The Montreux convention was scheduled for revision in 1956. In 1945, at Potsdam, it was decided that each of the Big Three would communicate its views directly to Turkey concerning this revision, but communicate its views directly to Turkey concerning this revision, but the USSR, having raised demands for joint control of the straits with Turkey, Great Britam and USA backed Turkey in rejecting these demands as inconsistent with its independence and endangeting its security. On May 30, 1953 the USSR, withdrew its demands of

1046.

Bried, International Strate, (Copenhauer Landon, 1930) vol. 18, part 19, "The Turkish Strate, 1930) vol. 18, part 19, "The Turkish Strate, 1941 vol. 18, Soriel, La Question d'Orneti au XVIIII sidele, and ed (Paru, 1891); S. Gornianov, Le Bosphore et les Durdsneller, French trans (1931); S. Gornianov, Le Bosphore et les Durdsneller, French trans (1931); S. Gornianov, Le Bosphore et les Durdsneller, French trans (1940); S. Gornianov, Le Bosphore et les Durdsneller, French trans (1940); S. Gornianov, Le Bosphore et les Durdsneller, 1940 vol. 1940,

### STRAITS SETTLEMENTS: SEE MALAYA

STRALSUND, a scaport, formerly in the Prussian province of Pomerania, and after 1945 in Mecklenburg, N. Germany, on the Baltic strait of Bodden, opposite Rugen island; it lies 135 mi, by rail N of Berlin.

Stralsund was founded early in the 13th century and, though several times destroyed, steadily prospered. It extorted from King Eric of Norway a favourable commercial treaty in 1284-85; and in the 14th century it was second only to Lubeck in the Hanseatic League. Its early Protestant sympathies placed it on the side of Sweden during the Thirty Years' War, and in 1648 it successfully resisted a siege of eleven weeks by Albrecht von Wallenstein. Under the Treaty of Westphalia (1648) Stralsund was ceded with the rest of Western Pomerania to Sweden; and for more than a century and a half it was exposed to attack and capture. It was taken by France in 1807, by Denmark in 1814, and in 1815 it passed to Prussia. In 1045 Stralsund was taken by Soviet troops.

STRAMONIUM, in medicine, a drug obtained from the leaves and seeds of the Datura stramonium (Jamestown, Jimpson or Jimson weed). Both contain atropine and other closely related alkaloids. The physiological action of stramonium resembles that of belladonna (see ATRORINE). It is chiefly used in asthma to relieve the bronchial spasm Cigarettes made of stramonium leaves may be smoked or the tincture may be taken internally.

STRANG, WILLIAM (1859-1921), British engraver and painter, was born at Dumbarton, Scotland, on Feb 13, 1859, and died at Bournemouth, Hants, on April 21, 1921 He studied at the Slade school, London, 1875-81, under Alphonse Legros (q v), whose influence is responsible for the Ostade-like grotesqueness of some of Strang's compositions, the strong reminiscence of I F Millet in others and the flavour of Anthony Van Dyck in his engraved postsaiture; Rembrandt and Whistler also helped to shape his style Strang used etching, mezzotint, drypoint and line engraving, and for the last introduced a hooked burin, intended to produce strong effects by being drawn, rather than ploughed, across the plate His portrait subjects included R L Stevenson, Tennyson, Bridges, Kipling, Thomas Hardy and George Meredith. he often made private plates for such sitters, the final-state proof being the only "original" He early made a reputation as an etcher of Biblical and imaginative subjects, illustrating The Pilgrim's Progress (1885), The Earth Fiend (Kipling, 1892), Don Quinote (1902), etc He also painted and etched landscapes, allegories and social subjects-of which last type "Salvation Army" (etching, 1889), "Socialists" (etching, 1891) and "Bank Holiday" (oil, 1912, Tate gallery, London) are noteworthy He was a foundermember of the Royal Society of Painter-Etchers, 1881, but 1esigned in 1902 over the society's accepting engraved reproductions of paintings for exhibition He was elected ARA in 1906, RA in 1021 and in 1018 had become president of the International Society of Sculptors, Painters and Gravers His work in engraving and painting (to which he gave more time in later years) is represented in the Tate gallery, the British Museum and elsewhere.

BIBLIOGRAPHY — William Strang. Catalogue of His Etched Work (Glasgow, 1906, supps 1912, 1923), F. Newbolt, Etchings of William Strang (London and New York, 1907), C. Dodgson, The Etchings of William Strang and Sir Charles Holroyd (London, 1933)

STRANGE, SIR ROBERT (1721-1792), Scottish engraver, was born at Kirkwall, Orkney, on July 14, 1721 He was apprenticed to Richard Cooper in Edinburgh Having joined the Jacobites in 1745, he engraved a portrait of the Young Pietender and banknotes for the coming régime, and fought at Prestonpans, Falkirk and Culloden. For a time an exile at Rouen and in Paris, by 1753 he had settled in London. There he made a reputation mainly with engravings after the Italian Baroque masters (especially Guido Reni), often using a mixed technique derived from the Watteau engravers, the outlines and main shading being etched in, and the plate then worked up with the burin. After quarrelling with Allan Ramsay over the engraving of some royal portraits, Strange travelled in Italy, 1760-65 Returning to London he was elected (1766) to the Incorporated Society of Artists, some of whose directors resigned in 1768 to form the Royal Academy. In 1775 Strange attacked the Royal Academy-which did not then admit engravers as full academicians-in An Enguery into the Rise and Establishment of the Royal Academy of Arts at London. In turn assailed by the press he lived in Paris until 1780, but returned to find royal favour through the good offices of Benjamin West and was knighted in 1787. He died in London on July 5. 1702. Among his book illustrations were two plates for William Hunter's Gravid Uterus (1750)

See J Dennistoun, Memors of Sir Robert Strange, Knt., and Andrew Lumisden, 2 vol. (London, 1855).

STRANRAER, a royal and small burgh and seaport of Wigtownshire, Scotland. Pop (1951) 8,622. It is situated at the head of Loch Ryan, an arm of the North channel (Irish sea), 52 mi, S.S.W. of Ayr by road. It lies 39 mi. E by N. of Larne in Co. Antrim, Northern Ireland, with which there is regular communication by mail steamer. Grain milling and nursery gardening are carried on, and there is a large trade in farm and dairy produce. Whitefish and herrings are caught and there are oyster beds at Cairn Ryan on the east side of the loch. Strangaer, originally called St. John's Chapel, became a burgh of barony in 1596 and a royal burgh in 1617. In the centre of the town are the runs of the castle of the 15th century, occupied for a time by John Graham of Claverhouse, Viscount Dundee, when he held the office of sheriff

of Galloway (1682).

Three miles east of Stranraer is Lochinch, the residence of the Chailes the Bald and Louis the German were taken there in 842, earl of Stan, a modern structure (1870) in the Scots baronial style. The grounds include the White and Black lochs, and the ruins of Castle Kennedy on the isthmus between. This castle was erected in the reign of James VI for the earls of Cassilis, passed into the hands of the Stair family in the 17th century and was burned down in 1716. The gardens, which contain the finest pinetrum in Scotland, were restored in the middle of the 19th century,

STRAP WORK, in architecture and the decorative arts, a form of ornament developed in Germany, Flanders and England during the latter half of the 16th and the 17th century and consisting of scrolls, straight lines, rectangles and shield forms carved or modelled in flat relief, often with a raised fillet at the edge, and often pierced with circular or oval holes, the whole composition is usually formed of connected units, all upon the same plane, as though made by an elaborately cut out and pierced strap applied to a background It is a development of certain Italian early Baroque motives, such as the multiple shield or cartouche frames, and certain approximations of it occurred in Italian metalwork as early as the silverwork of Benvenuto Cellini (1500-71); these forms are, themselves, Italian interpretations of the flat scrolls so common in Mohammedan metalwork Strap work was used extensively in the Renaissance woodwork of Germany and is occasionally found in stone, as in the Salzhaus at Frankfurt A M. (end of the 16th century). In Flanders and the Netherlands strap work received an even more complete development, for although in Germany it was usually only a subsidiary motive, in the architectural woodwork and furniture of the Low Countries it often became the only type of ornament used The form was introduced into England by the flood of Flemish and German woodworkers that came in in the latter part of the 16th (T F. H) and early 17th centuries.

STRASBOURG (STRASSBURG), a town of France, the capital of the department of Bas-Rhin, at the junction of the Ill and the Breusch, 2 mi W. of the Rhine, 88 mi. by rail N. from Basle. Pop. (1946) 175,515. The Ill divides into arms forming an island on which the city grew; it was long a strongly fortified place, and the removal of the fortifications immediately around the city gave opportunities of large expansion after about 1875. The old city contains the cathedral, or Munster (11th to 15th centurnes). Part of the crypt dates from 1015; the apse is Transitional; and the nave, finished in 1275, is pure Gothic. The elaborate west façade has a screen of double tracery, numerous sculptures and two towers, the northern with a tall spire The cathedral has some fine stained glass, a sculptured pulpit and the famous astronomical clock in the south transept; this contains some fragments of the clock built by the mathematician, Conrad Dasypodius, in 1574. The Protestant church of St. Thomas is a Gothic building of the 13th and 14th centuries.

The Palais de Rohan or old episcopal palace, built in 1731-41, was used for university purposes from 1872 to 1895; it is now the municipal museum of art. Other notable buildings are the Frauenhaus, with some interesting sculptures, and the Hôtel du Commerce, the finest Renaissance building in the town. The University of Strasbourg, founded in 1566 and suppressed during the French Revolution as a stronghold of German sentiment, was reopened in 1872 and again as a French institution in 1922.

The chief industries of Strasbourg are tanning, brewing, printing and the manufacture of metal goods, paper and tobacco. To these must be added the fattening of geese for Strasbourg's celebrated pâté de foie gras.

History.-Strasbourg has always been a place of great strategical importance, and as such has been strongly fortified. The pentagonal citadel constructed by Vauban in 1682-84 was destroyed during the siege of 1870. The site of the town was originally occupied as a Celtic settlement, which was captured by the Romans, who replaced it by the fortified station of Argentoratum, afterwards the headquarters of the eighth legion. In 357 the emperor Julian gained here a decisive victory over the Alamanni, who so years later re-conquered the whole of the district. Towards the end of the 5th century the town passed to the Franks, who gave it its present name. The famous "Strassburg oaths" between

and in 923, through the homage paid by the duke of Lorraine to the German king Henry I, began the connection of the town with the German kingdom which lasted for over seven centuries The early history of Strasbourg consists mainly of struggles between the bishop and the citizens. This conflict was finally decided in favour of the citizens by the battle of Oberhausbergen in 1262, and the position of a free imperial city which had been conferred upon Strasbourg by the German king, Philip of Swabia, was not again disputed. In 1332 there was an internal revolution, which admitted the guilds to a share in the government of the city.

In 1381 the city joined the Stadtebund, or league of Swabian towns, and a century later it helped the Swiss confederates at Granson and Nancy. The reformed doctrines were readily accepted in Strasbourg about 1523, and the city was skilfully piloted through the ensuing period of religious dissensions by Jacob Sturm von Sturmeck, who secured for it very favourable terms at the end of the war of the league of Schmalkalden. In the Thirty Years' War the town observed a prudent neutrality. In 1681, during a time of peace, it was suddenly seized by Louis XIV, and this unjustifiable action received formal recognition at the peace of Ryswick in 1697. At the French Revolution the city was deprived of its privileges as a free town. In the war of 1870-71 Strasbourg, with its garrison of 17,000 men, surrendered to the Germans on Sept. 28, 1871. The city and the cathedral suffered considerably from the bombardment.

The bishopric of Strasbourg existed in the days of the Merovingian kings, being probably founded in the 4th century, and embraced a large territory on both banks of the Rhine, which was afterwards diminished by the creation of the bishoprics of Spires and Basel. The bishopric was in the archdiocese of Mainz and the bishop was a prince of the empire. The episcopal lands were annexed by France in 1789 and the subsequent Roman Catholic bishops of Strasbourg discharged spiritual duties only.

Strasbourg is the seat of a bishop, of a prefect and of the departmental organization, and of the special government offices for the territories returned to France after 1918 Kehl, with a population (1939) of 12,138, on the German bank of the Rhine, opposite Strasbourg, was constituted one with the port of Strasbourg for purposes of exploitation for a period of seven years from 1919. Extensive improvement schemes were approved in 1924, including the creation of a large port above Strasbourg, connecting with the harbour by canal, and a petroleum harbour below the town.

Battle of Strasbourg (A.D. 357) .- A rising of the Sarmatians, Suevi and Quadi on the Danube compelled the Emperor Constantius to hasten there in 357. Julian, the Caesar, was at Sens with an army 13,000 strong, and as the emperor was unable to assist him he despatched Barbatio, magister pedutum and 25,000 troops to Gaul. Julian was to march north, and Barbatio to co-operate with him with Basel as his base of operations. The forces of the barbarians were to be enclosed between them.

Moving to Reims, Julian concentrated his forces. Thence he marched to Zabern. Meanwhile Barbatio who had refused to obey his orders was surprised by the Germans and driven back to Basel. Julian's position was now an extremely dangerous one; he was far distant from the emperor, and Barbatio's defeat had raised the morale of the Germans who, under the leadership of Chaodomar, crossed the Rhine and encamped on its left bank near Strasbourg. Undaunted by this mishap Julian set out from Zabern to meet the horde, which was some 35,000 strong. The Romans marched in close order and in two columns, the cavalry on the right and the infantry on the left, and as evening was approaching Julian was desirous of deferring the battle until the following day. His men, in spite of the heat and the long march, urged him to lead them on. This Julian agreed to, and took command of the right wing consisting of heavy cavalry and archers. This wing coming into contact with the barbarians was fiercely charged by light horse and driven back. A panic was only stayed by the Caesar riding among his men and exhorting them to rally. The brunt of the attack was borne by the Roman centre and the left, and it was a struggle of footmen against footmen. In spite of the valour of the barbarians, the discipline of the Roman intantry carried one year rarely contained members of the previous Boule, the the day, the Germans being driven into the Rhine where large numbers perished, 6.000 dead were also left on the field. Chnodomar was captured and sent a prisoner to Constantius

This victory resulted in the recovery of the upper Rhine, and the freeing of Gaul from barbarian invasions

See E Gibbon, The Decline and Fall of the Roman Empire, chap.
xix; The Cambridge Medieval History, vol 1 (J. F. C F)

STRATA-FLORIDA (Ystradflur), the runs of a Cistercian abbey of Cardiganshine, Wales, near the river Testi, 2 m from the village of Pontrhydfendigaid (bridge of the blessed tord) on the Testi Excavations have brought to light encaustic tiles The elaborate western portal is a fine specimen of transitional Norman-Irish 12th century architecture A silver seal of the

abbey is in the British Museum Founded and endowed in 1164 by Rhys ap Griffith, prince of South Wales, the Cistercian abbey of St. Mary (which was probably a revival of an older monastic house on or near the same site) was much favoured by Welsh bards, nobles and princes In 1138 Llewelyn ap Iorwerth, "the Great," summoned his vassals to this spot to do homage to his heir, Prince David II The abbey suffered severely during the Edwardian wars, and in or about 1294 a large portion of its build-

STRATEGUS, strictly a general, but frequently the name of a state officer with much wider functions (στρατηγός) found in many Greek states The best known is the Athenian strategus, originally a military official, who, in the latter half of the 5th century B.C., became the most important executive magistrate in the state: it is certain that until the end of the 6th century the archon (q.v.) was the most important state official The Strategia (board of ten generals) was a result of the tribal system of Cleisthenes Some maintain that Cleisthenes himself created it, but the evidence (Ath Pol. xxii.) is against this At all events, as late as the battle of Marathon the head of the army was the polemarch (See Archon ) It follows that the strategus was, until 487 B C subordinate to the polemarch, the story of successive days of command in Herodotus being due to a misunderstanding of the powers of the strategi at the time (cf. G B. Grundy, The Great Persian War). The tribal unit was represented in the army by the taxis, and each taxis was led by a strategus After the Persian wars the command of the taxis passed to officers called taxiarchs, who acted as colonels under the strategi. It was the customary practice in the 5th century to appoint a certain number of the generals, usually three or five, for a particular field of operations, and to assign the chief command to one of them. Exceptions to this rule are found in the well-known instances of the Sicilian expedition (when the three commanders, Nicias, Alcibiades and Lamachus were given co-ordinate powers), and the battle of Arginusae, when the command was divided among the whole board. In crises such as the Samian revolt, the outbreak of the Peloponnesian War, or that which led to the recall of Alcibiades. we find the whole board subordinated to a single member (e.g., Pericles or Alcibiades). Originally each strategus was elected by and out of the tribe he commanded (Ath Pol. lxi.) In the 4th century, however, the strategi were elected out of all the citizen body irrespective of tribes; in 433, one of Pericles' colleagues was Diotimus, a member of his own tribe (cf. Alcibiades and Adesmantus in 408 B C.). But from Xenophon (Memorab. iii. 4) we learn that one strategus was still elected by each tribe, ie., each strategus represented a tribe, though he might not be a member Though the strategi were the nominal heads of the army. they had no power to choose their taxiarchs, who were elected by the tribes. It was only the lockagoi (commanders of λόχοι, companies) that the Ecclesia allowed them to select.

In the course of the 5th century the powers of the strategia were increased by important political functions, especially in toreign affairs; hence the office unlike that of the archon (q.v.), remained elective and was held by the most important men (e.g.remained elective and was need by one most important mean tog-pericles, Nicles, Alchisides). As the Boulé was the chief admini-tifative body, it was necessary to bring the strategi into close con-nection with it; though not members, they were allowed to attend its meetings and to bring motions before it. As the Boule of

strategi acquired great power from the fact that they were frequently re-elected for many years together, and so had greater experience and continuity of policy In the Ecclesia, the strategus business took precedence (the meetings always discussed first the question of national defence), and he could, in cases of emergency, convene a special meeting (of Thuc ii. 50 and iv 118)

The strategia was by no means analogous to the British cabinet which has collective responsibility and whose members are heads of state departments The strategi had no collective responsibility, άκτήν, κ. τ. λ.) dates from the 4th century Without being actually a foreign office, they acted on undiquara of the Ecclesia in negotiating and concluding treaties and alliances Their real power was mainly due to two considerations They were elected, when other great officials were chosen by lot and thus were picked men approved by the Ecclesia. They were capable of re-election and a man who commanded the confidence of the people was often re-elected (e g , Pericles) Such magistrates gained wide administrative experience and enjoying the confidence of the Ecclesia were able to dominate their colleagues and the state (λόγω μέν δημοκρατία ξργω δέ τοῦ πρώτου άνδρὸς άρχή). It was to this personal ascendancy and hold over the Ecclesia rather than to the constitutional authority of his office that the power of the great strategus was due

BIBLIOGRAPHY —A H. J Greenidge, Handbook of Greek Constitu-tional History (1866), Gilbert, Greek Constitutional antiquities (Eng trans, 1895), Hauvette-Besnault, Les Stratèges athéniens (1885); Aristotle's Constitution of Alhens passim, but especially iv, xui, ri; the general histories of Greece.

STRATEGY. In a strictly military sense, the term means "the art of the general" (Greek strategos). Its meaning has changed with the social shifts among people, particularly in western civilization. During the 19th century, the term was expanded for use in the sphere of national policy, particularly in time of war, when the conduct of strategy demanded not only military adaptations, but also political, economic, psychological, technological and moral adjustments. The demarcation between military and national strategy is not, and cannot be, clear-cut since a decision in the military field may have a consequent result on the nation's strategy. Conversely, a revision in national policy may require military leaders to revise their strategy Accordingly, political leaders must understand multary strategy and military leaders diplomatic commitments.

Strategy is an art that concerns men and science It is never stationary, since the means of applying it are ever varying great captains of history-Alexander, Caesar, Jenghiz Khan, Gustavus Adolphus, Frederick the Great and Napoleon-understood the fine cohesion of military and national strategy because each was in his person the leader of both the state and the army.

#### STRATEGIC THEORY

Development of the Meaning .- Strategy as a term did not appear in literature until the latter part of the 18th century. The need for an inclusive word was becoming more apparent as the great wars of the 17th and 18th centuries and increasing attention to military matters evoked considerable comment upon the conduct of war. Frederick the Great, Maurice de Saxe, Louvois, Vauban, Guibert and many others wrote their observations on the aspects of war. Drill, training, discipline, supply, conduct of sieges and the organization of armies were the subjects most often discussed. Much less was said about strategy. Furthermore, none of these writers, except Frederick, concerned himself with strategy. Baron Jomini and Karl von Clausewitz, the chroniclers of Napoleon's battle strategy, were undoubtedly the first great students of strategy.

Possibly Machiavelli was the real forerunner of thinkers on the larger aspects of war and the methods of conducting it. His Art of War distinctly recognized for the first time the interlocking character of the civil and military spheres in time of war. Though not a military leader or a member of the military profession, he thought in terms of the necessity of considering military action in the accomplishment of the aims set forth for his state.

strategy into effect Before his time, strategy, whether called by that term or unnamed, was the art and science of directing military forces in time of war so as to defeat an enemy-or, in its negative aspect, to mitigate the results of defeat. The negative approach to strategy has been exhibited throughout history by commanders with inferior forces-like Fabius, Maurice of Nassau and Frederick the Great-who avoided pitched battles in an effort to exhaust the enemy and bring about a peace

In Napoleon's time, the strategy of the battlefield-the narrow definition above-was retained But added to it was the strategy of victory, which encompassed his political and economic moves to increase the chances of victory in the wars. Many writers concluded that this new development was a natural course of events and one that emphasized the social nature of warfare and therefore of strategy. Both Napoleon and Frederick the Great, as noted above, combined the offices of military commander and leader of the state Their decisions on the battlefield or in the councils of state were complementary. There could be no disassociation of the national policy and military strategic objectives

After the time of Napoleon, the American Civil War of the 19th century and the two great World Wars of the first half of the 20th increased emphasis on the larger aspect of strategy A new definition, to meet the broadened view of the conduct of war, was expressed by Maj Gen Su Frederick Maurice (British Strategy, Constable and Company, Ltd , London, 1929) as "the art of applying national power to achieve the object of war."

Relation to National Objectives and Policy .-- Modern nations have traditional and established objectives, sometimes assumed rather than written. The universal and primary objective of security was expanded in the course of two or three centuries from that of territory alone to include security of interests in the political, economic and psychological fields. Another objective is the nation's right to its livelihood. This has application in the access to trade and markets and in the desire to improve the standard of living of the citizens. Another objective is the spread of an ideology or faith.

National objectives influence the phrasing of national policies. both in the domestic and foreign fields. Conceivably, the objective of security underlies the expression of both these elements of

The methods of accomplishing policy goals form what might be called a national strategy, particularly as it pertains to war. However, in the terminology of the "cold war," with no overt military conflict, the term strategy was employed to designate the summation and direction of manoeuvres in such differing fields as the political and technological. Here is the real difficulty in the meaning of the term strategy. Ever present is the question of whether strategy refers to the positioning of armed forces in time of war; or the composite manoeuvre of a government in every sphere of endeavour, in time of war, or other period of international tension, in order to carry out its national objectives

If the term strategy is to retain any meaning, it is evident that it should be confined to the preparations for and conduct of war. It should also differentiate, as far as possible, between the military and civil power of a state by the designations military strategy and national strategy. Henceforth in this text, the reference to strategy, except in historical examples prior to Napoleon, is to the broader perspective of wartime utilization of all resources in order to achieve national objectives.

Aims of Strategy.-Defeat of the enemy forces has always been the aim of strategy in time of war. In ancient and mediaeval times, as well as in the early modern era, victory on the battlefield often meant the winning of a war and the accomplishment of the nation's objectives. When Scipio defeated Hannibal at Zama (in Tunisia), he assured victory for Rome over Carthage. When Ulysses and his Greek force made a landing and attacked the city of Troy, their sacking of the city and killing of its inhabitants was the closing act in the early war between Greece and Troy.

Throughout history, this aim of strategy has been accepted as valid. No exception, up to and including the defeat of the axis

Napoleon was the first great leader to put the new meaning of powers by the Allied powers in 1945, appeared in what is practically a law of warfare In the long history of conflict, land and sea forces have consistently brought wars to conclusion through the strategic defeat of the enemy's armed forces With a few exceptions, sea power alone has not been sufficient to bring about the accomplishment of this aim of strategy Rather it was the land forces which seized and held ground, and eventually defeated enemy land forces, which brought about the desired goal. Naval strategy, however, assumed importance in modern times and exerted a vital influence on the strategy of war

The introduction of the new dimension, the air, as well as the industrial nature of modern technological warfare, gave great impetus to a second aim of strategy. It is expressed in the phrase "to strike at the heart of the enemy." The heart of the enemy is undeniably its industrial strength or war-making potential Admittedly, too, the thrust was not within the capabilities of a land and sea force until it had overcome the numerous barriers, physical, natural and human, which had been established by an adversary for its security. Accordingly, air power offered the ability to hop over barriers and to strike with bombs against the industrial heart.

Even before this second aim of strategy had been put to trial in warfare, exponents appeared who were positive that the first aim was no longer an essential to strategy Some exponents compromised with the first aim, suggesting that it be revised to the extent of engaging the enemy's land and sea forces But they averred that the will of an opponent would be broken by aerial bombing of his wai-making power. The land and sea forces, as well as the air forces, of an enemy would wither on the vine The "strategy of exhaustion" of early writers would be accomplished not by the land and sea forces, but by the air forces and their strikes against the industrial core of an opponent.

World War II partially tested this thesis that the sole aim of strategy was to support the air forces to the end of annihilation of the enemy's industrial capacity. The evidence at mid-20th century was still unconvincing to adherents of both the new and the old ideas of strategy The an enthusiasts claimed they had not developed aircraft and bombs to the necessary capacity, while the land and sea disciples countered that it was ground and naval forces-in combination with the air forces-which made victory possible by defeating the enemy's armed forces.

The controversy was still further joined when the first atomic bomb was dropped by aircraft on Hiroshima, Japan, on Aug. 6, 1945. Here was a revolutionary weapon, some air strategists contended, which would make unnecessary the defeat on the battlefield of an enemy's armed forces, if dropped by aircraft on vital industrial centres of an aggressor

In the realm of strategy, this controversy underlay the postwar endeavour to unify the land, sea and an forces of the United States. Modern technology, in its revolutionary scientific contributions to warfare, had added another factor in considerations of strategy If the second aim of strategy-the breaking of an enemy's will to resist by the crippling of its industrial powerwas conceivably the sole valid consideration in national strategy, then the military strategy of combined land, sea and air forces to defeat an enemy's armed forces was no longer an overriding goal.

Technology was adding other new weapons, such as guided missiles and biological and radiological weapons, as potential armaments. The student of military history, however, had an understandable hesitancy in accepting the theory that new weapons would radically alter the strategy of warfare, as had been concluded with the introduction of gunpowder and the aeroplane These matters were in the realm of prophecy and should logically follow a detailed examination of such questions as, what strategy seeks to accomplish; how it is made effective; the restrictions of time and space, the expansion into three dimensions; and the like

Strategic Concept.-Regardless of whether strategy is national in scope or confined to the military sphere, it must have direction. This compass point, or intent, is known as the strategic concept. British strategy in the Napoleonic Wars was generally to seal off the continent with naval power, while carrying on a war of exhaustion on land through the medium of peripheral actions, such as Wellington's highly regarded Iberian Peninsular

campaign. In World War I, the strategic intent to blockade Ger- which the commander chooses to fight may exhibit certain charmany by naval power was augmented by the land campaign to meet the enemy forces head-on in a death struggle.

Strategic concepts underwent a great inflation in the global warfare of World Wai II The first decision which had to be made was in regard to where strength would be concentrated, in Europe or in Asia Obviously, the decision of the Allied powers was to place the primary emphasis on the successful resolution of the war in the Atlantic area.

Strategy must accordingly take into account the intent of its makers, because otherwise man power and materials might be dissipated uneconomically To the definition of national strategy the word "efficient" should be added so that it will state: The art of efficient application of national resources to the accomplishment of national objectives

On a lesser canvas the military commander of an overseas area in World War II likewise had a strategic concept to define his intentions in a subordinate theatre of war Of concern to him were the necessities of utilizing his means to effect the aims of strategy, both of defeating the enemy forces and of striking at the heart of the enemy Relatively early in a campaign, the strategy of pounding the enemy's industrial centres was possible through the air, while land and sea forces in co-operation with the air forces were pointed in that direction, at the same time accomplishing their primary objective of defeating the enemy's armed forces

Accomplishment of Strategy.-In the era of total warfare, once national strategy is formulated, its accomplishment requires the entire efforts of the whole society To make national strategy effective, nonmilitary endeavours must be considered and funnelled into the total effort. Increases in industrial production, the technological development of new weapons, a successful psychological attack upon an enemy people, the betterment of the home people's morale-all these and dozons of other endeavours become a natural part of national strategy, to be augmented by the military strategy of the battlefield. Policies and plans, in every phase of society, must be so integrated that victory, the national strategic aim, is accomplished.

Historically, success in military strategy has been the result of adherence to certain principles of warfare Though there is no complete agreement as to their number, these principles generally include: economy of force, surprise, the objective, the offensive, mass, movement, security, simplicity and co-operation authorities maintain that a number of these are methods, but despite debate over terminology, most multary students accept them as principles. However, it is possible that the principle of simplicity could be eliminated since it obviously underlies all others, and conceivably a principle of concentration could be substituted for the principles of objective and mass.

These traditional principles of warfare emphasize its social character, and all of them can be translated substantially into the accomplishment of national strategy. Economy of effort in the economic field, co-operation in the political field, the creation of new weapons as a surprise to an enemy, all lend themselves to the development of an effective national strategy,

These principles refer to the effecting of a general plan of military operations, which is the method of achieving the strategic goal of breaking the enemy's will to resist.

The problem confronting the military strategist is to utilize his fighting strength against an enemy. Of major importance is the directive from his superious, the leaders of the state. From these instructions the task takes form. The way in which the commander accomplishes his task is in the province of the fighting

Strategic aims are set forth for the commander but they do not explain how to draw up his plans, nor do they set forth the situation. The commander's task is to interpret the situation, both as regards his own forces and those of the enemy. He must take into account the factors of space and time and he must judge the possible reactions of the opposing commander. As Clausewitz said, matters of strategy are simple, but not necessarily easy There are many imponderables. The nature and strength of the enemy's fighting forces cannot be exactly known; the terrain on

acteristics not considered of major importance in the planning stage

Putting a strategic plan into operation is an extremely hazardous move Gen Dwight D Essenhower told of his fears, after all was prepared for the gigantic Albed landing in Normandy in Tune 1944, when his weather forecasters informed him of the unexpected and unseasonal strong winds and overcast skies in the Enghish channel After a one-day postponement, and despite the fact that weather was still unfavourable, Eisenhower gave the command to move Diplomatic commitments hung over his head, as well as the purely military consideration that a two-week wait for the favourable full moon might divulge the time and place of his main effort.

Time and movement are in the province of strategy, as well as combat and space In World War II, considerations of time and space were enhanced in importance because of machine warfare Three-dimensional warfare also added to the complications of bringing together a fighting force ready at a fixed time to move against an enemy-held area

Time and space considerations in bringing the mass of man power, machines and materials together in the Normandy landing were a definite part of military strategy As in the days of ground warfare, this was the modern counterpart of the positioning of the forces for the day of battle

The principles of war have been immutable since ancient times. The turn to the offensive, the concentration of force, the effort to gain suiprise, the movement of forces, their security from enemy attack or from sabotage or subversion-all are in the province of modern as well as ancient warfare Once the forces are brought to bear against the enemy there is still the need for military strategy by the high commander, but each subordinate will have his individual battle in the over-all panorama of war and his methods of fighting are known as tactics.

Relation Between Strategy and Tactics.-Tactics (q v.) pertain to land, sea and air forces where they concern the disposing and manoeuvring of forces on the field of battle They may relate to the actions of small bodies or to the combination of many arms on the battlefield. Prior to World War II, tactics usually referred to the combination of infantry and artillery in their fire and movement on a battleground In World War II, however, sea and air forces were brought into the tactical combination on the battlefield. For instance, the air support of fighter planes in "tank busting," the use of naval gunfire from the sea to help reduce strong points held by enemy battalions or regiments, were examples of the enlarged scope of tactics.

At what point tactics become strategy is difficult to determine When the fighting force was larger than a division, as was common in World War II, the army or army group commander placed his troops in battle positions in a manner comparable to that of commanders of history, whose sole strength was ground forces oftentimes far fewer in number than those of World War II army commanders

Superior to these battlefield tacticians were theatre commanders whose strategic efforts took in not only the purely military fighting forces of land, sea and air, but impinged upon the political and economic arena. The theatre commanders dealt with political situations on the ground after reference to the leaders of the state. but it was they who frequently had a considerable influence in the decision since they had on-the-spot information.

Strategy and tactics, as terms for manipulations of warfare, had undergone great transmutation The canvas had become much larger, the means much greater, and the methods of using fighting strength complicated by modern technology. However, there was still strong evidence to support the contention that strategy and the principles of war utilized in past wars should be studied for their future use. While it was true that conditions had changed. that the nature of warfare was undergoing vast alterations, the art itself remained unchanging. The fundamental truths, as in architecture and music, were still present to guide further study of war and strategy For that reason it is essential to survey briefly the history of war and the strategic examples of the past. Factors of Military Strategy.—Six Edward Hamley m his The Operations of War examined the various permutations and combinations of strategic manoeuvre. He emphasized that when meeting an enemy, the object is to take an advantageous position. This may be accomplished by one of the following manoeuvres (i) threat or attack against the enemy's communications with hasbs, (2) disruption of the co-ordinated action of his army "by breaking the communications which connect the parts", and (3) concentation of superior forces at vulnerable point.

The territory of a belligerent from which it draws its supplies and recruits is the base of an army. The front of any army is the line along which it is deployed. The communications or lines of communications are the routes along which an army is supplied.

The lines lead from the base to the front

With these factors in mund it is possible to turn to consideration of the strategic examples of history, realizing always, that a nation's strategy was a function of its geographic position, the temper of its people and the paticular skill or aptitude of a people for land or sea warfare. In fact, the considerations natural to a people influenced the making of strategy, and therefore at different times in history were responsible for variations in the art of strategy.

#### STRATEGIC PRACTICE

Alexander, Hannibal and Caesar—Tactical art was the lexystone of the battles of ancient times. Alexander the Great planned to carry out his designs on Persa so as to hiberate the Greek colomes in Asa Minor, a shad been envisaged by his father, Philip. After the latter's death in 336 sc, Alexander embarked on a strategic conquest of greater scope than any known before his day. With an army of 30,000 in 333 sc he was in Chica on a southward march into Syrua, along the eastern shores of the Mediterranean Because of a misjudgment he permitted Darnus to cut across his hie of communications at Issus, a strateger immoneries which might well have brought disaster to Alexander. Returning northward, Alexander sought to avert his danger Mennevhile, and the sea

Alexander lined up his army with the 16-man-deep phalanx in the centre, Macedonian cavality on the left and Greek cavality on the right. Personally in charge of the latter, he assaulted the Persian left, turned it and then made a wheeling movement against the Persian centre Darus fled, his army wildly follow-

mg his example.

Alexander continued to concentrate his relatively small force agunst the Petsians, but with due regard for the safety of his line of communications. After a victory at Tyre near Jerusalem following a seven-month siege, he moved eastward across the Tigrist of Arbela, north of Babylon With an army of 40,000, composed of the same elements as at Issus, he defeated by perfect tactics Darlus' host, estimated at 1,000,000 men and a number of elephants.

The Punic Wars between Rome and Carthage included a succession of tactical battles against a strategic backdrop. Both nations were fighting for trade supremacy in the western Mediterranean. As the wars continued, Rome developed a navy superior to that of Carthage, compelling the Carthaginians to utilize a long supply line through Spain and southern France and into northern Italy. This strategic advantage, won by the Roman navy, was vital after Hannibal practically destroyed the Roman legions at Cannae in what is considered the tactical masterpiece of ancient times Though urged to march on Rome, Hannibal understood that in enemy country, without allies, and at the end of a long supply line, he was in no position to engage in a war of attrition. Meanwhile, Fabius fended off the Carthaginians with the tactics of small battles and alert defensive manoeuvres which gave his name to such tactics However, most importantly, he defended Rome until it could recruit and train new forces.

Later, in 207 BC., Hasdrubal marched from Spain to join his brother, Hannibal. The Romans, having intercepted Hasdrubal's messenger with his plans, were able to defeat him before the

Factors of Military Strategy.—Sir Edward Hamley in his juncture in one of the world's decisive battles, Metaurus Suche Operations of War examined the various permutations and coses had attended the Roman strategy of preventing the Carthambinations of strategic manoeurer He emphasized that when main concentration of forces

A few years later, after Scipio had retaken Spain, be carned the war to Africa Rome's am was the annihalation of Carthage Aften the cleaning of Carthagnain forces from Europe, Scipio carried the war to Zama in Tunisia where he defeated Haaniha from whom he had learned the art of war After this last act of the Second Puruc War, Rome effected its strategy of annihilation as the closurs scene of the Third Pumc War

From a strategic standpoint, the Gallic Wais of Caesar illustrated the axiom that the best defense is the attack. Rome needed no fortifications or other defenses when it was causying the wais to the territory of its enemies. Caesar fought for Rome successfully, oblighying a mastery of tactics and of statemanship. He was ever careful no matter where he was fighting to maintain a secure line of communications and to concentrate forces on

ground of his own selection

The Middle Ages.—The Roman empire in its decine and fall was swept he fore the invading barbarians—the Huns, Visigaths and Goths These nomadic cavalrymen, at home in the saddle and able to live off the country, defeated the Roman forces which had become enervated by lethargy, soft living and life in the far reaches of the empire where they lost touch with their homeland. Their were no great evidences of strategy in the excursions of the Huns, or of the Mohammedian a few centures later, or in the crusades. The armed cavalrymen of the feedal age entered battle on their mounts and utilized the mobility of cavalry to catch their opponents off guard. The battles, often of short duration, were funous onslaughts of mounted men, oftentimes against the foot solder. Their tactics employed the shock action of cavalry, in sweeping asset opposition.

Of far greater moment from the standpoint of strategy were the campages of Jenghus Khan and his general Sabutat. Jenghus Khan swept across all of the vast area of Asas from Mongolia, and at one tune, in the first half of the right century, held temous sway over more than half the then-known world. His hardy cavalury lived off the country and fourth more for the exhibitation

of battle than for any gain or control of territory

Probably in all the centuries between the Roman republic and the Thirty Years' War in Europe, there is no better example of appreciation of strategy than that of Sabutas. After subduing Russia, Sabutai moved against Hungary, the last remnant of Turco-Mongols outside the domination of Tenghiz Khan's successors With three armies moving against Gran, the capital of Hungary. Sabutar executed the strategic manoeuvre of protecting his flanks by sending one army against the Germans While they were conquering the forces sent against them, Sabutai moved his two remaining armies by different routes against Gran All of them followed a prearranged schedule, arriving simultaneously, after marching about 200 mi in three days. From behind the Danube, the Hungarian army showed no inclination to fight. So Sabutai lured them out with a slow-paced, feigned retreat to Munkacz, Six days later when the river Sa io separated the opposing forces. Sabutai forded the stream and struck the Hungarians in the flank and rear, killing 70,000 of the 100,000-man army.

The attention to security of his own line of communications, the capacity for concentrating his forces, his surprise and his devastating offensive at the time and place desired marked Sabutai as

a master military strategist.

Gustavus Adolphus and Frederick the Great.—The decline of feudalism, introduction of gunpowder, the erection of fortifications, the beginnings of discipline and the organization of armies into units—all these brought about changes in the nature of warfare.

Though Gustavus is better known for his influence on modern tactics, he exhibited ability as a strategist when in one sweeping campaign he drove the imperaal amnes out of northern Germany In his campaign he fought two memorable buttles at Breitand and Litzen, defeating the two great imperial generals, Tilly and Wallenstein.

In the Seven Years' War, 1756-63, Frederick the Great gave the

first midication of the combination of military and national structure eagy. Faced by a coalition of Austria, France, Russia, Sweden and Saxony, and with a single ally, England, Frederick was compelled to fight from his central position, marching first against one enemy, then against another. In his secret instructions to his geneials, Frederick stated "Our wars must be short and quick, since it is not in our interest to drag them out. One long war would dimman our admirable discipline, depopulate our country, and drain our resources. You will force the enemy to give battle when you come upon him by a forced march that puts you in his rear and cuts his communications or when you threaten a city which it is in his interest to hold."

Consistently, Frederick used his central position on interior lines to concentrate against individual armses of the enemy. His battlefield tactics were generally sound, being based upon the oblique order of the Greek general Epaminondas. However, none of his battles were deathblows. Always, it appeared that hike an angry insect he flew here and there, but never successfully conquered one enemy. Such pinciples of war as the offensive, surpress, mobility and economy of force were well illustrated by Frederick. But from the broad strategic view, his war left his nation exhausted, and accomplished only the cession of Stlessi.

In that era of dynastic wars, there were few great contributions to strategy. Mest effort was placed on administration and many of the battles were fought in the vicinity of fortresses used as based to Sustavus, Mariborough, Frederick and others carried the fight to the enemy, in realization of the first aim of strategy—that of defeating the enemy's armed forces. It remained, however, for the commanders of the Napoleonie era, when dynasties were replaced by national armses, to bring about a significant development of modern strategy.

Napoleonic Wars.—The long war of the French Revolution and the Napoleonic era witnessed the greatest change in the methods of fighting. The nation in arms was decreed by the convention in 1793, calling upon all Frenchmen for service in the armse suntil the enemies were defeated. In 1796 when Napoleon Bonaparte emerged from the Rengin of Terori, he had at his disposal new means and methods of warfare, ripe for his use both tactically and strategically.

The new French armies were armed with a moral force new in the history of conflict. Imbued with a spurt of crusade, they made excellent soldiers. Every man was inducted for four years at the age of 20 but Napoleon induced the veterans to remind with him in the warfare on the continent. Fortunately for him, his predecessors had already introduced many movations. The duc de Broglie had created the divisional organization, the two Du Teils and Jean Gribeauval the lightweight artillery of greater range and firing power which accompanied the troops, staffs had been trained and officers were promoted by mert. Skirnish stactus, or the loose formation, were taken from the Americans' experience in their Revolutionary War.

Napoleon took this army into Italy in 1796-97 where he showed a genus for bringing a mass to bear upon the flanks of the enemy in battle after battle. Again and again his positioning of his forces on the battlefield and his strategic selection of battlegrounds davantageous to his forces gave him his name for military genius.

In the larger national strategy, the campaigns of the Najoleonic Wars were fought against a coalition of all Europe. The British naval blockade of the continent was met un part by the continently system of prohibiting British goods from entering. But this in turn brought Najoleon to his downfall, since he was needed everywhere at once to hold the coast lines, fight in Spain, in Holland, against Austria and Russia. Najoleon in one sense was a paradox. As a military leader he was unparalleled, utilizing military tractics and strategy with more completence than any leader in history. At the same time, he was unable to comprehend the national policy and strategy of Phintian and its slikes which placed him in a visellike grip. His French veteran man power became dissipated, compelling reliance on impressed nationalities of all Europe.

"Two great writers on war, Antoine Jomini and Karl von Clausewitz, interpreted Napoleon's strategic sense on the battlefield, showing how he had utilized the principles of war to his advantage. Surprise, mobility, concentration of force, both on the battlefield and in his campaigns, economy of force and all the other principles were well illustrated by Napoleon IIIs tactics and strategy influenced military leaders for a century On the Cvul War battlefields in the United States, his maxims were in the knapsack of every leading general

American Civil War.—Industrial power and railroads were of vital importance in the strategy of the Coul. War, fought in an area r, noo mit in length and 700 mi. in width. In this combat area, equal to the size of all western Europe, the opposing forces engaged in a war of manoeuvie. There was little formulated grand strategy for the war which directed the cohesion of widely scattered forces and the war industries which fed them munitions. Emphass was more upon local strategy and tactics.

While the Confederate states pursued the single aim of defeating the Federal forces on battlegrounds, often of their own selection, the north effected certain long-range policies A naval blockade was clamped on the entire south and though it was run successfully by specially fitted, fast ships, insufficient materials were brought in to save the Confederacy In the west, the Federal campaign to gain complete control of the vital Mississippi river artery was successful midway in the war when Vicksburg fell in 1863 As a consequence, the Confederacy was deprived of supplies and reinforcements from west of the river Subsequent strategic goals were the defeat of the enemy forces protecting the southern capital at Richmond, Va., and the "march to the sea" through Georgia to cut off supplies for the principal Confederate forces operating in Virginia As a further development of the Federal strategy, conscription provided the requisite man power for the military operations and the partial mobilization of industry and of the railroads evidenced the intent of applying Federal resources to attain victory

On the battlefields, military strategy was more effectively accomplished by the southern leaders, particularly Gen. Robert E. Lee and Gen Thomas J. Jackson 'The principles of war were well exemplified by these leaders, who most often outmanocurved and outguessed the northern generals with their larger armies. Stone-wall Jackson' 'Toot cavalry' ullustrated the principle of surprise in a number of battles, utilizing their mobility to strike northern forces of greater strength unexpectedly. Ecomomy of force, concentration, mobility and the offensive were principles of war at his ready command.

A dramatic climax of the war came on July 4, 1863, when Gen. U. S. Grant captured Vicksburg from the southern forces, while the Confederate General Lee was thrown back at Gettysburg, the lugh-water mark of the southern military effort. For almost two additional years, the Confederate forces attempted to prevent inevitable defeat by Federal forces which sought to bring them to buy in their home country along the Atlantic seaboard

War weariness by the north even then came near to depriving the military forces of the victory which they were slowly developing. Grant had failed to crush the Confederate armies at the Wilderness and Cold Barbor during the immediate pre-election months. But meanwhile, Gen William T. Sherman had struck to the southesst against the south's supply base at Atlanta, Gapturing it in September. His campaign was a strategic masterpiece, even though he cut himself off from his sole railtioad supply him for a 'time 'On numerous occasions, the Confederate forces on the strategic defensive were drawn into costly and vain attacks. Moreover, they were defeated separately by Sherman's strategy of menacing two cities. He feinted against one objective, then attacked the other

During Nov. and Dec. 1864, Sherman cut himself off allogether from his supply line, executing his famous march to the sea. By this manoeuvre, he captured the south's chief remaining ports and prevented supplies from going northward to Lee's army. In the spring Richmond surrendered, and Lee's army gave up before the frontal pressure of Grant a week later at Appomattox.

World War I.—The long years of tension between France and Germany following the war in 1870 culminated in a world conflict in 1914. France was supported by its allies of the Triple entente, Britain and Italy, and by Russia. Germany, as the leading nation

of the Central Powers, was assisted by Austria-Hungary. Intervening wais, like the South African and Russo-Japanese, had exhibited the tremendous fire power of the newly developed machine gun Against its great defensive power armies had been compelled to disperse on the battlefield, utilizing entrenchments and cover for protection Despite this battle experience, French and German military leaders were convinced that new weapons and new methods of control, the radio and telephone, improved the offensive capabilities of their mass armies

The strategy of World War I was largely determined by new developments arising during the period 1870-1014 Increased fire power in the machine gun, universal liability which made every able-bodied male citizen a soldier, rapid mobilization of reserve army units and the increased potential of fortifications made their impression on the minds of military leaders and upon their plans.

Before the long-expected war broke in Aug 1914, the German plans for a wide envelopment through the Low Countries into northeastern France had been prepared by Count Alfred you Schleffen Confronted by the possibility of a two-front war, against France and Britain in the west and Russia in the east, he planned to strike France first in an anticipated six-week campaign of annihilation Successful on the western front, the German armies were then to be swung against the Russians on the eastern front Schlieffen's envelopment through the Low Countries was rationalized as necessary Otherwise, how else were the German forces to prevent a long-drawn campaign against the French forts extending from Luxembourg to Switzerland, or in fighting through the Ardennes forest? Another great advantage of the Schlieffen plan, in German eyes, was that it neatly took into account the French doctrine of attack Some authorities have called this a pinwheel strategy, each nation attacking and driving the enemy back However, Schlieffen's planned envelopment was to be so powerful, so swift and so unexpected in the violation of Belgian and Dutch neutrality that the French armies would be encircled

In the actual invasion, 1.500.000 Germans in seven armies catapulted into Belgium, pulverized the Belgian forts with their new 17-in howitzers and entered Brussels on Aug. 20 Schlieffen had died the previous year, after admonishing his successors to keep "the right wing strong" However, the enveloping wing was not so preponderant as Schlieffen had wished and it was compressed into a smaller corridor by the political decision not to violate Dutch neutrality.

Though the French army's right wing had reached the Rhine, its centre was endangered by a German pincers Only a hastly withdrawal in that area and a general retreat early in September prepared the Allies for the "miracle of the Marne." This was a general counteroffensive, utilizing such hastily mobilized combat forces as Gen. Joseph Galheni's taxicab army, which struck the unprotected German right flank. Paris was saved.

Meanwhile, on the eastern front the German prewar strategy of a defensive holding until France had been defeated in a quick invasion was compromised by the Austrian desire to take the offensive against the Russians immediately upon the declaration of Though the Austrians were defeated by the Russians at Lemberg in September, the German forces simultaneously won the

tremendous victory at Tannenberg

By November, the war had become stalemated on both the eastern and western fronts. The conflict settled down into trench warfare from Switzerland to the channel, fortifications and siege-craft being of tremendous importance. Strategy had been forsaken as the machine gun and the French 75-mm, artillery gun dominated the battlefield.

Britain's naval blockade of Germany was the key to the grand strategy of the war. It was the same strategy that had been so potent against Napoleon. As in that era, the complementary aim of strategy was to defeat the enemy land forces in the field

Other major considerations in the grand strategy of World War I were the recruitment of replacement man power in great numbers through universal liability, the increased demands upon industry for the munitions of war and the need for technological developments-such as the tank and poison gas-to break the stalemate,

The German attempt to throw off the strangling blockade was submarine warfare. Counteraction by Britain took the form of search of neutral vessels so that Germany's plight was increased Moreover, the German methods eventually brought the United States into the war in 1917.

Gen John J Pershing, when he arrived in France, understood that the antidote for the battlefield stalemate was mobility. Warfare had to be due out of the trenches and become a thing of fire and movement.

The build-up of US forces was necessarily slow-time and space requiring their toll Once the requisite troops were assembled, the military strategy became one of reducing the salients within the Allied lines, such as that at St. Mihiel

When Germany had reached a stage of semistarvation, and its armed forces a point of exhaustion, it asked for an armistice. Hastening this decision was the defection of the other Central Powers during the autumn of tor8. The Allies had weathered the collapse of Russia in 1917, even though they faced in 1918 a superior German force. German leadership, well appreciating that 1918 was the year of decision before the full might of the United States was brought to the combat theatre, had put its resources into a great offensive which came near succeeding. However, by the late summer of 1018 there was the feeling among the Allies that Germany would inevitably fall by the spring of 1919.

Truly, "Germany won the battles, but lost the war." Acknowledgment that military strategy was a part of a greater national strategy was now accepted by students of warfare Churchill was not slow in pointing out that the decisions of state had a great influence on the strategy of the nation and of the troops in the combat arena. It was Georges Clemenceau who supplied the coup de grace to the historical overriding importance of military strategy, in his statement that war was much too important a business to be left to soldiers. Taken out of context the statement is probably more than Clemenceau intended. He still had great respect for the requirements of military strategy. His statement was an underlining of the social aspect of war and its increasing totality. Modern war could be waged effectively only under a cohesive national strategy.

1918 to 1939 .- The mud of the trenches in France and the superiority of the defense with its "strong right arm," the machine gun, brought forth many false conclusions about the nature of warfare. Strategy came to mean defense. In succeeding years, the Maginot line became the symbol of the defensive concept of warfare. But the strategy of defense had its vigorous opponents

Outspoken adherents of the new strategy of the third dimension. the air, proclaimed that because of its striking power, armies and navies had become lesser appurtenances of war. The bombing of cities and the knocking out of entire fleets were certain to reduce an enemy to submission. The aeroplane itself would be comparatively safe from reprisal from the ground

Meanwhile, land and sea forces would maintain a defensive role. the ground armies holed up in entrenchments or in fortresses The strategy would be that of the offensive, carried out with surprising suddenness and striking at civilian morale. The military muscles of an enemy would remain in existence, but the will power and the brain would be paralyzed. Concentration of air power was not envisaged by Giuho Douhet since he believed that a limited number of bombs and aeroplanes would accomplish the object.

Meanwhile, on the ground, the army generals went ahead with their schemes for breaking the superiority of the defensive. Whether from disagreement with the new doctrine of air power, or from the age-old tradition of seeking the solution on the ground. there began to evolve the modern cavalry of tanks. Development of the slow-moving, thin-skinned, light tank of World War I took the shape of heavier, more powerful, better-armoured vehicles. The Germans and the soviets took the lead in this field, followed in a lesser, experimental way by the United States and Great

Also, in France there were advocates, like Charles de Gaulle, of the necessity of fighting on the offensive in the Foch tradition. But the weight of a defensive morale among the French people was their overbalancing opponent. The cry of the disciple of mobility and of tank warfare was lost in the shouts of the populace for Maginot and "int-down" yarfare. In justice to the French, their losses from World War I had proved devastating, the will for the traditional offensive had been crappled. The populace was ready to accept any alternative which promised economy in human life.

The Germans, meanwhile, during the late 1930s, were foiging an assault team of tanks and air fighters which offered potential overthrow of defensive superiority. The strategy would be Freick the Great's "short and snappy" operations, while maneous team of the statlefield areas was to be a compound of Napoleon and the US Cavil War cavalyr tradition Offensive, surprise, concertation, mobility and co-operation were to be 1e-enshmed as positive principles of war and the backbone of a conquering strategy on the land, this method of war was to prevent the stalemate of World War I.

But Doubet was not to be denied. The bombing of the Allied line of communications and the fouling of that line further by strafing of civilians were to be compelling adjuncts to the efforts of the land forces in their action against the Allied armies However, the supplementary second aim of strategy—the air strike against the industrial and political centre of the British at London—was expected to have a decisive result

Naval strategists were also developing the speed and hitting power of their fleet units. High-speed battleships were produced by all the major sea powers, the Germans using their pocket battleships as sea raiders to prey on shipping. The aircraft carrier became a team member with the battleships, cruisers, destroyers and other fleet units At first, duels between ships appeared to be a normal method of sea warfare, but the battle of Midway in 1942 exhibited a new naval strategy in which opposing fleets never got within gun range of one another, but duelled with their air power and submarines More and more that became the tenor of sea strategy in the Pacific, with the naval task forces gaining strength in carriers and numbers of fleet aircraft. Fleet units throughout the offensive war took up position in amphibious assaults as supporting artillery. The army commander on the ground then had the novel support of artillery from the sea and air, as well as from his conventional land guns. The combining of arms reached a point undreamed of at any previous stage of war-

World War II.—The global warfare of World War II lifted strategy montrovertibly out of the sellm of the multary sphere into the field of international affairs. Global warfare called for global strategy. Nations, recognizing the total effort required in modern war, poured every resource into the accomplishment of their objectives. Waging war demanded a strategy which reached into every phase of lite—political, economic, psychological, technological and moral. Military operations were dictated by national strategies and affected by international commitments. All nations were deven into the content and occan, on the surface of the earth, shove it and below the seas. Massive armed forces, technological developments, three-dimensional warfare, unheard of industrial production and logistical miracles were features of this global war.

The prelude to World War II was supplied by actions of the axis nations—Germany, Italy and Japan. Germany marched into the Rhineland; Italy attacked Ethiopia; and Japan invaded China on the Asiatic mainland.

Germany again sought to avoid a two-front war, while making its position secure in central Europe. Austria and Cezcholovvalat were quickly compured before the commencement of the shooting war. Then with its western front secured by the Slegified fortifications and with the Soviet Union wrapped up in a non-aggression pact, Germany moved tinto Poland on Sept. x, 1939, without a-declaration of war. 'Norway was next captured, permitting Germany to move its submarines into the Atlantic occas.

When the preliminaries had been completed, by May 1940, Germany struck at France in a modified Schieffen plan, again entering Belgium but making its primary blow at the Ardennes forest area. The strategic manocuvre on the ground brought about

the defeat of the French, Belgian, Dutch and British forces A supplementary strategic air bombardment was thrown against the Island home of Great Britain in an attempt to bring capitulation. Though hammered unmercfully, the British people should up to the challenge, their defensive fighter force gradually whitting down the bomber strength of the aggressor. Before the German strategic decision to invade Britain was prepared, it was too late in the vest for a cross-channel amphibious operation.

Meanwhile, Germany had overrum half of France and obtained sufficient submarine bases to permit free operations in the Atlantic Strategically, Germany had won a decisive victory on the western front. It was possible then to turn toward the Balkan and middle east theatres. Success attended the former campaign, and the conquest of the Suez canal and capture of the middle east was averted by a narrow margin. Butish forces fighting in the Libyan desert gave ground but evaded annihilation, while holding on to Egyot.

British strategy during this tenuous early period of the wan centred on an aggressive delense, including the preservation of the life line of the empire through the Mediterranean and Suecanal to India and southeast Asia. In the air, Britain's strategic air force began to make raids against German-held territory on the continent. The national endeavour was to hold on doggedly until the Allies brought assistance, particularly the United States and the Sowiet Union.

His western front scure, Huter began to consoludate his eastern. His western front sent the Balkans. Sover protests to these German movements to the Balkans Sover protests to these German movements of the crystallans. Hite's deed protect to the sovert there. Multary observers concluded that the German blutzkring was powerful enough to accomplish what Napoleon had not been able to do. But the German army, once through the Stahm line fortifications, quickly learned that their antagonist did not capitulate. Instead, the sovert defenders fought doggedly, whether in partisan warfare behind the German lines, or in last-ditch stands before Moscow, Lemngrad and Stalingrad.

When the winter of 1041 caught the Germans unprepared and still seeking victory, they obtained the support of Japan, which made a surprise attack on the United States armed forces at Pearl Harbor, Hawau. Immediately, the Japanese struck southward against the Philippines, Medanesia, Indonesia and southeast Asia

The strategic contest was then joined. The axis nations, operating on interior lines, were able to supply their forces with the requisite munitions of war. The Allies, other than the Soviet Union, were compelled to fight on extenor lines, their logistical support fanning out from factories in Britam and the United States to all comers of the globe. Once again, the strategic formula of blockade against the axis countries was applied. And once again, Germany and Japan resorted to large-scale submanne operations to cripple the life lines to forces oversees and reduce supplies flowing from the United States and Britain to the Soviet Union.

On the Allied side, the USSR continued a one-front strategy, maintaining until the last weeks of the war a neutrality on its far eastern front. Britain and the United States, on the other hand, were fighting a two-front war. The grand strategy demanded a concentration of strength. Germany was the primary and most callenging enemy in raw power and in its threat to the democratic peoples of Europe. National strategy dictated concentration in the Atlantic world. The defensive was to be turned to full-fledged offensive when the war-making potential of the western world was more fully realized. Time and space were major considerations. Somehow axis forces in Europe had to be contained and the devastating submarine warfare blunted.

Meanwhile, the U.S.-British Pacific strategy was determined as the strategic defensive initially, to be followed by the offensive-defensive. The military terminology of the strategic defensive might be summed up as a hold-the-line effort with minimum resources, while storing up land, sea and air forces in preparation for later small-scale offensive operations. When the period of the offensive-defensive strategy was reached, allocations of resources would be large enough to permit offensive operations of wider scope. Eventually, when the war in Europe was won, the strategy would be an all-out offensive.

In Europe, the US-British forces took the initiative in the air bombardment of German-held territory from the United Kingdom base, while utilizing land, sea and air forces in North African operations to assure the line of communications through the Mediterranean and save the middle east Subsequently, operations against Sicily and Italy knocked Italy out of the war, made available air bases for attack against Germany from the south and prepared the way for the essential return to the continent by invasion. By that time, the offensive strategy of the Allies from both east and west was in full swing. The soviets and the western Allies were then able to bring terror to German strategists in a full-scale two-front was. When the combined assaults reached a crescendo, the basic aim of strategy-the defeat of the German armed forces-was to be achieved. From the orthodox and traditional viewpoint, Germany must then fall,

In co-operation with this land-sea effort, the Allied forces employed their bombing fleets, the "strategic air forces," against the axis powers. An strategists postulated the second aim of strategy, in extension of Doubet. They believed that the capitulation of Germany could be assured if the air forces, in sufficient strength, were brought to bear against the industrial warmaking production As a necessary prelude to all-out, round-the-clock bombing, air commanders stressed the need for control of the air The Germans and Japanese had effected a partial defense against the bomber both through the employment of anti-aurcraft artillery and more devastatingly through air fighter fleets. The latter needed to be whittled away before the bombers could accomplish their task without prohibitive losses During the war, air power was not able to prove its decisive nature, according to many air enthusiasts. From a strategic standpoint, it was impossible during the fighting

of a war to put all production, man power and other resources into the untested air strategy Consequently, air power was allocated only a share of Alhed resources, while a substantial portion was given to the ground and naval forces

ground and maval irores

The aim of conquering the axis armed forces was vigorously pursued once the Allied armes had taken up the offensive. Into the combined effort was thrown every available resource. Amphibious assaults were necessary from North Africa to Normandy in the European theatic, and from Guadalcanal to Okinawa in the Pacific, before the victory

was won type of landing, but he had to assure his supply line into the area Furthermore, bases were usually selected in areas where the Allied fleets could operate. Finally, the normal course was to select landing areas within efficient range of fighte aircraft, normally estimated at 125 mi maximum.

Great care was exercised also in selecting amphibious landing areas in which there was the opportunity to strike at the rear of the enemy, or at least to make him retire. The most abortive of such efforts was the ill-fated Anzio operation, north of Salerno, behind the German lines. The Allied forces on the main land offensive were held up in the Monte Cassino area, permitting the Germans to bottle up the amphibious flank attack for several months.

Casano area, pe mutting the Germans to bottle up the amphibious flank attack for several months. The several months is a several months of the global curves effortive was made to outperform the strategion to the global curves effortive was readed to outperform the strategion of the publication of the properties of the composition of the opposition of the properties of the composition of the opposition opposition of the opposition oppo

fighters leading the assault. Combat operations were rarely static. The German fortification of the West wall proved no more an obstacle to the Allies than the Magmot Ine had to the Germans

On the soviet front, mass, concentration of forces and surprise with huge manocuvres outflanking the Germans were the keynotes. The offensive studegy of the Red army was one of massive encirclements, tultizing guerrilla strength behind the German lines, and tank assaults. in which thousands of tanks participated, supported by the obstinate efforts of the soviet soldier and the tank-busting, low-flying soviet air

Strategy came of age in World War II. Science, diplomacy, industry and psychology were all harnessed in the total effort of each artagonist to win the war. Although military shategy—the positioning of the armed forces—for battle was of immense importance, it was overshadowed by the national strategies involving the social character of entire peoples Critics of the strategy of World War II found certain pelling need for the creation of over-all strategic principles which would assure each element of the nation's strategy, whether military, economic or political, its appropriate share in the making of decisions. If one general criticism of the conduct of World War II is to be made, it is that political policies and decisions were not given sufficient weight over purely military decisions in the development of strategy On this over purely military decisions in the development of strategy. On this inc, the military stategy was rightfully concrosed with winning the war many stategy was rightfully concrosed with winning the war prolongation of the war for the accomplishment of a political objective might have been more in the long-term interests of a number of nations. Later Strategy; Korean War.—Of great significance in the post-war era was the "old war" strategy. Its base and was peace. This

war era was the "cold war" strategy. Its basic aim was peace. This goal demanded deterrents to var, with such preparation as swe sestifial goal demanded deterrents to var, with such preparation as we sestifial was not synonymous with weakness. There was no other term than strategy to sum up adequately the national efforts, the action and counteraction of political, economic, ideological and psychological forces, supported by troop movements short of a full-scale "shooting force, supported by troop movements short of a full-scale "shooting to the property of the strategy of the strate

The accomplishment of national objectives without recourse to total war had become the ultimate aim of strategy, a nation which could attain its goals without touching off World War III had certainly used its national resources efficiently

its national resources efficiently

Two new strategic developments were exhibited in the postwar era

When the USSR made Czechoslovakia a satellite, it utilized coordinated political, economic, military and psychological pressures. The

Atlantic nations outside the soviet orbit created the North Atlantic Treaty organization for the defense of the western nations Signifi-cantly, the mittal effort was to assist the western European nations to regain their economic strength as a foundation for the creation of regain tueli economic steingm as a roundation for the reaction of military defense in a sense, concentration of soviet power against Czechoslovakia and the economic rehabilitation of western Europe as an underpinning for military defense are strategic developments in a newer, more extended frame of reference Logically, this expansion of newer, more extended frame of reference Logically, this expansion of strategy into every field of national endeavour was a recognition of the social aspects and total nature of conflict.

one social supecis and total nature of contict.

The Korean war commencing in 1950 brought into combat the North
KT has Korean war commencing in 1950 brought into combat the North
KT was the Combat 
Overshadowing the possibility of future world war was the threat of the atomic and hydrogen bombs, guided missiles and chemical, biological and radiological weapons.

What had been the effect of these scientific developments on the nature of warfare and therefore upon strategy? From all appearances, nature of warfars and therefore upon strategy? From all appealances, strategy defined as the efficient application of national issuaues to the achievement of national objectives was still valid. The great question concerned the methods and means of warfare New developments such as guided missiles and army artiflery with a tomic washeads and nadar-operated acoplanes promised many changes in the air of war and in strategy. In the debate between those who placed pumary reliance on the new methods of war and those who chammoned outhodox land-sea-air forces supplemented by atomic weapons, advocates of both methods substantially agreed that there would be no victor in the devastation of another world war. The strategic aim was to prevent holocaust. (See also War)

holoszust. (See also Was)

Bustzonsary:—Robert G. Albion, Introduction to Military Huttory
(1990); Hermann Foertich, The Art of Modern Warfars (1940); Sit
Frederick Mautice, Pranciples of Strategy (London, 1990); Hanson
Balkwin, The Friez of Fourer (1947); Dwight D. Ewenhower, Crasade
Balkwin, The Friez of Fourer (1947); Dwight D. Ewenhower, Crasade
Balkwin, The Friez of Fourer (1947); Dwight D. Ewenhower, Crasade
Balkwin, The Friez of Fourer (1947); Dwight D. Ewenhower, Crasade
Balkwin, The Friez of Fourer (1947); Dwight D. Ewenhower, Crasade
Handle Marchael (1948); Ewent D. Handle (1947); Wanner Benk, Modern Arms and Free Men (1949);
War on Land (1947); J. F. C. Fuller, Machine Warfare (1942), Grayson L. Kirk and Kichnel P. Stebbuns, ed. War and Maltonel Miller
(1942); Lynn Montros, Wer Through the Ages (1946); William A.
Mitchell, Outlance of the World's Milliany Buttors (1931); A. F. Vich
War to Society (1949); Allred Vogta, The History of Militarian
War to Society (1949); Allred Vogta, The History of Militarian

(1937); William Mitchall, Winged Defense (1932). Henry H. Anold and Ita C Eaker, Winged Worfare (1941). Alford J Williams, Airpower (1940). John C Slessor, Air Fower and Armses (1936). Sit Edward Hamley, Feb Operations of War (1865). Benard Brode, ed., The Absolute Wenpon, Atomic Fower and World Order (1936). John by the Steptems Commander to the Combused Charles of Step on the Operations in Europe of the Albade Especiationary Force, of June 1944 to Set May 1945 (1946). Google C Masshall, Benmal Report of the Chief of Steff of the Wented Stetes Army, July 1, 1941 to June 1944 (1946). Steff of the Winted Stetes Army, July 1, 1941 to June 1944 (1946). Steff of the Winted Stetes Army, July 1, 1941 to June 1944, 1944, 1946 (1946). Steff of the Winted Stetes Army, July 1, 1942 (1946). June 1944, 1944, 1946 (1946). Steff of the Winted Stetes Army, July 1, 1948 (1946). June 1944, 1944, 1946 (1946). Steff of the Winted Stetes Army, July 1, 1948 (1946). June 1944, 1944, 1946 (1946). Steff of the Winted Stetes Army, July 1, 1944 (1946). June 1944, 1944, 1946 (1946).

STRATEGY, NAVAL: SEE NAVAL STRATEGY AND TACTICS. STRATFORD, JOHN DE (d. 1348), archbishop of Canterbury, was born at Stratford-on-Avon and educated at Merton college, Oxford, afterward entering the service of Edward II He served as archdeacon of Lmcoln, canon of York and dean of the court of arches before 1323, when he became bishop of Winchester, an appointment which was made during his visit to Pope John XXII at Avignon and which was very much disliked by Edward II. In 1327 the bishop joined Queen Isabella's partisans; he drew up the six articles against Edward II, and was one of those who visited the captive king at Kemilworth to urge him to abdicate in favour of his son. Under Edward III he became a member of the royal council, but his political importance dates from the fall of Roger Mortimer. In November 1330 Stratford became chancellor, and for the next ten years he was the king's most prominent adviser and the "head of the Lancastrian or constitutional party" (Stubbs) In 1333 he was appointed archbishop of Canterbury, and he resigned the chancellorship in 1334. He was again chancellor from 1335 to 1337 and for about two months in 1340 In November 1340 Edward III, humiliated, impecunious and angry, returned suddenly to England from Flanders and vented his wrath upon the archbishop's brother, the chancellor, Robert de Stratford Fearing arrest John de Stratford fled to Canterbury, but after a violent dispute the principle was established that peers were only to be tried in full parliament before their own order (en pleyn parlement et devant les piers). The archbishop acted as president of the council during Edward's absence from England in 1345 and 1346, although he never regained his former position of influence. He died at Mayfield in Sussex on Aug. 23, 1348.

STRAIFORD, a city and port of entry of Ontario, Canada, and capital of Perth county, situated 83 mi W.S.W. of Toronto by the Canadian National railway on the Avon river. Pop. (1937) 18,785. The repair and engineering shops of the railway, flour and woollen mills, furnature and agricultural unplement works are the principal industries. It is in the heart of itch dairy county, and there is a large export trade in cheese and farm profluce.

STRATFORD DE REDCLIFFE, STRATFORD CAN-NING, VISCOUNT (1786-1880), British diplomatist, was born in Clement's Lane in the city of London, on Nov. 4, 1786. His father, Stratford Canning, uncle of George Canning (q v.), who had been dismherited for his marriage with Mehetabel Patrick. died when the boy was six months old. He was educated at Eton, and had kept two terms at King's college, Cambridge, when, in 1807, his cousin, George Canning, gave him an appointment in the foreign office. In 1808 he was appointed first secretary to Robert Adair, ambassador to Constantinople. When Adair was transferred to Vienna in 1810, Canning remained at Constantinople as chargé d'affaires. Canning was lest entirely to his own discretion. In May 1812 he helped to arrange the peace of Bucharest between Turkey and Russia, which left a powerful Russian army free to repel Napoleon's invasion, Canning was able to basten the decision of the Turks, by making judicious use of Napoleon's plan for the partition of their empire. A copy of it had been left in his hands by Adair to be used at the proper moment. In July he left Constantinople with the desire to enter political life at home. But Castlereagh arranged for him to receive a retaining fee binding him to the service. He spent four years as minister at Berne (1814-18). In 1819 he was appointed minister at Washington, a station of great difficulty owing to the

many questions outstanding between the British and the US governments Cannang, who had a quick temper, came into occasional collision with John Quancy Adams, the US secretary of state Yet they paited with mutual respect Canning returned to England in 1823. The general treaty he had arranged with Adams was rejected by the United States senate

In 1824 Canning was selected as ambassador to Turkey, and proceeded to Constantinople after a preliminary visit to Vienna and to St Petersburg, where he discussed the Alaska boundary question and sounded the Russian government as to the course to be taken with the Greek revolt against Turkey He left for Constantinople in October 1825 At Constantinople he was engaged with the French and Russian ambassadors in the hopeless task of inducing Sultan Mahmud II to make concessions to the Greeks, without the pressure of armed force After the battle of Navarino (q v ) on Oct. 20, 1827, the ambassadors retired to Corfu Canning then went home, but was sent back on July 8, 1828 Canning did not agree on all points with Lord Aberdeen, and in 1829 he, for the time being, turned from diplomatic to parhamentary life. He sat for Old Sarum, for Stockbridge (rotten boroughs) and for Southampton, but did not make much mark in parliament He was twice absent on diplomatic missions At the end of 1831 he went to Constantinople to attend the conferences on the delimitation of the Greek frontier, arriving immediately after the receipt of the news of Mohammed Ali's invasion of Syria. (See Mohammed All) Sultan Mahmud now proposed to Canning an alliance between Great Britain and Turkey, and Canning strongly urged this upon Palmerston, pointing out the advisability of helping the sultan against Mohammed Ali in order to forestall Russia, and of at the same time placating Mohammed All by guaranteeing him certain advantages. This advice, which largely anticipated the settlement of 1841, was not followed, but Canning himself was in high favour with the sultan. In 1833 he was selected as ambassador to Russia, but the tsar Nicholas I, who knew his peremptory methods, refused to receive him

Canning was again sent to Constantinople in Jan 1842 and remained there as ambassador until 1858. His tenure of office in these years was made remarkable-first by his constant efforts to induce the Turkish government to accept reform and to conduct stself with humanity and decency; then by the Crimean War (q.v.). Canning had no original liking for the Turks He was the first to express an ardent hope that they would be expelled from Europe with "bag and baggage"-a phrase made popular in after times by Gladstone. But he had persuaded himself that under the new sultan Abd-ul-Mepd they might be reformed the fall of Palmerston's ministry in Feb 1858 he resigned He had been raised to the peerage in 1852. During his later years he wrote several essays collected under the title of The Eastern Question (1881). In 1873 he published his treatise, Why I am a Christian, and in 1876 his play, Alfred the Great at Athelney. The only son of his second marriage died before him. His wife and two daughters survived him Lord Stratford died on Aug. 14, 1880, and was buried at Frant in Sussex. A monument to him

was erected in Westminster abbey in 1884.

Ser S. Lane Poole, Life of Lord Stratford & Redelife (1888),
STRATFORD-ON-AVON, a municipal borough mainly on the west bank of the Avon, in the Warwick and Leamington parliamentary division of Warwickshire, England; served by the G.W., L.M.S. and L.N.E. milawas. (London 924 mi.; Birmingham 334). Pop. (1951) 14,980. Area 10.8 sq.m. The neighbourhood is beautiful and the river flows in exquisite wood teaches, navigable only for small boats. The Stratford canal communicates with the Warwick and Birmingham canal. The river is crossed at Stratford by a stone bindge of 14 arches, built by Sir High Clopton in the regin of Henry VII. The church of the Holy Tot. When the sales of the control of the

sione," in connection with which the church became collegiate The present choir was built by Dean Balshall (1465—91), and in the reign of Henry VII the north and south transepts were errected A window commemorates the Shakespearan scholar Hallwell-Phillipps The chaple of the Guild of the Holy Cross was begun by Robert de Stratford. The guild, for both serse, was in exastence early in the 13th century, and was incorporated by charter from Edward III in 1322. It was dissolved in 1547. The guildhall is a picture-que half-timbered building. A beautiful 16th century house belonged to Thomas Rogers, whose daughter was mother of John Huvard, founder of Harvard college, U S A Among public buildings are the town hall (1654, rebuil 1767, altered 1863), market house, com exchange and three hospitals. Brewing is Desempts and there is an agricultural tade, founsits bring much bustness.

modern eyes the buildings which Shakesneare saw was not entered upon till the end of the 18th century, when much of the visible connection with his times had been destroyed. A 100m, by tradition his birth room, is shown The walls bear innumerable signatures, among which such names as Walter Scott, Dickens and Thackeray may be deciphered Part of the building, used by the poet's father as a wool shop, is fitted as a museum. Shakespeare may have attended the grammar school in Church street, a foundation in connection with the Guild of the Holy Cross, but refounded after the dissolution by Edward VI in 1553, and bearing his name The site of "New Place," built by Sir Hugh Clopton and bought by Shakespeare in 1507, was acquired by public subscription, chiefly through the exertions of J. O. Halliwell-Phillipps. and handed over to the Shakespeare Birthplace trustees in 1876. Shakespeare is buried in the chancel of Holy Trinity church next his wife. Over his grave are the lines beginning

## Good Frend, for Icsus sake forbeare To digg the dvst enclosed heare

For the effigy see STARKESPEAR, WILLIAM, POSTRAILS. Further connections with the poet and his family are to be found The museum adjacent to New Place was the house of Thomas Nash, who married Shakespeare's granddaughter Elhzabeth Hall. A Shottery, I mi W. of Stratford, is the thatched cottage in which shakespeare's wife, Anne Hathway, was born I twas purchased for the nation in 1892. The poet's mother was Mary Arden, and this name, that of an ancient county family, survives in the "Forest" of Arden, northwest of Stratford Al Snitterfield to the north lived Shakespeare's grandfather and uncle.

The principal modern monument to the poet's memory is the Shakespeare Memorial, erected in 1837 to contain a theatic, picture gallery and library. Of this the theatre was destroyed by fire on March 6, 1926, but a new one, designed on modern lines by Elizabeth Scott, was opened on April 25, 1932. A Shakespearian season is given annually.

History.—Stratford is a place of great antiquity. A Roman road may have run past the site coins, etc, have been found, and the district at any rate was inhabited in Roman times. The manor was granted by Offic to the bishops of Worcester; and it was under the protection of the bishops of Worcester; and the was under the town early assumed burghal rights. The Guild of the Holy Cross, founded in the 13th century for the support of poor priests and others, exercised authority over the town for many years. Its dissolution was the cause of the incorporation charter of Edward VI in 1535. Another charter, altering the constitution of the corporation, was granted in 1611. Other charters were granted in 1664 and 1674.

STRATHAVEN (hoally pronounced Strion), a manufacturing and market town in Avondale civil parish, Lanatschire, Sociald. Pop (1937) 4,288. It is on the Avon, 16 ml. S.S.E. of Glasgow by road, and is the termitius of the LaM.S.R. company's branch line from, Hamilton. The local trade is chiedy in chees and grain, but there are manufactures of silk, cotton and hosiery. The ruins of Avoidade castle are on a stream that trues through Strathaven to join the Avon, a mile below the town. St miles S.W., on the moor of Drumclog, the Covenanters defeated John

Graham of Claverhouse, Viscount Dundee, June 1, 1679. A granite obelisk commemorates the battle.

STRATHCLYDE, the name given in the 9th and 10th centures to the Britsh (Welsh) kingdom, which from the 7th century enward was probably confined to the basin of the Clyde, together with the adjacent coast districts, Ayrahire, etc., on the west of Scotland Its capital was Dumbarton (fortress of the Britons), then known as Alculut On the south this kingdom bordered on the territories of the Nichari Picts of Galloway, including the modern counties of Wigtown and Kirkculdright. Stratchyde is also sometimes called Cumbria, or Cumberland, and the survival of the latter name on the English side of the border preserves the memory of a period when the territories of the northern Welsh were of much reader extent.

After the withdawal of the Roman in the 5th century the
Shakespearian Connection.—The task of preserving for northern Bittons seem to have sowns greate determination in
ordern eyes the buildings which Shakespeare saw was not entered
maintaining their independence than any of the southern lingone till the end of the 18th century, when much of the visible
of one till one of of the 18th century, when much of the visible
of one and, according to Welsh taddition, Cured the ancestor of
the kings of Gwynedd, had himself come from the north. In the
n his birth room, is shown The wells bear numerable sig-

Such notices as we have of the history of Strathclyde in the 7th and 8th centuries are preserved only in the chronicles of the surrounding nations and even these supply us with little more than an incomplete record of wars with the neighbouring Scots, Picts and Northumbrians It is probable that the Britons were allied with the Scots when Aidan, the king of the latter, invaded Northumbria in AD 597. In 642, however, we find the two Celtic peoples at war with one another, for in that year the Britons under their king Owen defeated and slew the Scottish king Domnall Breac In the same year they came into conflict with the Northumbrian king Oswio. In 649 there appears to have been a battle between the Britons and the Picts, but about this time the former must have become subject to the Northumbrian kingdom. They recovered their independence, however, after the defeat of Ecginth by the Picts in 685 In 711 and again in 717 we hear of further wars between the Britons and the Scots of Dalriada, the former being defeated in both years. Toward the middle of the 8th century Strathclyde was again threatened by an alliance between the Northumbrians and Picts, and in 750 the Northumbrian king Eadberht wrested from them a considerable part of their territories in the west including Kyle in Ayrshire. In 756 the North Britons are said to have been forced into submission and from this time onwards we hear very little of their history

In 870 Dumbarton was attacked and destroyed after four months' siege by the Scandinavian king Ivarr, and for some time after this the country was exposed to ravages by the Norsemen It is believed that the native dynasty came to an end early in the 10th century and that the subsequent kings belonged to a branch of the Scottish royal family. Toward the end of the reign of Edward the Elder the Britons of Strathclyde submitted to that king together with all the other princes of the north. In the reign of his successor Aethelstan, however, they joined with the Scots and Norwegians in attempts to overthrow the English supremacy, attempts which were ended by their defeat at the battle of Brunanburh in 937 In 945-946 Strathclyde was ravaged by King Edmund and given over to the Scottish king Malcolm 1. the kingdom was only temporary, for we hear of a defeat of the Scottish king Cuilean by the Britons in 971. In the 11th century Strathclyde appears to have been finally incorporated in the Scottish kingdom, and the last time we hear of one of its kings is at the battle of Carham in 1918 when the British king Owen fought in alliance with Malcolm II.

BIBLIOGRAPHY.—Chronicles of the Picts and Scots, edit. by W. F. Skene (1867); W. F. Skene, Cellic Scotland (1876); and Sir John Rhys, Cellic Brilats (1904).

STRATHIONA AND MOUNT ROYAL, DONALD ALEXANDER SMITH, BARON (1826-1914). Canadan statesman and financier, was born at Forres, Scotland, on Aug. 6, 1820. In 1838 he was appointed a junior clerk in the Hudson's Bay company, sent to Labrador and stationed at Hamilton Inlet. For thirteen years he roughed it there, learning the fur trade. Then was for the years on Hudson bay, rising in the company's serv-

ice to be a chief trader and then a chief factor

In 1868 he was appointed to the post of resident governor, with headquarters at Montreal.

The construction of the Canadian Pacific railway had become a practical question in 1872. Smith, together with his cousin George Stephen, and other Canadian and US financiers, boughet he insolvent St. Paul & Pacific railway which by 1873 had been completed from St. Paul to Breckenridge The new owners persuaded the government of Mantioba to build a line from Winnipeg to Pembria on the US frontier. This done, in 1879 the partners formed the St. Paul, Minneapolis & Mantioba Railway company, and by continuing the line from Breckenridge to Pembria united Mantioba with the south and west. In 1880 the government made a contract for building the Canadian Pacific railway with a syndicate of which Stephen was the chief director, and in which Smith, from the first largely interested, came more and more to the front. On Nov. 7, 1885, at Cragellachier in the Rocky mountains, Donald Smith drove the last spike of the first Canadian transcontinental railway.

In 1882 he left parliament, to which he had been elected first in 1872, but returned to it in 1887, and represented Montreal West until 1896, when he was appointed high commissioner for Canada. In that year he was made G C.M.G., in 1897, he was raised to the peerage and in 1909 made G C.V.O. In 1889 he became governor of the Hudson's Bay company.

He died in London on Jan. 21, 1914.

STRATHNAIRN, HUGH HENRY ROSE, 1ST BARON (1801-1885), British field-marshal, third son of the Right Hon Sir George Henry Rose of Sandhills, Christchurch, Hants , minister plenipotentiary at the Prussian court, was born at Berlin on April 6, 1801 He was educated at Berlin, and received military instruction at the cadet school. He entered the army in 1820. and received rapid promotion. As a major in the gand Highlanders he was employed in maintaining order in Ireland in 1830 He then served in the Mediterranean. In 1840 Rose, now a heutenant-colonel, was selected, with other officers and detachments of Royal Artillery and Royal Engineers, for special service in Syria under the orders of the foreign office. They were to co-operate on shore, under Brigadier-General Michell, R A --in conjunction with the Turkish troops-with the British fleet on the coast, for the expulsion of Mohammed Ali's Egyptian army from Syria. Sir Stratford Canning sent Rose from Constantinople on a diplomatic mission to Ibrahim Pasha, commanding the Egyptian army in Syria, and after its execution he was attached. as deputy adjutant-general, to the staff of Omar Pasha, who landed at Jaffa with a large Turkish force from the British fleet, Rose distinguished himself in several engagements, and received many honours. Shortly after he succeeded to the command of the British detachment in Syra with the local rank of colonel, and in April 1841 he was appointed British consul-general for Syria. For seven years, amidst political complications and mtrigues. Rose, by his energy and force of character, did much to arrest the horrors of civil war, to prevent the feuds between the Maronites and Druses coming to a head, and to administer justice impartially; and he saved many Christians from massacre.

In 1848 he left Syria on leave, and did not return, as Lord Palmerston appointed him secretary of embassy at Constantiople in January 1851. In 1852 he was charge d'affaites in the absence of Sir Stratford Canning during the crisis of the question of the "help places." During the Ctimean War Rose was the British commissioner at the headquarters of the French army, with the local rank of brigadier-general. For his services he received the medal with three clasps and the thanks of perlainannt, was promoted to be major-general, and was made K.C.B. and commander of the Legion of Honour. On the outbreak of the Indian Multip in 1857 Rose was given command of the Poona division. He arrived in September, and took command of the Central India force, In January 1858 he marched from Mhow, captured Rathgarh after a short slege, and defeated the raja of Banpur near Barodia in the same month. He then relieved Saugor, captured Cartakota and the fort of Barodia, and carby in March defeated

the rebels in the Madanpur Pass and captured Madanpur and Chanderi He arrived before Thansi on March 20, and during its investment defeated a relieving force under Tantia Topi at the Betwa on April first. Most of Rose's force was locked up in the investment, and to Tantia Topi's army of 20,000 he could only oppose 1,500 men, yet with this small force he routed the enemy with a loss of 1,500 men and all their stores. Thansi was stormed and the greater part of the city taken on the 3rd, and the rest the following day, and the fort occupied on the 5th Kunch was captured, after severe fighting in a temperature of 110° in the shade, on May 7. Under the same conditions the march was made on Kalpi. The rebels attacked his small force, exhausted by hard marching and weakened by sickness, but after a severe fight (May 22) they were utterly routed and Kalpi occupied the following day Sir Robert Napier (qv) had been appointed to succeed him, when news came of the defection of Sindhia's troops and the occupation of Gwalior by Tantia Topi Rose at once moved on Gwahor by forced marches, and on June 16 won the battle of Morar Leaving Napier there, he attacked Gwalior on the 19th, when the city was captured The fortress was stormed and won the following day, and Napier gained a signal victory over the flying enemy at Taora-Alipur on the 22nd. Rose then made over the command to Napier and returned to Poona It was to Rose's military genius that the suppression of the Indian Mutiny was largely due, but owing to official jealousy his ment was only tardily recognized. But in June 1860 he succeeded Lord Clyde as commander-in-chief in India. Rose improved the discipline of the army, and his powerful assistance enabled the changes consequent upon the amalgamation of the East India Company's army with the Oueen's army to be carried out without friction

and you the three states of the state of the

See Sir Owen Tudor Burne, Clyde and Strathnairn, "Rulers of India Series" (1801).

STRATIPEFFER, village in Fodderty civil parish, Ross and Cromarty, Scolland, 5 mi. W. of Dingwall by the L.M.S railway. Fop (1937) 4479 It lies in a valley, sheltered on the west and north There are several sulphurous and chalybeate springs, no great repute for the cure of rheumatism, skin diseases and anaemia, and Strathpeffer is the most fashionable spa in Scotland There is a vitrified fort at Knockfarrel, 3 mi. E.

STRATHSPEY, Scottish dance believed to have had its origin in the 18th century in the valley, or strath, of the Spey, whence its name.

STRATIGRAPHY is a branch of science which may be defined as the study of the relative position and order of succession of deposits containing or separating archaeological material. Stratified deposits may be classified under (1) Archaeological, (2) Archaeological and Geological, (3) Geological.

(1) A purely artificial accumulation, as on a town or settlement site of historic or comparatively late prehistoric age. The section through the Temple of Artemis Orthia at Sparta is a fine example of stratigraphical work yielding chronological information covering at least 1,000 years. Study of this section shows the older deposits divided from the newer by a sand stratum The lower levels dated by their respective potteries, cover the period of an early temple represented by an altar and walls. The sacrificial deposits are of unequal thickness on both sides of the altar, indicating that one side was kept clear for officiation. The altar was therefore in existence while the surrounding strata were accumulating. Contrasted with this is the uniformity of level near the walls, showing that these are more recent than the deposits through which they were cut This early temple appears to have been destroyed by flood, and our next period belongs to rebuilding in the 6th century BC. The site was artificially levelled up by a sand deposit of 11 metres thick in order to raise the new temple above flood level. The Greek altar and associated deposits belong to this period This building remained in use until a following the construction about 178 a.c. The Roman period is superirested, beginning about 350 years later. Inscriptions, ranging from the 4th century B C to AD 235 built into the foundations of the theater prove that it can hardly be earlier than AD 250, since a stele is unlikely to have been thrown aside less than 25 years after its creetion

(a) A combination of natural and artificial conditions, best exemplified by cave deposits, showing strate of early human occupation, interbedded with strate of godegal formation such as stalgamute floor, or flood-borne silf. Cavyan and after the contraction of the stalgamute floor, or flood-borne silf. Cavyan and after the contraction of the contract

In the section through the Rock Shelter at Laussel, S France, we have strata tilting and overlapping. The oldest deposits of lower and middle palacolithic age lie some distance from the sheltering chiff. There follows a long interval when the site was abandoned and chiff detrius and humus raised the level. Upper palaeolithic man returned and resumed discontinuous occupation Deposits cover probably a period of at least 25,000 years. The section illustrates the confusion in interpretation of sequence which would result from unsuable methods of excayation.

(3) Stratigraphical condutions fall within the domain of archae ology. There comes, however, a point at the bennume of the human record when archaeological stratigraphy merges into pure geology. River-terrace gravels listinate this category. The major river valleys frequently show old terraces of sand and gravel at various beglats above the present stream These mark former levels. In many cases these old terraces contain fossil animal remains and palaeolithe fluit implements of different ages. In the case of river gravels, however, the usual law of stratigraphical sequence as shown in (r) and (2) is inverted; the highest terrace will normally (though not invariably) have been deposited first, and will contain the oldest material, whilst the formation of the lower terraces will be episodes in the later degradation of the river bed. Material from the older deposits may consequently be washed into the later ones; the true age of an alluval deposit is that of its most recent content.

The section of the Somme near St. Acheul, France, shows that river gravel stratigraphy is rendered additionally complex by over-lying deposits of later date covering older and younger terraces which contain in their turn archaeological material

See J. P. Droop, Archaeological Excavations (1906). (G. C.-T.)

STRATOSPHERE, the portion of the atmosphere lying above six miles in elevation, where the temperature ceases to fall with increasing altitude, is called the stratosphere or, more descriptively the isothermal layer. From the earth's surface up to about six miles, the temperature diminishes nearly uniformly at the rate of about 6° C. per kilometre (1° F. per 300 feet) reaching the low level of about -55° C. (-67° F.). Beyond this height there is little change or a slight rise of temperature to an elevation of at least 25 miles. Two considerations indicate that much higher temperatures prevail in the atmosphere above 60 miles. Firstly, loud sounds are sometimes heard at great distances, though silent at intermediate localities. Those atmospheric layers near the earth's surface, where temperature falls with increasing height, bend the sound path upwards, and those at high levels, where the gradient is rising, reverse the curvature and lead the path downward to the distant listener. Investigations of sound reception indicate that the atmospheric temperature above 60 miles is at least as high as that of the earth's surface at the tropics. Secondly, studies of short wave radio reception have led several authors to suggest that much higher temperatures, even perhaps 1000° C. (1800° F) must prevail at a height of 200 miles in the atmosphere,

The causes of the remarkable temperature conditions of the stratosphere and higher are not fully worked out They depend on the absorption and emission of radiation—solar, terrestrial, and atmospheric. These depend particularly on the proportions of exone, carbon dioxide, and water vapour which are there in minute proportions not yet exactly known.

The barometric pressures prevailing at high altitudes are of course very low, as shown by the table.

Barometric Pressure at High Altitudes

Altıtude in miles.		,	5	10	15	20	25
Percentage of sea level	pressure		35	10	3.0	0.85	0.25

By 1943, the highest level yet reached by unmanned sounding balloons carrying selfrecording instruments was about 25 miles Manned balloons require hermetically sealed chambers fed by oxygen, and specially air-conditioned, to reach heights or ro to 75 miles As such enclosures are necessarily very heavy, the sizes of balloons required to float them in highly rarefied air become immense, and prohibitively costly.

Exact knowledge of stratospheric conditions was greatly pronoted by the ascension of the immense manned balloon "Explorer II," of 3,700,000 cu ft. capacity, on Nov. 11, 1935, under the joint auspices of the National Geographic society and the United States air corps, with co-operation by other institutions. See National Geographic society publication, "Stratosphere Series Number 2," Washington, 1936. The extreme altitude reached was 72,305 ft. Houzontal and vertical cosmic rays were found of equal intensity at 72,000 ft. At ceiling the electrical potential of the balloon was 400,000 volts above the earth. One-fourth of the atmospheric ozone lay below 72,000 ft The air was very slightly less rich in oxygen at ceiling than at ground level. The sky above 72,000 ft was only one-twentieth as bright as at ground level. Five bacteria and five moulds were found surviving at 36,000 ft. A remarkable horizontal photograph, taken at ceiling, shows the curvature of the earth and the blackness of the sky. (C. G. A)

STRAUBING, German town in Lower Bavaria, on the Danable, 25 ml. S.E. of Regensburg, by rail to Passau, Pop. (1335) 29,180. Straubling is a town of remote oragm, believed to be identical with the Roman station of Sorbodusum. In definite history, however, it is known only as a Bavarian town, and from 1353 to 1425 it was the seat of the ducal line of Bavaria-Straubing. Its oldest building is the tail square tower dating from 1205. The industries are iron and tin founding, tanning, brewing, manufacture of machinery and chemicals, trade in wine and cattle.

STRAUSS, DAVID FRIEDRICH (1803-1874), German theologian and man of letters, was born at Lardwigsburg, near Stuttgart, on Jim. 27, 1808. After a short interval of teaching he went to Bershu (1831), but Hegel died jiu sat it the time of his arrival, and of Schleienmacher's lectures only those on Jesus interested him. But he mixed with the disciples of Hegel, and conceived the main idea of his two great works—the Leben Jesus and the Christitche Dognastik. He returned to Tülbingen, where he lectured for a time, but soon found it necessary to give his whole energies to the preparation of his book, the Leben Jesus (1835). The work produced an immense sensation by its destructive method. In 1840 and the following year he published his Christ-liche Glaubenslehre (2 vols.), the principle of which is that the history of Christian doctrines is their dissusceration.

Between the publication of this work and that of the Priedline's Bildier be had been elected to a chair of theology in the university of Zbrich. But the appointment, provoked such a storm of popular ill will in the cannot nat the authorities pensioned him off before he was installed. With his Claubenslehre he took leave of theology for upwards of twenty years. He then published a series of biographical works, which secured for him a permanent place in German literature (Schubarts Leben, 2 vols., 1849, Christian Marklin, 1851, Nikodemus Frischlin, 1855, Ulrich von

Hutten, 3 vol., 1859–1860, 6th ed. 1895, H. S. Reimarus, 1862). With this last-named work he returned to theology and two years afterward (1864) published his Leben Jess für des deutsche Volk (13th ed., 1994). His Cheristus des Glaubens und der Jesse der Geschichte (1865) is a severe criticism of Schleermacher? lectures on the life of Jesus, which were then first published From 1865 to 1872 Strauss resided in Darmstadt, and in 1870 published his lectures on Volleure (9th ed., 1907). His last work, Der alte und der neue Glaube (1872, 16th ed., 1904, English translation by M Blind, 1873), caused some consternation among his friends. Like all his critical works it suffered from his lack of critical study of the text themselves

of critical study of the fevts increase very published in a collected edition in 1 vol. by E. Eelist (1856–58), without in Christickie and the contract of the

STRAUSS, JOHANN (1804-1849). Austrian orchestral conductor and composer of dance music, was born at Vienna on March 14, 1804. In 1819 he obtained his first engagement as a violumist in a small band then playing at the Sperl, in the Leopödstadt, and after acting as deputy-conductor in another orchestra, he organized in 1853 a little band of 14 performers on 18 own account. It was during the carrival of 1826 that Strauss inaugurated a long line of frumphis by introducing his band to the public of Vienna at the Schwan, in the Rossau suburb, where his famous Taubert-Walzer (op. 1) at once established his reputation as the best composer of dance music then living. Upon the strength of this success he was invited back to the Sperl, where he accepted an engagement, with an increased orchestra, for six years.

Later he was appointed kapellmeister to the 1st Burger regiment and charged with the duty of providing the music for the court balls. With the growth of his fame so did the size of his orchestra increase until it ultimately numbered over 200 performers In 1833 he began a long series of tours throughout northern Europe, eventually visiting England in 1838. In Paris he associated himself with Musard, whose quadrilles became not much less popular than his own waltzes, but his greatest successes were achieved in London, where he arrived in time for the coronation of Queen Victoria and played at 72 public concerts besides innumerable balls and other private entertainments. The fatigue resulting from these long journeys seriously injured Strauss's health, but he soon resumed his duties at the Sperl, and on May 5, 1840, he removed with his band to the Imperial Volksgarten, which thenceforth became the scene of his most memorable successes, his conducting being marked by a quiet power which insured the perfection of every mance.

He revisited London in 1849 and after his farewell concert was escorted down the Thames by a squadron of boats, in one of which a band played tunes in his honour. This was his last public things H. Ad idd in Vignes of Series of 1840 of 1840 in the contract of 18

triumph. He died in Vienna on Sept. 25, 1849.

Strauss-was survived by three sons—Johann (1825–99) (q.v.), Joseph (1827–70) and Eduard (1835–1916), all distinguished as composers of dance-music.

STRAIJS, JOHANN, THE YOUNGE (1825-180), Austrian musician, was born in Vienna, Oct. 25, 1835. He was educated at the Gymnasium and the Polytechnic Institute in Vienna and then became a bank clerk, since his father, Johann Strauss (qv), wished him to follow some other profession than music. He studied the violin without his father's knowledge, however, and in 1844 openly declared himself a musician by conducting an orchestra in a public performance. In 1849 the elder Strauss died and the younger, combining his own wortherster with his father's traysled with the group in Austria, Poland sind Germany, winning steep topularity whereven he went. In 1869 he married Jettl Treftz, a popular singer of the day, and in the same year relinculsted the leadership of his orchestra to his two brothers. Josech

and Eduard, preferring to spend his time writing music.

His most famous single composition is An der schonen blauen Donau (The Blue Danube), but he was the composer of so many other medotious and highly successful waltzes, including most notably Wiener Blut, Kunstleiteben and Mon lebt nur enmad, that he won the tutle of "the Walta King" Of his operetus, Die Fledermaus (1874) is the best known, but he wrote 15 others, including Der Karneval in Rom (1873), Caglustor (1875), Prinz Methiusalem (1877), Eme Nacht in Venedig (1883), and Waldmester (1865). He died in Venna, June 3, 1899

STRAUSS, JOSEPH BAERMANN (1870-1938), US engineer, was born in Cincinnati, Ohio, Jan 9, 1870 He was educated at the University of Cincinnati, from which he graduated with the degree of civil engineer in 1892 In 1897 he was appointed designer for the sanitary district of Chicago and in 1904 he founded the Strauss Engineering corporation, of which he remained president until his death About this time, having become interested in bascule bridges, he determined to devote himself exclusively to their design. He subsequently invented five kinds of trunnion bascule bridges, which later became known as Strauss trunnion bascules, and two kinds of lift bridges, also named for him. He was the designer of more than 500 bridges in Canada, the United States, Europe and Asia during his lifetime, including most notably the Golden Gate bridge, which spans the Golden Gate in California and contains the longest single span in the world, the Arington Memorial bridge, Washington, D C, the Columbia river bridge, Longview, Washington; and the Montreal-South Shore bridge, of which he was co-designer. He was also consulting engineer for the George Washington Memorial bridge, which connects New Jersey with New York city. Strauss was one of the first to simplify the design of bridges and to rely for beauty not on decorations added to his bridges, but on line alone

His inventions included the bascule door hangar; a yielding bariter, used not only for the protection of motorists at grade crossings but to assist the landing of planes on aircraft carriers, and a new kind of safety net for workers on bridges. He died in Los Angeles, May 16, 1938.

STRAUSS, RICHARD (1864-1949), German composer, was born at Munich on June 11, 1864, the son of Franz Strauss, an eminent hornist. To some extent a prodigy, Strauss was something of a pianist at four, a composer at six, and at ten he was already seriously studying music under F W Meyer, Munich Hofkapellmeister. Soon the result of this study began to make itself apparent. Singers sang Strauss's songs; the Walter quartet played his Quartet in A (op 2), Hermann Levi performed his D minor Symphony; and Bulow took the composer under his wing and introduced his early Serenade for wind instruments to the Memingen public. For obvious reasons Strauss had not yet found himself. He had passed through the gymnasium and the university, and his music studies had been thorough, but all this had made of him merely an excellent technical musician, who in his Eight Songs (op. 10) and in his Pianoforte Quartet (op. 13) showed how strongly he was influenced by predecessors, Liszt in the one case, Mendelssohn in the other. To Bulow, and even more to Alexander Ritter, Strauss owed the awakening in his own mind of the interest in the modern development of music,

In 1885 Strauss succeeded Billow as conductor of the Meiningan crockestra, but the appointment was held only for a few months, since in April of this year Strauss resigned his post. in order to travel in Italy, and on his return in the early autumn be became third conductor of the Munich opera under Hermann Levi. Four years later he was installed in Welmar as Hofkpaplimester, but once again he held his post for only a brief period, for in 1894, the year of his marriage to Pauline de Ahna, the eminent singer, he was promoted to be first conductor at Munich. Between these various Strauss travelled considerably in the near east and over Europe. He conducted a performance of Elektra, in Beccham's season at Covent Garden unt he spring of 1910, and 483 min 1913 (When his Ariadne auf Nazos was given at His Majesty's), in 1914 (When he conducted his Legend of Joseph at Drury Lane), in 1923 and 1926.

It has often been said that signs of the real Strauss are not to be

perceived before his Don Junn (op 20) and Macbeth (op 23) A year only divided Macbeth (1887) from Don June (1883) Tod mad Verklarmey (1889) is a sensational work. Between it and Till Eulenspiegels Intigen Streiche (1894), Strauss's first opera, Gunteran, finds place (first performance, Wennar, 1894), the latter a work that in spite of much réclame for the composer failed to hold a nosition upon the stage

In Tul Bulenspeeps, one of the most bullantly clever scores eyer penned, is to be found a sense of fun that is worthy of note (as of emulation), and it is perhaps worth recording that no more noteworthy cample of the rondo form exist, in modern muse, while its approximate successor, Don Quizota (1897), is an equally outstanding example of the variation. In Don Quizota the senth as a musical realist was reached. In between came another symphonic poem on the most ambitious scale, inspired by and named after Nietzsche's Also sprack Zaralistiva (1895), which stirred up more temporary strife than any of its piedecessors, if not so much perhaps as was aroused later by the production of Enr. Heldenbelon (1898), or by the comparatively ingenious Symptosia.

phoma domestica (1904).

Up to 1910 Strauss had composed four operas Of these Gimtrem was on frankly Wagnerna lines and had hitle success. Feuersnot, on the other hand, despite the fact that it is largely in the nature of a satural skit at the expense of Munch and its citzens, remained sufficiently alive to ment performance at His Magesty's theatte, London, under Thomas Becknims' direction in July 1910. At Covent Garden in March 1910 Elektra was played to crowded houses and aroused gerat discussion by reason of what was then regarded as its unbridled violence and sensationalism. And later came the not less novel and starting setting of Oscar Wilde's Salome, first produced at Dresden in 1905 and afterward performed at Covent Garden.

A still more important work than any of these was the gay and monance, which was first brought out at Diesden in 1911. Later came Ariabae and Jazos, forming part orignally of a seminuscial setting of Mohere's Le Bourgeon. Gentilomme but subsequently rearranged as an independent work. This was followed, after the dramatic ballet The Legend of Joseph, by Due Fran ohne Schatten (The Woman suthbaut a Shadow), first heard at Vienna in 1913 and containing some of the finest music which the composer ever wrote for the stage; to which were subsequently dedded a "comite play-open". Schomener (Whipped Crosm), both produced at Vienna in 1924, and the opens Helen of Expty (1928), Arbeita (1932), Des schweigsmen Frau (1935), written to Stefan Zweig's libretto of Ben Josson's The Silom Woman, Fredenstag (1937) and Captracio (1941). His Olympic Hymn was a feature of the Bethin Olympia (1936).

In addition to his operas and big orchestral works Strauss wrote more than 100 songs, not a few of which rank hum a true descendant of the line of German song writers During World War II he was absent from public view and was therester a controversial figure, having taken no stand on the political issues of nazism. In 1947 he resumed the baton at the Strauss Festival arranged in his honour in London, where he was warmly received. In 1948 he was officially cleared of all charges by a denazification court. He died at Garmisch-Partenkirchen, Cer. Spot. 8, 1949.

STRAVINSKY, IGOR FEDOROVICH (1882—), Russian composer, was born at Omninchaum, near St. Petersburg (now Leningrad), on June § (old style), 1882. He first studied law, and it was on Rimsky-Korsakov's advice that he made music his career. His first work, a symphony, was followed by other orchestral places. In 1910 he wrote his first bailet, The Priebird, for Diaghliev's Russian company, with which he was later closely associated. This made an immense impression on musicians and the public by the novelty of its construction. It was followed by Petrushka (1911), usually considered his masterpiece, and Le Sacre da pristemps, produced in 1913 in Paris. He then wrote an opera on Hans Christian Andersen's "The Nightingale" (1914).

This was not a success, and in 1917 he rewrote the second and

third acts as a symphonic poem, "The Song of the Nightingale,"

and also staged it as a ballet Next came Renard, L'Histoire du Soldat, Pulcmella, a ballet with songs after Pergolesa, performed in Paris in 1920, a one-act comic opera, Mawa, performed in Paris in 1922, and Les Noces ("The Wedding") (1923)

In his oration-opera Octobe Res (1927) he went back to classical drams. The dramatic interest resides in the vocal parts, the orchestra providing often a mere accompaniment of transparent texture, moving statuesquely, with practically no thematic development and a preponderance of wind over strings in Latin and the chorus is a male one. Against this sober background the solo voices are treated with extraordinary freedom. To the year 1927 also belongs the ballet Apollon Musagdes. Other Stravinsky ballets include Perséphone (1933), Jeni de Cortes (1936), and Orpheus (1948). Stravningly opera The Rebe's

Progress, first performed in Venuce, It, n. 1951, won wude acclaim. Besides his works for the stage he wrote a symphony for wind instruments (1920; rev. 1947); nagtume for small orchestras; Concentro for string quartet (1926), symphony in three movements (1948); he for string quartet (1926), symphony in three movements (1948); become for small chorus and ten undi instruments (1948); pieces for pano, including a sonata, ctudes and two concertos for two unaccompanied panos, and numerous other works, both for orchestra and for small groups of instruments. In 1940 he went to the United States, where he became a lecturer at Harward university. He later became a naturalized US citizen. Stravinsky wrote an autobiography, Chromole of My Life (Eng trans. 1936), and Poetra of Music (1947). See F. W. White, Stravinsky (1948) and A. Tansman, Stravinsky (1948).

STRAW AND STRAW MANUFACTURES. Straw is the generic name applied to the drued stems or stalks of certain creals, such as wheat, barley, cats and rye. The first use of straw was probably as bedding or floor coverings for manked or as fodder and latter for cattle. The value of straw for cattle was early recognized, for im making conditions of land tenure, it was, and still is, customary to prohibit the removal of the straw residue which, as litter, became the only fertilizing agent. Thatching to primitive shelters and body coverings for man were some of the succeeding utilization adventoments.

Straw is now the raw material of many important industries, viz., mat-making; the stuffing of bedding; the weaving of hats, plats and baskets; twisting into ropelike bands for tying up sheaves and trusses of corn and hay and for rolling into "skeps" or beehives; for various methods of ornamentation; for the making of pulp for paper and the species of carriboard known as strawboard and the making of "envelopes" for the protection during transit of glass and earthenware. The two most important of the control of t

In the plait and hood industry throughout the world, cereals are specially grown and carefully selected for good colour, length, lightness in weight and toughness. Certain soils are necessary for the growth of straw fulfilling these requirements. These are found in Bedfordshire, Buckinghamshire and Hertfordshire, in England, Tussany in Italy, on the eastern seaboard of China and in nearly all parts of Japan. These various centres employ different means of cultivation and of treatment of the stalks after growth. In England the wheat crop destined for plait is carefully mown by hand with a stickle or sychych, the stalks when thoroughly ripened are tied up, just below the ears, into small sheaves, the loose leaves at the knots are removed by means of a special comb, leaving only the pipes of the straw, which are finally cut up into suitable lengths between the knots.

In Tuscany, before the grain is fully ripened, the stalks are pulled up by the roots and spread out to be dried and bleached in the sun. The upper part of the stalk down to the first knot, being exposed to the elements during growth, develops a colour known as "Tuscan" and is termed panta or point. This part of the straw is used for making the well-known "Legborn" hats, as well as for plaits of many designs under the generic name of "fuscan." The plaits of many designs under the generic name of "fuscan." The

lower portion of the stalk, when denuded of its sheath, is of a pearly white colour and is called the peddle or foot. This is lighter in weight than the panta and is utilized for hats and plants of high quality under the name of "Pedal" China and Japan follow these methods as the nature of the straw or the soil may recurred.

Varieties of Straw Hats .- Straw hats comprise (1) those made of plants sewn in overlapping 10ws either by hand or machine, (2) those woven like a basket called hoods, (3) those, like the "Leghorn," which are made of plants laid edge to edge These last have, for fixing the rows of plant together, a fine cord threaded through the loops resulting from each bend of the strand of straw at the turn of the pattern, which when tightened interlocks the rows in such a manner as to conceal the cord entirely. forming when finished practically a flat surface, while the sewn hats, having each row overlapping the next with the stitch taken through, present a fuller and richer appearance. Hoods are woven in various "wattle" and "crisscross" patterns of plain or fanciful nature. All methods commence at the centre of the top of the crown and the starting spiral or knot is termed the "button" In addition to the "Panamas" and "Brazilians," there are the Yedda, Hemp, Raffia, Bowen, Buntal Rush, Java, Bankok and Manila hoods which, although in the plait and hat trade are called straws. are of other vegetable fibres. They are all of exotic growths: the well-known "Panama" derives its name from the locality from which it was first exported 300 years ago; the area of its production has since greatly extended, Ecuador and Colombia being now important centres of manufacture The names of Bankoks, Brazilians, Javas and Manilas announce their source, yeddas and bowens come principally from Sumatra, rush hats are made in China: raffias come from islands of the Caribbean sea, and hemps from Switzerland, Italy, China and Japan. Synthetic braids are made mostly in Switzerland. The principal variety, "Neora Split," is a combination of cellophane and ramie, an Asiatic grass boiled into a fibrous substance Another has cellulose or gun cotton for its base, as have synthetic straw bodies

The making of plaits or braids for sewing to shape is of much more recent origin than the weaving of hats or hoods and this development was introduced into Scotland by Mary Queen of Scots in 1752. After the accession of her son, James I, to the English throne, the industry migrated toward the south and settled in the district between Dunstable (Bedfordshire) and Hemol Hempstead (Hertfordshire) in the early days of the 17th century. From that date hats and bonnets were all made or sew by hand until 1870, when the first hat was machine-sewn in Luton (Redfordshire).

Many machines have been invented for the sewing of plait, of which only three varieties are now extensively in use. The 1870 type machine, greatly improved, has a visible stitch similar to that of an ordinary domestic sewing machine; another type, subsequently invented, has a specially designed inchanism by means of which the concealed stitch of handsewing is closely imitated; these produce the overlapping row result, but in the third and latest machine a zig-zag stitch provides for the sewing of plaits edge to odge

The sulphur and acid processes, for long the only methods of bleaching straws, have been replaced by the use of "electrolytic hydrogen peroxide," by which all tones of white, from paper to ivory, can be obtained. In like manner, the old-time logwood fustic, sumes, opperas and other similar dyestuffs have been superseded by aniline and alizarine processes. Hats and hoods are stiffened with gelatine size, and after drying are blocked into the required shape with the aid of damp heat and pressure, either by hand or by hydraulic or vacuum machines. (H. I.; X.)

STRAWBERRY, well-known fruit-plants of the genus Fraguria. Native of the temperate regions of the old and new world, as well as of mountain districts in warmer regions, one species is also found in southern Chile. The common cultivated varieties were derived by bybridizing the meadow strawberry (Fraguria wirginiana). of eastern North America with the beach stawberry (R. okidensis), native from Alaska to central California, the coast: of southern Chile and the mountains of the Hawaiann Islands. In 1943, Early Cheyenne, Cheyenne X, and

Cheyenne 2 varieties were introduced, all three hybrids of cultivated varieties with a third species, P ovalis (fomerly P cimerfolia), a native of western North America from New Mexico to the Pacific and north to Alaska P vesca, the fourth species, is crummolar and is now (or nossibly indipenous) in the mountains



Fig. 1.—WILD STRAWBERRY (FRA-GARIA VESCA), IN FLOWER AND FRUIT

FRUIT

A. Longitudinal section through
flower (enlarged)

of the West Indies, Mexico rather fragile woodland species. lacking the vigour of garden strawbernes. The "alpine" varieties are everbearing selections of F vesca from the mountains of northern Italy Though the fruit of the alpines is much smaller than that of the common cultivated varieties, it is highly aromatic In several varieties it is fairly common in European gardens but is rare in America The alpine varieties come true to seed in contrast to the great diversity of the seedlings raised from seed of ordinary garden varieties A few varieties of F. moschata, a fifth species native to central Europe are also raised in European gardens Its berries are vinous

gardens Its bernes are vinous manufactured and the most aromatic of all However, the plants are only moderately productive and the bernes are small in size a Milied to P sesse are two other rather distinct species, P, milger-ressis of southern Asia and P wirids of Central Europe, both have usual and eupromising fruit. The so-called Indian straw-production of the most productive production of the productive production of the productive production of the productive productive production of the productive productin

Before the white man reached America the Indians of Chile had selected and were cultivating native strawberries that bore fruit of exceptional size—"as large as a walnut." The berries were pale red with firm, meaty, almost white flesh and a delicate aroma. In 1714 M Frezer took to Europe five plants of this Chilean strawberry. Plants of the North American meadow strawberry were already growing in European gardens, and from crosses of these two the modern strawberry evolved. Varieties grown in North America originated there while most of those grown in Europe originated there while most of those grown in Europe originated there (Huxley = Ettersburg 80 is the chost exercision.)

In the United States the acreage in strawberries averages about 18,0000 acres with a croy value of about \$3,000,000. It is grown in every state of the United States and in most provinces of Canada on a wide range of soil types, from sand to day. In all except sections near the Gulf coast and on the Parlic coast the plants are usually set in early spring 10 3 ft, apart in rows 3 ft, distant and fruit the following year. Near the Gulf coast plants are sti nthe fall and fruit during the following winter or in eirly spring. On the Parlic coast plants are

Duing the summer runners grow from the original plants and form new plants at their tips. By fall a matted bed of plants will have formed. Fruit buds form in the crowns of the plants in the fall. These develop into flowers and berries the following spring. Because of the warmer winter and the short days from eastern North Carolina west to Louisana and southern Texas fruit buds form all winter and into the spring, resulting in a second crop of fruit following the first crop. Plants formed late in the fall or crowded in dense rows so that they have only two or three leaves may bear five to ten berries in the spring. If the plants are formed early in the summer and are well spaced so that they have 20 or more leaves they may bear as much as a quart the following spring. To obtain such large plants the original mother

plants set 2 ft apart in the row may form five runner plants include glass bottles, clothing, food, agricultural implements, fursnaced about 12 in apart or eight runner plants spaced 8 in apart All runners after these have rooted are cut oif The larger the plant in the fall the greater the crop the next spring, and runner restriction, use of fertilizers, irrigation or any other cultural practice to increase the size of the plant in the fall will increase the next year's crop

The strawberry is only a half-hardy plant and may be badly injured by temperatures of 10° to 15° F in the fall and winter. For this reason the plants are covered with r to 6 in of wheat straw or other mulching material before temperatures as low as 15° F occur One inch of straw is sufficient from Maryland to Kansas, 2 in. from New England to Illinois, and 3 to 6 in in Wisconsin. Iowa, Minnesota and northward

In 1943 less than 20 varieties constituted 95% of the acreage in the US Important varieties were Missionary in Florida; Klonmore in Louisiana, Blakemore from Maryland to Oklahoma south to 100 mi from the Gulf of Mexico, Klondike near the south to too in Missouri, Kentucky and southern Illinois and Indiana, Dorsett, Fairfax, Chesapeake, Joe and Lupton from the eastern shore of Virginia to southern New York and New England: Howard 17 (Premier), northern New Jersey to Canada and

west to Minnesota; Dunlap and Beacon in Wisconsin, Iowa and Minnesota, and Marshall on the Pacific coast

Everbearing varieties differ from others in forming fruit buds in the long days of summer at relatively high temperatures They are adapted to northern sections with cool summers, as from New Jersey and New England to Iowa and Munesota and northward Rockhill, Gem and Green Mountain are good everbearing varieties for the U.S. and Canada.

Serious diseases are the leaf spots, red stele root disease, spring and summer dwart (due to nemas), fruit rots and virus diseases. Serious insects are the bud weevil, root weevils, crown bores, cyclamen mite, leaf roller, white grubs and the red-spider mites

In England and Wales the acreage was 26,750 in 1935 In Scotland about 2,000 ac and in Ireland about 1,000 ac, are grown Kent county is the largest producer in England, with nearly onethird of the entire acreage of England Hampshire, Cambridge and Norfolk counties also have large acreages. Plants are set in the spring or autumn 12 to 15 in, apart in the rows with the rows 30 in distant. Paxton is best on heavy soil, Royal Sovereign on lighter soil and Jucunda on peaty soil. The fields may be kept till the fourth year but not usually more than that long.

See "Strawberry Improvement," U.S. Department of Agriculture Yearbook, 1937

STRAWBERRY-TREE (Arbutus unedo), a beautiful ornamental tree of the heath family (Ericaceae, q v ), native to southern Europe and also to southwestern Eire (Keiry), and widely planted in warm countries. It grows from 10 to 30 ft. high and has smooth red bark, which peels in thin plates, and oblong, glossy, dark-green leaves The white or rose-coloured flowers, arranged in short, drooping clusters, are borne in autumn intermingled with the scarlet granular berries, about \$\frac{1}{4}\$ in. across, which ripen only the second season after flowering. (See MADROÑO)

STRAWBOARD: SEE CARDBOARD.

STRAW HATS: see STRAW AND STRAW MANUFACTURES. STRAYS, a term used in radio to denote electromagnetic disturbances in reception other than those produced by radio trans-

multing systems STREATHAM, a large residential and shopping district in south London, England, within the municipal borough of Wandsworth and the parliamentary division of Wandsworth Streatham. The common is 67.75 ac. in extent and rises to about 250 ft. Streatham park, which was, until pulled down in 1863, on the south side of Tooting Bec common, was often visited by Samuel Johnson when Henry Thrale lived there.

STREATOR, a city of La Salle county, Illinois, U.S.A., on the Vermilion river, 90 mi. S.W. of Chicago. It is served by the Burlington Route, Gulf Mobile and Ohio, New York Central, the Atchison, Topeka and Santa Fe and the Wabash railways. The population was 16,469 in 1950 and 14,930 in 1940 by federal

niture and truck bodies The first settler in the immediate vicinity came from Virginia in 1831. About 1860, after coal had been discovered, a village grew up along the bluff (called Hard Scrabble and later Unionville) and in 1866 the Vermilion Coal company (whose president was W L. Streator) began mining on a large scale The town was planned in 1868, incorporated in 1870, and in

1882, when the population was about 6,000, was chartered as a city. STREET, ALFRED BILLINGS (1811-1881), U.S. author, was born in Poughkeepsie, NY, Dec. 18, 1811 He was educated at the Dutchess county academy until 1825, when his family moved to Monticello, NY. After that time he studied law with his father, the district attorney of the state. He practised law in Monticello and later in Albany but was never devoted to the profession and in 1848 abandoned it to become state librarian, a position he held for many years. He also served for a time as state law librarian Although Street wrote both poetry and prose, he is far better known as a poet than as a prose writer. Most of his verses treated of the history and the natural beauties of New York state and he was particularly praised for his descriptive passages He wrote The Burning of Schenectady, and Other Poems (1842), Drawings and Tintings (1844); Frontenac, or the Atotarho of the Iroquois (1849), Woods and Waters (1860), The Indian Pass (1860); and several other volumes, as well as a number of single poems which were printed in contemporary periodicals The Poems of Alfred B. Street appeared in 1845 His "The Settler," "Lost Hunter" and "The Gray Forest Eagle" a perhaps his best single poems He died in Albany June 2, 1831

STREET, GEORGE EDMUND (1824-1881), English architect, was born at Woodford in Essex on June 20, 1824, and died on Dec. 18, 1881 He was the third son of Thomas Street, solicitor. He was educated at Mitcham and at the Camberwell collegiate school. In 1841 he became a pupil of Mr. Owen Carter at Winchester. Afterward he worked for five years as an "improver" with Sir George Gilbert Scott in London and in 1840 began to practise on his own account. At an early age Street became deeply interested in the principles of Gothic architecture. and studied the finest examples of mediaeval buildings in England and on the continent. His first commission was for the designing of Biscoray church, Cornwall In 1840 he took an office of his own. He was a draughtsman of a very high order, and his sketches are masterpieces of spirit and bulliant touch In 1855 he published a careful and well-illustrated work on The Brick and Marble Architecture of Northern Italy and in 1865 a book on The Gothic Architecture of Spain, with beautiful drawings of

Street's personal taste led him in most cases to select for his design the 13th century Gothic of England or France, his knowledge of which was very great, especially in the skilful use of rich mouldings. By far the majority of the buildings erected by him were for ecclesiastical uses, the chief being the convent of East Grinstead, the theological college at Cuddesden and a large number of churches, such as St Philip and St. James's at Oxford, St. John's at Torquay, All Saints' at Clifton, St Saviour's at Eastbourne, St. Margaret's at Liverpool and St. Mary Magdalene, Paddington. His largest works were the nave of Bristol cathedral, the choir of the cathedral of Christ Church in Dublin and, above all, the new courts of justice in London The competition for this was prolonged, and much diversity of opinion was expressed. Thus, the judges wanted Street to make the exterior arrangements and Barry the interior, while a special committee of lawyers recommended the designs of Alfred Waterhouse. In June 1868, however, Street was appointed sole architect. The building was not completed at the time of his death.

Street was elected an associate of the royal academy in 1866 and R.A. in 1871. At the time of his death he was professor of architecture to the royal academy, where he had delivered an interesting course of lectures on the development of mediaeval architecture He was also president of the Royal Institute of British Architects. He was a member of the royal academy of Vienna, and in 1878, in reward for drawings sent to the Paris excensus. Coal mining was formerly important; industrial products hibition, he was made a knight of the Legion of Honour. He was buried in the nave of Westminster abbey

See A E Street, Memoir of G E Street, R A (1888)

STREET CRIES. The stinerant vendor has always adopted a distinctive cry to draw attention to his wares, and, as a French writer says, the origin of these cries "se perd dans la nuit des temps." The earliest record possessed in English is that given in the New English Dictionary of a cry of 1393 "Kokes and here knaues crieden hote pyes hote"-a cry which with but slight variation was preserved to the close of the 18th century The earhest collection of street cries is to be found in the 14th-century poem London Lackpenny The author of this poem is, on John Stow's authority, John Lydgate (1370-1450), a Benedictine monk of the abbey of Bury St. Edmunds Among the many cries included are those of "Hot peascods," "Strawbernes ripe and cherries in the rise" Pammelia: Musicke's Miscellanie was published in 1600-18 and contains a number of cries, but the most important collection of the time is P Tempest's The Cryes of Old London (1668), a work with which Samuel Pepys was familiar In Smollett's Humphrey Clinker it will be recalled that the author protests against "noisy rustics bellowing 'green peas,'" and Herrick long before had introduced stray street cries in his Hesperides. The cnes of Paris are of very remote origin and Le Livre des Mestiers contains examples of the time of Saint Louis; Guillaume de la Villeneuve compiled a famous collection known as Les Crieries de Paris As in London and elsewhere the incunabula of the street cries of Paris are rich in pictorial illustration, and the old collections provide a perfect mirror of the times. Every town possesses its distinctive cries, but, save when there are enthusiasts such as A. Carracci (1560-1609), who preserved those of old Bologna, these are hard to come by

BIBLIOGRAPHY.—Charles Hindley, A History of the Cries of London (1881), Sir Frederick Bridge, The Old Crye's of London (1921); Victor Fournel, "Cries of London," in Grove's Dictionary of Music, Les Cris de Paris (1887). (H L Mo)

STRELITZ (STRVELETS), a body of Russian household troops orignally rased by the tsat Ivan the Terrible in the middle of the 16th century. They numbered 40,000 to 50,000 mfantry and formed the greater part of the Russan armies in the wars of the 16th and 17th centuries. They were a fietce and ill-disciplinable in peace. Their mutnies were frequent and dangerous, and at last, in 1683, an unusually serious outbreak led Peter the Great to compass the abolition of the force. The Streitis were gradually drawn to the western frontier of Russia, and in 1658 they rose in mutiny for the last time. Crushed in battle by Peter's general Patrick Gordon they cessed to exist as a military force, and about 2,000 of them who fell into the hands of the tsar were barbarously tortured and put to death.

STREPTOMYCIN is an antibiotic substance produced in cultures of Strephonycer gristes (Actanomyces gristes). It was first described by A. Schatz, E. Bugge and S. A. Waksman in 1944 Of greatest use in the treatment of tuberculous, streptomycin inhibits the multiplication of susceptible bacteria or kills those bacteria, depending upon the concentration of the drug achieved in the blood stream of the patient. The drug has only a local reaction in the gastroinestunal tract if ingested. For systemic action it is given by injection into muscle tissue, from where it is rapidly absorbed into the blood stream Tuberche bacilli can become resistant to streptomycan during a single genetic mutation. Other drugs may be given concurrently to related this phenomenon.

Other drugs may be given concurrently to retard this phenomenon.

Streptomycin may cause vertigo (dizziness) or loss of hearing or both after prolonged treatment.

Although the chemical formulas are known, the drug is not synthesized. It is produced by growing the mould in suitable media and isolating the antibiotic by physicochemical methods.

3. A closely related antibiotic, dihydrostreptomycin, is produced

2'A closely related antibiotic, dihydrostreptomycin, is produced by the chemical addition of hydrogen to streptomycin. Its antibiotic action and toxic effects are very similar to those of streptomycin.

"See monograph in American Medical Association, New and Nonoficial Remedies (1952). (Ws. H. B.)

STRESA, a village of Piedmont, Italy, in the province of

Novara, situated on the west side of Lago Maggiore, on the Simplon iallway, 10 mi N of Arona, 673 ft above sea level Pop (1951) 4,574 It is noted for the beauty of its scenery and its fine villas and is a health resort

STRESEMANN, GUSTAV (1878-1929), German stateman, was born in Berlin on May 10, 1878. He was educated at the Berlin gymnasum and at the universities of Berlin and Leipag where he studied philosophy and political economy. A liberal and a radient patition the drew his political inspiration from Baron H F K vom und zum Stein, from Prince K A von Hardenberg and Rudolf von Bennigson. He was a love of art and interactive These early interests and ideals he maintained throughout his life At the age of 28 he entered the Retchstag On the death of Ernst Bassermann in 1917 he became leader of the National Liberal party

During World War I be urged a more vigorous mobilization of the national effort, and he helped to bring about the fall of T von Bethmann-Hollweg whom he accused of weakness and indecision After the revolution he tried to form a united Liberal party. When this failed he became leader of the new German People's party which represented the right wing of the old National Liberals Although he was himself a monarchist he fully accepted the republican constitution of Weimar. He had always been in favour of responsible parliamentary government. He hoped that his party would form a bridge between the old and the new Germany He condemned every kind of intransigent opposition and afterward made repeated efforts to induce the German National party to take part in the responsibility of government. In 1919 he voted against ratification of the treaty of Versailles which he believed to be unjust and unworkable. But once the decision was taken be thought that Germany must accept the consequences, it was powerless and disarmed; recovery could be achieved only if the treaty were revised by agreement The Franco-Belgian occupation of the Ruhi in 1923 was, he held, a crass infringement of the treaty intended to bring about the economic rum and dismemberment of Germany, He was at first a strong supporter of passive resistance

In Aug 1923 Stresemann became chancellor and foreign minister at the head of a "grand coalition" of all parties from the Social Democrats to the German People's party. The separatists, who were encouraged by the French in the Rhineland, the Communists in Saxony and Thuringia and the right-wing extremists in Bayaria threatened the unity of the reich The collapse of the mark made normal economic life impossible. Stresemann therefore decided to end the passive resistance. The reform of the currency was achieved by Hans Luther, and by Hjalmar Schacht, who was Stresemann's personal choice. The reichswehr under emergency decree, took strong measures against the Communistcontrolled government of Saxony and, after the Hitler-Ludendorff Putsch, they restored order in Bavaria The Social Democrats resigned because they considered the action against Saxony unconstitutional. Stresemann fixed to start negotiations with France but his overtures were rejected by Raymond Poincaré. The cabmet fell in December.

net rein in December.

Stressmann remained foreign minister He served in a series of coalitions under Wilhelm Marx (centre), Luther (nonparty) and Hermann Müller (Social Democrat). At the London conference in 1924 he accepted the report of the Dawes committee on replanation of the London conference in 1924 he accepted the report of the Dawes committee on replanation of the London on the London conference in 1924 he accepted the report of the London of the Cornel of the Cornel of London of the Cornel o

In 1925 Stressmann, encouraged by the British ambassador Lord D'Abernon, took the initiative in seeking a political settlement between Germany, France and Great Britism. These negotiations culminated in the Locarno pact (q:0). Stressmann had become convinced that there was no real conflict of interests between France and Germany and that, once the French demand for security had been satisfied, fruitful co-operation in political and

economic matters would be possible. In face of great difficulties he maintained his belief that Aristide Briand would loyally support this policy In 1926, after Germany's entry into the League of Nations, he held private conversations with Buand at Thorry They discussed the possibility of the evacuation of the Rhineland and the return of the Saar and of German financial assistance to France

Stresemann's hopes for revision of the territorial clauses of the treaty of Versailles remained infulfilled. In 1020 he accented the Young plan which was intended to be a final settlement of reparations The Allies agreed to evacuate the Rhineland in 1030. Stresemann carried his policy in the Reichstag, in spite of strong opposition from the Nationalists and Communists Schacht, who had been the chief German expert on the Young committee, turned against him on the grounds that he had won meagre concessions in return for financial obligations which could not be fulfilled.

In 1026 Stresemann signed a treaty of neutrality and friendship with the U S.S R He was anxious that Germany's entry into the League of Nations should not lead to a break with Soviet Russia In the published sources there is no indication that he favoured an eastern in preference to a western policy. Nor is there any evidence that he ever envisaged a departure from the methods of peaceful negotiation. He came to identify the interests of Germany with the interests of Europe as a whole. He was awarded the Nobel Peace prize in 1926. He died in Berlin on Oct 3, 1929

See Gustav Stresemann, His Dianes, Letters, and Papers, ed and tr by Eric Sutton, 3 vol (London, 1935-40), Rochus von Rheinbaben, Stresemann the Man and the Statesman (1939) (A H-M)

STRETFORD, a municipal borough in the Stretford parhamentary division of Lancashire, England, contiguous to Manchester and Salford on the southwest It is on the Bridgewater canal and contains a considerable part of the Trafford park trading estate (next to the Manchester Ship canal) and Old Trafford, the Lancashire cricket ground. The town hall and a technical college are in the civic centre. Pop (1951) 61,532. Area 5.5 sq mi. The two manors of Stretford and Trafford have, since about 1260, descended in the family of Trafford, the borough was incorporated in 1933. The name of the town (Street-ford) refers to the crossing of the Roman road from Chester to Manchester and the River Mersey

STRETTO (It. Stringers, to pull close), musical term signifying the device in fugal writing whereby subject and answer are brought closer together and thereby made to overlap, the one beginning before the other is ended (See Fugue.)

The term signifies also an increase in tempo toward the end of a passage. This effect is to be found chiefly in Italian opera.

STREUVELS, STYN (1871- ), pen name of Frank Lateur, Flemish writer, and the nephew of the priest-poet Guido Gezelle. Essentially a man of the soil, he nevertheless possessed a delicate artistic sensibility and acquired considerable literary culture. He was the most popular writer of his time in Flanders and enjoyed a great reputation in Holland, although he frequently introduced the Western Flemish dialect into his writings Many of his novels were translated. De Vlaschaard (The Flax Field, 1907) is considered one of his best works.

STRICKLAND, AGNES (1806-1874), English historical writer, was born in 1806, the third daughter of Thomas Strickland, of Reydon hall, Suffolk. Her first literary efforts were historical romances in verse in the style of Walter Scott-Worcester Field (published without date), Demetrius and other Poems (1833). From this she passed to prose histories, written in a simple style for the young. A picturesque sketch of the Pilgrims of Walsingham appeared in 1835, two volumes of Tales and Stories from History in the following year. Then, with the assistance of her sister, she projected a more ambitious work, The Lives of the Queens of England, from Matilda of Flanders to Queen Anne. The first volume appeared in 1840, the twelfth and last in 1849, Miss Strickland was a warm partisan on the side of royalty and the church, but she made industrious study of "official records and other public documents," gave copious extracts from them and drew interesting pictures of manners and customs. While engaged on this work she found time in 1843 to edit the Letters of

Mary, Queen of Scots, whose innocence she championed with enthusiasm In 1850 she followed up her Queens of England with the Lives of the Queens of Scotland, completing the series in eight volumes in 1859

Uniesting in her industry, she tuined next to the Backelor Kings of England, about whom she published a volume in 1861. The Lives of the Seven Bishops followed in 1866 after a longer interval, part of which was employed in producing an abridged version of her Queens of England. Her last work was the Lives of the Last Four Stuart Princesses, published in 1872. In 1871 she obtained a civil-list pension of £100 in recognition of her merits She died July 8, 1874

A Life by her sister, Jane Margaret Strickland, appeared in 1887. STRICKLAND, WILLIAM (1787-1854), U.S architect and engineer, was born in Philadelphia, Pa, in 1787. He first became known as an artist, although he studied architecture under Benjamin Latrobe. In 1810, however, he designed the Masonic hall in Philadelphia and was thus well launched as an architect. Although the hall was Gothic in design, Strickland later turned to the classic Greek style, and his next important work, the United States bank in Philadelphia, took the Parthenon for its inspiration Strickland also designed the Merchants' Exchange building, the United States Naval asylum, the United States mint and the United States custom house, all in his native city and Washington's marble sarcophagus at Mount Vernon

His engineering projects were nearly as well known as his architectural In 1825 he was sent to Europe to study internal improvements and on his return did much to encourage the construction of the original line of the Pennsylvania Railroad company, one of the first designed to carry passengers in the United States. He also constructed the Delaware breakwater, a commission he received from the US government. At the time of his death he was in Nashville, Tenn, superintending the construction of the state house, which he designed and which is regarded by many as his best work. He died in that city April 7, 1854, and by a special act of the state legislature was buried in the building

He was the author of several technical publications relating to engineering and architectural projects which he headed; author of Reports on Canals, Railways, Roads and Other Subjects (1826). the report he made on his return from Europe, and, with two others, of Reports, Specifications and Estimates of Public Works in the Unsted States (1841).

STRIGIDAE: see OWL

STRIKES AND LOCKOUTS. Strikes (often called turnouts or sticks in the early 19th century) are concerted refusals to work under the conditions required by employers. Lockouts, strictly speaking, are occasions on which employers close their establishments against their employees until they accept the terms offered them; but the word lockout is often used, especially by workers, to cover occasions on which the employer attempts to worsen the terms of employment and the workers abstain from work in protest Lockouts in the strict sense became uncommon in the first half of the 20th century; formerly they occurred especially when an employer or group of employers was attempting to ban union membership and refused employment to workers who would not sign a pledge not to belong to a trade union. Later they arose most often when a body of employers retaliated against a strike at a particular works by closing all factories until the str'kers returned to work. When the word lockout is used in its wider sense the distinction between it and a strike is often hard to draw, and workers will describe as a lockout what the employers call a strike. Statistically, no separation can be made, and strikes and lockouts are lumned together under the heading of stoppages. or trade disputes.

## EUROPE AND BRITISH COMMONWEALTH

Types of Strikes and Lockouts.-Strikes (and lockouts) can be classified into a number of types. The simplest is the normal type of trade dispute turning on a difference about wages or conditions of employment, or about some special issue of discipline or trade union practice, when the strikers (or lockers-out) are the parties directly involved. Sympathetic strikes or lockouts are those in

which a part is taken by persons or associations not directly involved in the original dispute, but striking or closing their establishments in sympathy with one of the original parties. What are called general strikes may be either very extensive sympathetic strikes or concerted stoppages over a wide range of industries for a common object. The political general strike belongs to the latter type, it can be either a mere protest stuke, called for a single day or for a limited period, or a strike designed to last until it has achieved its purpose or failed, as in the German general strike against the Kapp Putsch of 1920. The British general strike of 1926 was simply an extended sympathetic strike in support of the Mmers' federation, whereas the threatened strike of 1920 against British participation in the Soviet-Polish war belonged to the same type as the strike against the Kapp Putsch. A special variety of strike, which may belong to any of the foregoing categories, is the sit-down or stay-in strike (stay-down, in mining) in which the strikers occupy their places of employment and either do no work or attempt to carry on production on their own account (as in the Italian stay-in strikes after World War I). The stay-in strike was extensively used in France in the 1930s at the time of the popular front and is also a familiar technique among native workers in colonial areas The general strike as actually practised has to be distinguished from the general strike as aspiration or "social myth"-sometimes called the social general strike, which is a mass strike of workers designed to bring about a social revolution and the establishment of a workers' society. Its earliest advocates were the anarchist-communists (see A, Roller, The Social General Strike, 1905); and the idea was taken up by the French syndicalists It was Georges Sorel, author of Reflections on Violence and other books of syndicalist theory, who introduced the idea of the general strike as a "social myth," inspiring workingclass revolutionary feeling and giving a heightened meaning to ordinary strike action, even if in practice it never occurred. The French syndicalists also introduced the conception of la grève perlée (sometimes anglicized as "the strike with knobs on") by way of contrast with la grève aux bras croisés-the former being accompanied by acts of sabotage or violence.

Official and Unofficial Strikes .- Strikes may be either spontaneous or organized A great many strikes have begun as spontaneous reactions by a group of workers to a particular grievance, such as the dismissal of a fellow-worker whose "victimization" for trade union activity was suspected, or the employment of unskilled workers on jobs normally reserved for skilled workers, or the cutting of a piecework price, or any of a hundred other things. Such sudden strikes may become organized subsequently, if a trade union takes them up, or sometimes if the strikers throw up leaders of their own. Strikes may also be either official or unofficial. they are official when they are called or approved by a trade union, which takes control of the proceedings and of any negotiations designed to settle them; unofficial strikes are either strikes apart from trade unions, or strikes called by trade union branches or districts without the support of the union as a whole in accordance with its rules. Since in many countries, organized national collective bargaining has been introduced into most industries and collective agreements have laid down procedures to be gone through before an official strike can be called, an increasing proportion of all strikes tends to be unofficial-for example, a group of workers, tired of waiting to have its grievance dealt with by often dilatory negotiating procedures, strikes contrary to the provisions of a national or other collective agreement. The proportion of unofficial strikes is also increased when laws have been passed either forbidding strikes or imposing a compulsory period of delay for investigation before they can be lawfully called (the Lemieux system, used in Canada, and called after its proposer, Rodolphe Lemieux). Groups of workers will often dare to strike "against the law" when trade unions, fearful of having their funds attacked or their recognition by the state suspended or removed, hesitate to endorse a strike and so make it official.

The Law Relating to Strikes and Lockouts.—The law relating to strikes and lockouts has varied greatly from country to country and from time to time. When there is no industrial conscription or compulsory labour, a man is free individually to with

draw his services without penalty, provided that he works out the period of notice stated or implied in his contract. When long contracts are allowed, this right may be greatly limited, and so it may be where there are laws, as there used to be in many countries (in Great Britain up to 1867), against "leaving work unfinished" Moreover, the laws relating to "breach of contracti" differ widely

In Great Britain it used to be a criminal offense for a workman to break a contract of service, and imprisonment or fine was the penalty, whereas a master breaking his contract could only be sued civilly for damages Only in 1875 were employers and workers in Great Britain in normal cases made equal parties to a civil contract; and even in the middle of the 20th century exceptions remained so that a strike in essential public services or in circumstances which endanger life or valuable property could, if it involved breach of contract, render a striker liable to criminal prosecution Usually, however, breach of contract gives rise only to a civil action. Breach of contract is, of course, an individual matter between an employer and a single workman. Trade union collective agreements in Great Britain are not contracts enforceable at law, though they can be invoked in establishing implied terms of individual contract (the "custom of the trade") In Great Britain, except under wartime regulations, there have never been any penalties for breach of collective agreements, even where agreed or even compulsory reference of disputes to arbitration has been in force. In other countries which applied compulsory arbitration, there have often been penalties against trade unions which have called strikes contrary to law-the most usual being the withdrawal of recognition from the offending union so as to prevent it from bringing cases before the arbitration court, with the result either that a rival union can supplant it or that there remains no lawful way of pressing the case of the workers concerned

In Great Britain, the Trade Disputes and Trades Unions act of 1927 (passed after the general strike, but repealed by the Labour government in 1946), created a special category of illegal strikes and lockouts (in which it was unlawful for trade unions or employers' associations to engage) and laid down a procedure of injunction for determining the illegality in any particular case, but this provision was never in fact used. In totalitarian countries strikes have usually been forbidden altogether, and severe penalties laid down against their inciters. In countries where personal freedom is recognized as a basic principle the question of legality is more difficult. If an individual is free to withdraw his labour, subject to not breaking his contract, what can make it unlawful for a number to do the same? The law courts used to answer this question by invoking the common law notion of conspiracy in restraint of trade, under which concerted action could render criminal what it would be fully lawful for one man to do This was the legal doctrine under which strikes were held criminal, or usually held so when a case came before the courts, up to 1700, when a general act (amended in 1800) was passed forbidding all forms of working-class combination. Thereafter, until 1824, all strikes working-class combination. Thereafter, until 1824, all strikes could be treated as criminal either under the Combination acts or as conspiracies at common law to violate the Combination acts. These acts were repealed in 1824, and under a statute of 1825 strikes for a narrow range of purposes (wages, hours, etc.) were barely legalized, provided they involved nothing that the courts regarded as violence or intimidation As this latter term was not defined, legality remained highly precarious up to 1871, when the Trade Union act laid down that acts done by a number of persons in concert in pursuance of trade disputes were not to be regarded as criminal conspiracies-that is, that the mere fact of concerted action by a number could not, in such cases, constitute an otherwise lawful act a crime. Thereafter, in Great Britain, the legal right to strike seemed to be securely established, until it was challenged by the Taff Vale railway judgment of 1901, which decided that trade unions could be sued for damages arising out of their agents' actions. (See TRADE UNIONS.) This decision was reversed by the Trade Disputes act of 1906, which gave trade unions and their agents a wide immunity, making trade unions virtually unsuable in their industrial activities and giving a wide freedom from prosecutions for incitement to breach of contract in connection with trade disputes.

is, mainly, stationing representatives at the entrance to a works to warn off potential "blacklegs," but also, sometimes picketing the homes of such persons. A blackleg (or scab, or knobstick) is a worker who is prepared to work while other workers of the same group are on strike or locked out, he may be either a regular worker who refuses to join the strike, or a substitute brought in from elsewhere to help in breaking it Picketing is normally done by one or a few men, stationed at each point; but there is also mass picketing, which means assembling a large body of strikers to obstruct entry to the place of work. Much trouble arose over the legal aspects of picketing. In Great Britain peaceful picketing was authorized by statute in 1850, but the right was withdrawn in 1871, replaced only in a restricted form in 1875, fully restored in 1906 by the Trades Disputes act, drastically limited in 1927 by the Trade Disputes and Tiade Unions act, which wholly forbade picketing of a worker's home, and restored in the 1006 form in 1946

Political Strikes—Strikes have taken place from time immemoral They go back much further than trade unnos and still occur frequently among unorganized workers in the less developed countries without any trade union support They offen lead to the formation of permanent trade unions, as in the West Indies, in Brutish Africa and in many other places. In such areas it is often almost impossible to distinguish between stukes having industrial and strikes having political objects, for the two are often inextracibly mixed up. An instoncial parallel can be seen in the extensive British sixtles of 134s, known as the Ping plot These, political strikes for the enactment of the Poople's charter. There was a similar imaging of political and economic objects in the popular front strikes in Prance in 1936-193, and in the strike waves that accommanded the Russain revolutions of 1905 and 1917.

The Financing of Strikes—Strikes for industrial jumposes constitute the immense majority. When trade unions are behind them, there is usually strike pay (dispute benefit) unless the unions if fundar union ut When unions have only scartly funds; rether list had may be given instead of strike pay. This is common in the less advanced countries, and used to be common deswhere in earliers days. It is common for unions involved in costly disputes to re-ceve financial help from other unions, particularly where national trade unions have not developed, or have not accumulated large funds. One of the principal purposes of local trades councies has been to authorize appeals for help of this kind. The London Tindes councies for councied (1860) arose in this way, out of a temporary grouping formed to assist the London builders in their lockout of 1859. The London dock strike of 1858 and the porthesis coast inne-hours.

TABLE I .- Great Britain, Trade Disputes, 1803-1052

						- 70 - 70-	
Year	No of stoppages	Workers involved (in ooo)	Working days lost (in ooo)	Year	No of stoppages	Workers involved (in coo)	Working days lost (in oco)
1893*	500	634	30,440	1023	628	405	10,670
1804	993	322	0,510	1024	710	613	8,420
1805	728	250	5,700	1925	601	441	7,050
1806	906	102	3,560	1026*	323	2,734	162,230
18971	848	220	10,330	1927	308	108	1,170
18081	695	252	15,250	1928	392	124	1,300
1890	710	170	2,500	1929	431	533	8,287
1000	633	185	3,000	1930	422	307	4,399
1901	631	179	4,130	1931	420	490	6,983
1902	432	255	3,440	1932	389	370	6,488
1903	380	116	2,320	1933	357	136	1,072
1904	346	87	1,400	1934	471	134	959
1905	349	92	2,370	1935	555 818	271	1,955
1900	479	218	3,020	1936		316	1,829
1007	385	146	2,150	1937	1,120	610	3,413
1908‡	389	293	10,790	1938	875	274	1,334
1900	422	207	2,690	1939	940	337	1,356
1910	522	514	9,870	1940	922	800	940
19115	872	. 952	10,100	1941	1,251	360	1,079
1012*8	834	T,462	40,800	1942	I,3Q3	450	1,527
1913	1,450	664	9,800	1943	1,785	557 821	1,808
1914	972	447		1944	2,194	531	3,714 2,835
1915	672	448	2,950	1945	2,293	520	2,158
1016	532	276	3,450 5,050		1,721	610	
1917	730	872	5,830	1947		424	2,433
1918	1,165	1,116	34,070	1949	1,759	433	1,044
10104	1,352	2,591	20,570	1950	1,339	302	1,389
1921*	1,607	1,032	85,870	1951	1,710	379	1,694
1931	761	552	19,850	1952	1,718	415	1,793
19221	576	58*	10,020	1934	1,710	4.3	4,793

\*Large coal-mining stoppage | Large engineering stoppage, ‡Cotton and shipyard stoppages | Transport stoppages, ||General strike,

Picketing.—Strikes are often accompaned by picketing.—that, manily, statoning representatives at the entrance to a works with one potential "blacklegs," but also, sometimes preketing he homes of such persons. A blackleg (or scab, to knobstuck) me bomes of such persons. A blackleg (or scab, to knobstuck) me so is such persons. A blackleg (or scab, to knobstuck) memors in France and elsewhere. In some cases there are centra a worker who is prepared to work while other workers of the me group are on strike or locked out, he may be either a tegular thing, for example, is one of the main functions of the British order who relixes to join the strike, or a substitute brought is cleared. Federal red dearly on which from for finded buttons funded in 1891.

Statistics,-Statistics of strikes and lockouts are usually cal culated in terms of numbers of disputes involving stoppages o work, numbers involved, and numbers of working days lost No single measure is satisfactory. One big national strike involves more workers and days lost than a great number of small disputes and even a short national stoppage in a big industry outweigh: many smaller disputes in terms of numbers involved Still less satisfactory are the attempts to assess the results of strikes on a statistical basis by distinguishing between strikes won, lost and compromised So high a proportion of all disputes has ended in compromise that the figures show almost nothing, for compromise solutions may range from almost complete successes to barely qualified defeats. All that is effectively possible is a very broad measurement of fluctuations in strike activity from year to year After 1026 there was no year of considerable strike action in Great Britain, and the years after 1945 were remarkably free from disturbance in comparison with those after 1918 But only the broadest conclusions can be drawn from the available statistics. Table I shows the number of disputes, workers involved and working days lost in Great Britain on account of trade disputes from the inception of the returns in 1802

the inception of the returns in 1892. It will be observed that there was a much greater fall in the number of strikers and of working days lost than in the number of strikes. This is because many disputes dump. World War II and after were small and short unofficial stoppages in a single works or colliery or dock. Attempts are sometimes made to classify stoppages by causes—for example, wages, hours, recognition, work rules, etc—but the resulting statistics are of scant vialue, as more than one factor is often involved. Nor does the altempt to analyze methods of settlement yield valuable results: it would be much more important to know the numbers of disputes settled without stoppages of work by the vanous methods—for example, factor engotiation, conciliation, arbitration, etc.—but no statistics on this matter were available by the moddle of the soft ceatings.

Bautoomenw—Pre-1939 data are summaused in the I.LO. Fear Book of Lobury Schistics for 1939; but they are defective Reference to some of the puncipal strikes are given in the annual reports of the ministries of labour of the various countries. See also G. R. (Lord) Askwith, Industrial Problems and Disputes (1920); S. and B. Webb, Hastory of Irade Uniontine, were, et. (1920), Lord Amultee, Industrial Arbitration in Great Britism (1920), J. H. Richardson, Industrial Re-Organized Labour in Four Conditionents (1930); G. D. H. Cole, Morth History of the British Working-Class Movement, 1780—1947, rev et (1938), K. G. J. C. Knowles, Sinkes A Study in Industrial Confict; with Special Reference to British Experience Between 1911 and 1947 (1932).

## UNITED STATES

A strike of journeymen printers at New York, N.Y., m x,76 for an increase in wages is the earliest recorded strike in U.S. history. Prior to 1837 disputes were on a small scale for higher wages or the ten-hour day. The years 1835–37 saw "wuld-art" prosperity which saw the cost of living rus rapidly. To maintair their standards of living, workers organized trade unions and trades' unions (city centrals) to gain financial and moral support in their struggles for higher wages. While this "false" prosperity continued, the workers' demands tended to be granted, but th financial panic of 1837, with its consequent unemployment, mean defeat for the trade unions on the economic front.

After the Civil War, unionism took on a national character. This strike of nation-wide extent was on the Pennsylvania an Baltimore and Ohio railroads in 1877, at the depth of a prolonge depression. The Pittsburgh freight yards of the Pennsylvani railroad were burned and looted. State troops brought in from Philadelphia, Pa, because of the inaction of local authorities an the untellability of local state troops were forced to surrende free strike, which many feared might be the U.S. counterpart of

the commune of Paris, was quelled by the dispatch of units of Feb. 1913, an armed railway train machine-gunned a miners' tent the US army colony at night. A similar incident of industrial autogracy oc-

On May 1, 1886, approximately 340,000 workers went on strike in response to a call by the national trade union federation, which became the American Federation of Labor in 1886, to secure the eight-hout day. Explosion of a bomb in Haymanket square in Chicago, Ill., on May 4, 1886, supposedly by anarchists, and the consequent public clamour against radicalism and unmoism was blamed by Samuel Gompeis for arresting this promising move undicaterer. A revival of the demand for an eight-hour day occurred in 1890, when carpenters struck throughout the nation and were generally successful in achieving then objective

Skilled organized workers at the Homestead, Pa, plant of the Camege Steel Co in July 1892 refused to accept a wage reduction, and in the process gained the support of the unorganized workers Thereupon Henry C. Frick, general manager of the company, shut down the entire plant and refused to negotiate any further with the Amalgamated Association of Iron, Steel and Tin Workers, until then the strongest union in the world. As texthe issue settled down to one of continued union recognition, Frick imported strike breakers and armed guards. In the clash which ensued between the guards and strikers, several were killed on both sides. The strike ended in U.S. unionsm's most decisive defeat.

Organized labour's defeat in the American Railway union strike, or the so-ralled Pullman company boycott of 1804 was of another order. The union, young and weak, instituted a sympathetic strike to assist the Pullman local's resistance to a 25% wage cut. Violence and mass destruction of property occurred, centring in the Chicago yards. The railroad asked for federal intervention, and 2,000 federal troops were sent to Chicago. However, the strike was really broken by the issuance of nijunctions in the federal courts secured at the insistence of the attorney general of the United States on the basis of the Shreman Anti-trust law as one of the

grounds.

The successful strike of the bituminous miners in 1897 resulted in establishment of an agreement for the so-called central competitive field, with Illinois as the union's stronghold for decades

thereafter. The collective agreement, after an apparently hopeless strike begun with an empty union treasury, founded an "industrial government" based on reciprocal rights and obligations of both parties and pointed the way in all of the coal industry and

other industries as well.

In 1902, 150,000 anthracite miners struck to achieve a reduction of hours, an increase in wages and recognition of their union Violence occurred in areas where strikebreakers were hired to nune coal. To preserve order the national guard was sent to certain cities. As winter came, the situation grew worse, and Pres. Theodore Roosevelt intervened and arranged for arbitration. The miners won a roy mcrease in wages and a shorter working day, but their union was not recognized. The outstanding figure of this struggle was the miners' leader, John Mitchell, who sustained the hope of his polyglot following and won public sympathy by his moderation.

moderation. The next big strike was that of the coat and suit makers (women's) in 1970. It produced a second major pattern of industrial government, added to that of the soft-coal miners. Following a two months' strike in New York, a "protocol of peace" established a tripatite beard to settle differences between the manufacturers and the union under the agreement. Louis D. Brandels, later on the United States supreme court, mediated in the strike and devised a compromise in the "preferential union shop" in lieu of the closed shop visualy demanded by the union. This proved a major invention. A four-months' strike against Hart, Schaffner and Marx in Chicago stablished a similar pattern in the men's division. In this strike, as in the working of the agreement, Sid-willment, later a major leader in U.S. uniquosum, made his dobut.

Stable industrial government in the bituminous coal industry was, constantly menaced by nomunion competition. Continuous efforts were made by the United Mine Workers to organize the West Virginia, mines; but the operators, with state support, successing in repelling organization. Union members were evicted from company houses, and forget to live in tent colonies, and in Feb. 1913, an armed railway train machine-gunned a miners' tent colony at night. A similar incident of industrial autocracy occurred in Colorado In 1913–14 the national guard machine-gunned miners' tent colonies, and the miners retablated by killing mine guards and destroying mine property. Federal troops were called to bring order in April 1914, but the strike was not called off until December.

An attempt made to organize the iron and steel industry during and immediately after World War I was a major effort to response and proposed to the stress of the stress of the stress of the stress of the responded to a strike started in Sept 1919, but strike-smaller was employed extensively The men held out for six weeks at the cost of 18 lives, and then mass surrenders began

The New Deal.—With the New Deal, strikes began to evolve to the meature of diminishing violence because of a more considerate treatment of strikers by government and employers. Yet this may be said to date only from the "little steel" strike of 1937 and the La Follette committee investigation of demal of rights to

wage earners

A long-horeman's strike in San Francisco, Calif, m May 1934, developed into a general strike. Union recognition and control of the hiring halls, in essence the closed shop, and better wages and hours were the issues Serious rioting began when the employers attempted to operate the docks by force The California national guard was called out Labour became steadily more embittered, and in July sympathetic strikes started, and the principal highways into the city were closed. The general strike called on July 16 lasted four days, but the strike committee permitted the entrance of food trucks. The longshoremen's leader in this strike was Harry Bridges, subsequently known in Pacific coast and Hawanian industrial relations

To force "little steel" recognition of the Steel Workers' Organizing committee (C10) a strike was called in May 1937. The struggle was attended by considerable violence and, although 'big steel's' recognition of the Steel Workers' Organizing committee had occurred early in 1937, "little steel" (the independent producers) continued to resist unionization for a few more years

World War II and After.—Prior to Pearl Harbor two allegedly Communst-led strikes threatened to hold up the national defense program. In June 1941 leaders of the United Automobile Workers' local at the North American Aviation Co. in Inglewood, Calir., called a strike in violation of an interim agreement negotiated with the aid of the National Defense Mediation board. This unauthorized strike was proken through plant seizure by the government and a dispatch of troops. A strike at the Allis-Chalmers plant in Milwaukee, Wis (1941), crippled vital defense production.

Production losses caused by wartime strikes were relatively small except for soft-coal mining. An outgrowth of two strikes during 1943 was the Smith-Connally or War Labor Disputes act

With the termination of the no-strike pledge at the end of the ar came renewed industrial warfare. The restriction of wage war came renewed industrial warfare. increases during the war, fear of unemployment and some reduction in income because of "cut-backs," and the conviction that organized labour was to be subjected to a concerned employer attack created a favourable climate for widespread strikes. It was expected that the events of World War I and its aftermath would be repeated. In that war the wartime truce had been followed by a triumphant employer counterattack which not only "contained" unionism but regained most of the ground lost to management. Just as 1919 had seen a new record in the number of strikers, it was expected that 1946 might approach that record and possibly bring about a comparable defeat for labour. What happened was something entirely different prosperity held and the unions continued to gain in membership, notably in the newer of New Deal-sponsored unions

A number of the postwar strikes were industry-wide, and most of them of considerable duration. During the 12-mo, period following V-J day, work-stoppages resulted in almost 12,000,000 mandays of idleness Strikes were called in the oil, lumber, auto, steel, electrical manufacturing, med-packing, coal, rallroad and mantume industries. A strike by the United Automobile Workers against General Motors began in Nov. 1945 and continued until March,

1940 The leader of this strike, Walter Reuther, championed the business activity and sustained near capacity production levels had on consumers' cause as well as that of the strikers. He sourned any wage increase that might result in a rise of the prices of cars, but he was certain that the demanded increase could be met out of the corporation's accumulated profits This "public-minded" attitude proved somewhat embarrassing to Philip Murray of the Steel Workers union, whose members were equally pressing for a wage raise from an industry that did not have such profit reserves. The bituminous coal miners were on strike from April 1 to May 20. 1046, interrupted by a truce from May 13 to May 27 The railway trainmen and engineers struck on a nation-wide scale for two days in May 1046 but were defeated by Pres Hairy S Truman's radio appeal Smaller but equally crucial strikes were the tugboat and building employees' in New York, N.Y., and the public utility strike in Pittsburgh, Pa.

On the all-important wages question, the matter arranged itself in three "rounds" over 1946-48. Peculial to this period was the importance of "pattern settlements." The first settlement reached in a mass-production industry tended to set a pattern which all other industries accepted As the cost of living became stabilized, unions turned their attention to nonwage demands, such as employer-financed pension and social insurance programs. This

demand was stimulated by the mability of unions to break the "little steel" wage formula during the war and gained added momentum from an agreement signed in 1946 between the United Mine Workers and the government in which a health and welfare fund was set up to be financed by a contribution of five cents on each ton of coal mined From coal, "social security by contract"

spread to the other basic industries

The postwar years intensified the periods of industrial strife in the bituminous coal industry. Work stoppages were variously termed walk-outs, memorial holidays, stabilization periods and just plain strikes Since the industry was a "sick industry"—the coal demanded by the nation could be produced if the miners worked only three days a weekthe union assembled using national varieties and relational varieties and the control of the con wardly with a court order to resume work, but without actually do-

The steel strike of 1949 typified the new day in industrial conflict. The steel strike of 1949 typified the new day in industrial connuct. While the cost in dollass was great, the jails were empty. Not a cent was spent on strikebreakers, tear gas, not guns or arms of any kind There was no loss of human hie. This absence of violence, formerly so prevalent in US labour disputes, stemmed from the Wagner act, the state of the strike of the state of the strike of the state of the strike of the state of t the rise of a new kind of employer and a well-disciplined trade union membership

membersup
Following the outbreak of the Kosean war, the number of work stoppages increased sharply In 1950 there were 4,843 stoppages, as opposed
to 1948 with 3,665 stoppages The postwar peak occurred in 1946 with
4,985 stoppages The demand for wage increases came to the fereiront as unions proposed and obtained increases in anticipation of federal

Table II -Number of Workers Involved in U.S. Work Stoppages,

		1920	30		
Year	Workers	Year	Workers	Year	Workers
1916 1917 - 1918 1919 1920 1922 - 1922 - 1923 1924 1925 1927	1,600,000 1,230,000 1,240,000 4,160,000 1,460,000 1,700,000 1,500,000 757,000 655,000 428,000 330,000	1928 . 1929 . 1930 . 1931 . 1932 . 1932 . 1935 . 1935 . 1937 . 1937 . 1938 . 1938 .	314,000 289,000 183,000 342,000 324,000 1,170,000 1,120,000 789,000 1,860,000 688,000 1,170,000	1941	2,360,000 840,000 1,980,000 2,120,000 3,470,000 4,600,000 2,170,000 1,991,000 2,410,000 2,420,600 3,500,000

wage controls Following the establishment of federal wage controls

wage controls Following the establishment of federal wage controls in 1951; the unions once again shifted their emphasis to demands for fringe adpartments (e.g., wearton and holday pay, shift differentials from the state of the effect that expanding of the state of the state of the effect that expanding of the state of the state of the effect that expanding of the state of the state of the effect that expanding of the state of the effect that expanding of the state of the state of the effect that expanding of the state of the state of the effect that expanding of the state of the state of the state of the state of the effect that expanding of the state of the state of the effect that expanding of the state of the s

. "YEs.

Table III - Man Days of Idleness in U.S. Work Slobbases, 1027-52

Year	Day., of idlencis	Year			Days of idleness		
1027	26,200,000	1910			6,700,000		
1928	12,600,000	1941		- 1	23,000,000		
1020	5,350,000	1912		- 1	4,180,000		
1930 .	3,420,000	1913		- 1	13,500,000		
1931 .	6,800,000	1914		- [	8,720,000		
1932 .	10,500,000	1945		- 1	38,000,000		
1933	16,000,000	1916		ł	116,000,000		
1934	10,000,000	1947		- 1	34,600,000		
1035	15,500,000	1948		- 1	34,100,000		
1930 .	13,000,000	1019		- (	50,500,000		
19.17	28,100,000	1950		- 1	38,800,000		
1938	0,150,000	1951		- 1	22,000,000		
1939	17,800,000	1952		. 1	55,000,000		

labout-management relations This settlement influenced the peaceful conclusion of wage agreements made by the Chrysler and Ford com-panies with the UAW in 1950 Another important feature of labour-management relations after out-

break of the Korean war was the active participation of the federal government in the settlement of labour disputes

The Wage Stabilization board was authorized in April 1951 to investigate and recommend settlement in any dispute which was not resolved by collective bargaining or mediation, which threatened national de-fense, where the dispute was referred to the board by the parties inby ollective barganing or measurement of the board by the parties involved or by the president of the United States. In 1957, the president not be the president of the United States. In 1957, the president and transport coupment industion. Also in 1951, the president referred the important steel dispute to the board. The steel union demanded an hould by any Emergence and fringe benefits including shift premiums and holiday pay. The board recommended a wage increase was criticated by industry members because it threatened the anti-inflationary program of the federal government and it imposed a union shop on the modustry. The union issued a stike notice in April 1952 when shop on the modustry. The union issued a stike notice in April 1952 when seed shifts were search by the characteristic average the strike, the when negotiations broke down In an effort to avert the strike, the steel plants were seized by the federal government in April 1952 This seizuie was declared unconstitutional by the US supreme court in June 1952, and the president directed return of the mills to the owners Immediately following the return of the mills the steel workers went out on strike

out on STIKE

This steel strike lasted 54 days and was responsible for one-half
of the \$5,500,000 man-days lost in 1952 through work stoppages.
Steel production was not resumed until a new contract was signed
granting an hourly wage increase and some of the fringe demands
Following the wage increase the acting defense mobilizes ordered the Office of Price Stabilization to authorize increases in the price of basic

The government also participated directly in the settlement of two major railway disputes Following an unsuccessful attempt to settle an 18-mo. dispute between the rail carriers and the major railway unions the government prevented a walkout by seizing the railways in Aug. 1950 The dispute centred about the unions' demands for a 40-Aug. 1956. The dispute centred about the unions' demands for a 4,000 hour week for yard workers and rules changes for road service embour week. For yard workers and rules changes for road service embour was reached in Sept. 1950. The dispute with the trainmen order in May 1951. However, an agreement between the railways and the other operating unions was not reached for another year. Consequently federal operation of the railwads anded in May 1952.

sequently federal operation of the railloads ended in May 1952.

BBILDOBARY—Monthly Labor Review (May Issue 1947-92) Ethelbert Stewart, A Documestary History of the Early Organizations of May Issue 1947-92 (1948). The Review of the Common and others, History of Johan in the World States (1942). Solip Perlman, History of Trade Unionium in the United States (1942). Solip Perlman and Philly Tadf, Labor Movements, vol. is, in "History of Labor in the United States Series" (1935); Philip Taff, Economics and Problems of Jabor (1942).

STRINDBÉRG, JOHAN AUGUST (1849/1912), Swedish dramatist, novelist and poet, born in Stockholm Jan. 22, 1849, grew up under poverty-stricken and unhappy conditions, and after a short period at Uppsala university, became a school teacher; then a wealthy doctor interested himself in Strindberr and undertook to complete his education in medicine. Strindberg first found his feet as a dramatist. He wrote Hermsone (1869), an ambittous tragedy in verse; and a one-act piece In Rom (1870) was performed. For a year or two he struggled as a journalist in Stockholm, until in 1874 he was appointed librarian in the Royal library. In these years he completed his first great play, Master Olof (Master Olof, 1874), with the Swedish reformer Olaus Petri, as its central figure, and Roda Rummet (The Red Room, 1879), a satiric novel suggested by The Pickwick Papers. Strindberg then wrote the dramas Gillets hemlighet (The Secret of the Guild, 1880), Lycko-Pers resa (Lucky Peter's Travels, 1880), and Herr Benets hustru (Str Benet's Wafe, 1882) In 1882-82 followed the splendid stories of Svenska oden och aventyr (Swedish Fates and Adventures), which established his fame. In 1875 he met Siri (Signid) Wrangel, the wife of an officer, and became entangled in a fateful passion, which after her divorce in 1877, ended in marriage After a year or two his love turned to suspicious hatred and the first signs of persecution mania showed themselves He had described his early life in the autobiography Transtekvinnans son (The Son of a Bondswoman, 1886); and his unhappy marriage is the theme of the revolting and self-lacerating En dares for sparstal (A Fool's Defence, 1893) His relations to Siri Wrangel colour all his imaginative work in this period. In the early 1880s he lived for a time in Paris and Switzerland, where his literary activity ranged from lyric poetry and satire to studies of the French peasant, and the masterly novels of Utobier 2 verkligheten (Realssed Utopias, 1885). With the stories and sketches of Giftus (Married, 1884-86) he launched an attack on marriage which involved him in a prosecution, resulting, however, in acquittal. The plays Fadren (The Father, 1887) and Froken Julie (Lady Julia, 1888) open a new phase in Strandberg's dramatic work, and form a landmark of importance in the history of European realism Similar plays followed, most of which turn around the author's own marital tragedy. But in those years he also wrote his greatest contributions to Swedish fiction, the masterly novels Hemsoborna (The People of Hemsö, 1887), and I Havsbandet (In the Outer Skerries. 1890) A very dark period followed. His marriage was dissolved in 1801; his misery was accentuated by money difficulties, and for a time he hovered on the brink of insanity. A second marriage with an Austrian lady, Frida Uhl, was even more disastrous than

The dark experiences of these terrible years found their precipitate in Inferno (1897), Legender (1898), and the great allegorical drama in three parts, Tull Damascus (To Damascus, 1898, 1904); to this period belong, too, Advent (1899) and the effective play Brott och brott (Crimes and Crimes, 1899). When reconvalescence set in. Strindberg returned to the historical drama and produced a long series of works of power and originality. the finest being perhaps Gustav Vasa (1899) and Gustav Adolf (1900); he also wrote a number of symbolic poetic plays, notably Ett Dromspel (A Dream Play, 1902) In 1901 appeared the engaging drama Påsk (Easter) and the masterly realistic tragedy Dodsdansen (The Dance of Death), the greatest of his harrowing marriage dramas. For the théâtre intime which he established in Stockholm he also wrote many short pieces, prominent among them Stocksonaten (The Ghost Sonata, 1007). Of the prose works of his last period may be mentioned Fagervik och Skamsund (Fairhaven and Foulsound, 1902) and Taklagsol (The Festival of the Finished House, 1906), which affords a glimpse into Strindberg's third marriage with the actress Harriet Bosse. In 1903 appeared the last volume of his autobiographical writings, Ensam (Alone), a book of tragic pathos; and in 1907-08 what is perhaps the most significant work of his last period, En bldbok (A Blue Book), of which further volumes were published after his death. Strindberg died in Stockholm on May 14, 1912. He is Sweden's greatest modern writer, and has exerted a deep and lasting influence on the European novel and drama,

the European novel and drama.

Branconawny:—The standard edition of Strindberg's Samiade
Striller is that edited by J. Landquist, aç voi. (Stockholm, 1912-191.

Striller is that edited by J. Landquist, aç voi. (Stockholm, 1912-191.

Striller is that edited by J. Landquist, aç voi. (Stockholm, 1912-191.

Stockholm, 1912-191.

Striller is that the striller is the striller works the root course, appeared also in French. The Anglo-Swedish Foundation began (1929) the publication of a new translation of bit dramas. The publication of a new translation of bit dramas. (Stockholm, 1921); there is an English like by Miss I. Lind of Hageby (Glockholm, 1921); there is an English like by Miss I. Lind of Hageby (Glockholm, 1921); there is an English like by Miss I. Lind of Hageby (Glockholm, 1921); there is an English like by Miss I. Lind of Hageby (Stockholm, 1921); there is an English like by Miss I. Lind of Hageby (Stockholm, 1921); there is an English like by Miss I. Lind of Hageby (Stockholm, 1921); there is an English like by Miss I. Lind of Hageby (Stockholm, 1921); there is an English like by Miss I. Lind of Hageby (Stockholm, 1921); there is an English like by Miss I. Lind of Hageby (Stockholm, 1921); there is an English like by Miss I. Lind of Hageby (Stockholm, 1921); there is an English like by Miss I. Lind of Hageby (Stockholm, 1921); there is an English like by Miss I. Lind of Hageby (Stockholm, 1921); the strill like by Miss I. Lind of Hageby (Stockholm, 1921); the strill like by Miss I. Lind of Hageby (Stockholm, 1921); the strill like by Miss I. Lind of Hageby (Stockholm, 1921); the strill like by Miss I. Lind of Hageby (Stockholm, 1921); the strill like by Miss I. Lind of Hageby (Stockholm, 1921); the strill like by Miss I. Lind of Hageby (Stockholm, 1921); the strill like by Miss I. Lind of Hageby (Stockholm, 1921); the strill like by Miss I. Lind of Hageby (Stockholm, 1921); the strill like by Miss I. Lind of Hageby (Stockholm, 1921); the strill like by Miss I. Lind of Hageby (Stockholm, 1921); the strill

STRINGED MUSICAL INSTRUMENTS may be diyided into five different classes, according to the method whereby the strings are set in vibration.

Strings Plucked by Fingers or Plectrum.-Twanging the strings by the fingers is the most primitive method, probably suggested by the feeble note given out by the tense string of the hunter's bow. The nanga of the ancient Egyptians, of which

specimens are preserved in the British Museum, is the only link as yet discovered between the bow and the harp

The next step observed is the device of stretching the strings partly over a soundboard and partly à vide, as in the cithara. the lyre, the rotta, the crwth, etc. In this stage the strings were made to bridge an open space for greater convenience in twanging them with both hands The gradual closing up of this open space marked the steps in the transition from cithara to fiddle.

When the principle of stopping strings by pressing them against a fingerboard in order to obtain several sounds from each had been discovered and applied by adding a neck to the body, a new subdivision was created in this class of instruments. This principle involved a very great advance in technique, and produced the two great families of guitar and lute. The addition of a keyboard to the psaltery created another new class of instruments. of which the principal members were the clavicymbalum, the virginal, spinet and the harosichord

Strings Struck by Hammers or Tangents.—The earliest known instrument thus played was the Assyrian dulcimer or pisantir. In this, as in the psaltery, the strings were stretched over a rectangular or trapezoid sound-chest and were struck by sticks or hammers. The dulcimer has survived in the cembalo or cimbalom of the Hungarian gypsies. The addition of a keyboard produced the clavichord, and later the pianoforte.

Strings Set in Vibration by Friction of a Bow .-- Although used with various other instruments, such as the oriental rebab and its European successor the rebec, with the oval vielle, the gustar or troubadour fiddle and the viols, it is with the effect of the bow on the perfected type represented by the violin family that we are mostly concerned. The strings in this case are all of the same length, difference in pitch being secured by thickness and tension The fingers, by pressing the strings, produce a variety of notes from each string at will by shortening the vibrating section as the position of the fingers shift in the direction of the bridge. To this class belong also the Welsh crwth and the tromba marina.

Strings Set in Vibration by Friction of a Wheel.-This class is small, being represented mainly by the organistrum, and the hurdy-gurdy and a few sostenente keyboard instruments. In these instruments the rosined wheel performs mechanically the function of the bow, setting the strings in vibration as it revolves A row of 10 or 12 keys controlling wooden tangents performs the function of the fingers in stopping the strings.

Strings Set in Vibration by the Wind .-- An example is the aeolian harp. The eight strings of different thickness, but tuned strictly in unison and left slack, are set in vibration by a current of air passing obliquely across them causing the strings to divide into aliquot parts, thus producing various harmonics

In regard to the structural features of stringed instruments the construction of the sound-chest divides those played by hand into two distinct classes, viz., those with the box-form type, consisting of back and belly (or sound board), joined by ribs of equal width, and those with a vaulted back to which is attached directly a flat sound board, without the intervention of ribs.

STRIPE (CHEVRON): see Insignia, Military. STROBL, KARL HANS (1877-1946), Sudeten-German writer, born at Jihlava (Iglau) in Moravia on Jan. 18, 1877, was educated at the gymnasium there and at the University of Prague. From 1898 to 1913 he was in the finance department of the Austrian government, during which time he was also theatrical critic for the Brno Tagesboten. From 1913 to 1915 he edited a Leipzig paper, travelled extensively in Europe and wrote voluminously. He served as a correspondent on nearly all the fronts during World War I. From 1018 until his death on March 10, 1046, he lived as a writer in Perchtolsdorf, near Vienna. His works (novels, tales, lyrics, plays, essays and sketches) run into 80 vol., the best-known being tales of terror and ghost-stories: Eleagabal Kuperus (1910), Lemuria (1917); Umsturz in Jenseits (1920); Gespenster im Sumpf (1920); and Die Eier des Basilisken (1926). Among his student-stories, Die Vaclavbude (1902) and Der Schipkapass (1908) were popular. The Bismarck-Trilogie (1915-19) was probably his most successful historical novel. Other works are

Dorf im Kankasus (1936), Die Runen und das Marterholz (1936), Totenhorn Sudwand (1939), and Gluckhafte Wanderung (1942) See Anton Altrichter, Karl Haus Strobl, em Lebens-und Schaffunbid (Leipzig, 1927), R. A. Thalhammer, Karl Haus Strobl (1938)

STROBL DE KISFALUD, SIGISMUND (1884— ), Hungarian sculptor, was born at Abbrayk, Hung the studied at the Royal academy in Budapest, at the Académic Julan in Paris, at Vienna and in Italy. His early work, including the "Bather" at Amsterdam and "Woman with Lizard" at Budapest, was in the strictly classic style and was all in marble Later he did much work in contemporary portraits, a distinguishing characteristic of these is that intales are in bronce, whereas women and children are in marble. He spent much time in England, where he did busts of the duke of Kent, Lord Rothermeet, the earl of Athlene, Googe Bernard Shaw, Six Austern Chamberlan, Lord Allenby, Lady modables.

Among his best-known busts of Hungarian statesmen is that of Count Albert Appony! He had several erbiblions at the Royal academy in London, and a one-man show at a London gallery in 1935 In 1924 he was appointed professor in the Royal Academy of Art. Budanest.

STROBOSCOPE. The word stroboscope is derived from the Greek and means "whirling mark" or "whilling view." It designates an instrument which imparts the appearance of rest or of slow motion to bodies in rapid motion.

When a body moving with high velocity is illuminated brillhantly for a sufficiently short interval of time it appears to the eye to be at rest. For very high speeds the light intensity may not be great enough to reveal the body because of the extremely short exposure period required to arrest its motion successfully. However, if the motion recurs periodically and the body is lighted successively at precisely the same phase of its motion, then the additive effects give a clear view of the body at a faxed position

This "freesing" of motion of a wibrating or spinning body may be accomplished by permitting the eye to see the body only at certain recurring instants, or by the use of successive flashes of high intensity ilumination. In either case the illusion depends upon the physiological effect known as persistence of vision. To make the image formed on the retina appear continuous, the requency of interruption of viewing, or of flashing of light, must be greater than about 35 cycles per second.

The basic principle of the modern stroboscope is attributed to Joseph Antonne Ferdinand Plateau (1836). It had been used earlier in a less precise manner by Michael Faraday. August Töpler (1866) was among the first to reduce the method to an exact science.

In the early researches, particularly those concerned with observing acoustical vibrations, two types of procedures were employed. The first made use of intermittent vision; the second employed interrupted light. In both cases a spinning or vibrating disk equipped with a narrow slit allowed a view of the object at periodic intervals of time; or it permitted light to illuminate the body at successive instants. Thus, the body was exposed to view, or was illuminated, at precisely those times when it passed a given point in its mother.

Research reports and technical literature from the mid-roth century described many types of strobeogoic devices. Plateavidisk with radial slits was used to determine the rotational speed of wheels and shafts. The prongs of the strobescopic tuning fork were coupped with slotted disphragmas to create periodic interruptions in a beam of light. Rotating and vubrating mirrors were used to produce periodic pulsing of light for strobeoscopic observation. Mirror strobescopes are in use for viewing high-speed operations in spinning machines and in many other mechanisms. Electronic controls were added to secure accurate frequency control and synchronization of the light fishes.

Most stroboscopes employ the method of successive light flashes, the rate of flashing is altered a spinning or vibrating body appears to assume various speeds lower than its true frequency. A familiar example is that of moving automobile wheels viewed on a motion-picture screen. If the shutter frequency of the movie

camera agrees with that at which spokes on the wheel are passing a given point, the wheel apparently stands still. If the shirler frequency is greater than that of the successive passage of spokes, the wheel appears to turn backward. Conversely, at a shirler frequency slightly lower, the wheel seems to rotate slowly in the forward direction.

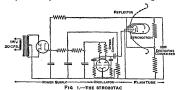
A common application of the stroboscopic method is determination of "slip" frequencies in electrically driven induction motors. The armature of a four-nole synchronous motor operated on a 60cycle line rotates exactly 1,800 times per minute. The speed of a four pole induction motor, on the other hand, is less by an amount which depends upon the type of motor and its loading. A circular cardboard disk divided into eight equal sectors alternately coloured white and black is attached to the end of the induction motor shaft. When the disk is illuminated by a pulsed light source operated from the same 60-cycle line, such as a spark occurring 120 times per second, the disk appears to rotate slowly in the backward direction. If, for example, the rotational frequency of the disk as determined by counting and the use of a stop watch is 20 r.p.m, the shaft speed of the induction motor is 1,800 minus 20, or 1,780 rpm. The speed of the shaft for a particular motor load can thus be directly compared with the frequency of the alternating current supply.

Disadvantages of old types of stroboscopes using mechanically produced light pulses are low light intensities and lack of accuracy and fleability in control of the rates of flashing. Sparks between short air gaps yield high intensity flashes of very short duration. They are, however, erratic in behaviour, are difficult of accurate frequency control, produce objectionable vapours and require constant attention. Modern stroboscopes employ electric gaseous discharge lamps filled with gases at reduced pressures, which produce very short flashes and are capable of high pulsing rates.

The neon-electric stroboscope employs a low voltage neon discharge tube, or "stroboglow" lamp. This lamp is caused to light up intermittently by the discharge of a condenser. Between flashes the condenser voltage builds up slowly, the instant at which the flash occurs being controlled by means of a grid in the neon tube. A thermione oscillator is used to furnish the pulses of grid voltage which effect the recurrent discharges of the gas. Although at provides feedible frequency control and is very reliable in operation, the neon stroboscope dees not furnish high illumination intensity.

Several types of gaseous discharge lamps produce light fishes of very high intensity suitable for photographic purposes. With precise synchronization of the flash and the recurrent motion of a body it is possible to obtain pictures with excellent definition. Minute details of rapidly moving machine parts such as gears, shutters, spinning looms, etc., may be photographed under normal operating condutions. Phasing of the light flash enables observations to be made of a mechanism at any desired instant of its mo-

The fundamental investigations of Harold E Edgerton and his associates at Massachusetts Institute of Technology, Cambndge, has resulted in the commercial development of a variety of stroboscopic flash lamps. Small bulbs are available for single flash



This strobescope is capable of producing low intensity light flashes. The flash lamp (Strobetron) is a neon thyratron yielding light bules 40 µsec in length. The speed control permits continuous variation in rate of flash ing over a range of frequencies from 600 to 14,140 pulses per minute

photographic work. A number of instruments using flash dis- to 200 mm. Hg. The two electrodes between which current flows charge lamps are also made, a simplified diagram of the essential parts of one of these units, the Strobotac, is shown in fig I

The neon lamp (Strobotron) is essentially a gas-filled thyratron having a suppressor grid A potential of about 125 v D C 1s applied to the discharge condenser and firing electrode of the lamp Except when pulsed the suppressor grid has a steady potential which prevents discharge of the condenser through the gas The oscillator supplies voltage impulses to the grid at a rate determined by the resistance and capacitance of the circuit At each impulse the lamp fires The mean duration time of the light pulse is about 40 µsec

Rate of flashing is governed by the speed control used to change resistance of the R-C circuit. Values of frequency are indicated on a calibrated dial Rates of from 600 to 14,140 pulses per minute are provided in two frequency ranges The unit is housed in a box which is approximately a 10-in cube, one side of which carries a 5-in, reflector for the flash lamp,

This device has a great variety of applications for precise frequency determinations and for observations of moving parts. A familiar demonstration in the physics laboratory or in the study of musical instruments is "freezing" of the motion of a vibrating string to show the number and position of nodes and loops. Hundreds of these instruments are in use in engineering and science laboratories and in industry

The Strobotac is employed as a basic speed control umt for operating other devices For technical operations requiring a much higher light intensity than that provided by the low power neon pulse tube two other units have been developed The Strobolux uses an argon-filled flash lamp, while the Strobolume employs a xenon discharge. These devices greatly expedited the use of stroboscopic methods in all types of analyses such as those required in factory production lines

A number of high-speed motion-picture cameras employing flash lamps were also developed. One type of instrument uses standard 35-mm film driven at high speed. The camera has no shutter, the framing being accomplished by a commutator on the film drive sprocket which flashes a power stroboscope at intervals of one frame Speeds up to 1,500 frames per second are obtained This instrument has been applied to the study of transient motions in automatic machinery, details of factory processes, cavitation of propellers under water, and to many kinds of studies requiring single and multiple flash photography.

Cameras manufactured for ultra-high-speed photography are particularly useful in studying the flight of bullets and jet-propelled missiles. Flash tubes are made having light pulse durations of the order of 1 µsec. A mercury flash tube of this type is used on a unit weighing about 20 lb, manufactured for scientific photography. It provides sufficient illumination for photographing objects up to 3 ft, when a lens aperature of f/4 and high-speed emulsions are used. For military applications special types of gas discharge lamps were developed in which the pulse is shorter than a tenth of a microsecond and with which very high rates of

repetitive flashing are attained.

The scientific development of electric flash discharge lamps was very rapid in the 1940s and thereafter. Great versatility was achieved to meet the demands of a variety of technical requirements. These lamps range in radiation brightness from low voltage neon glow tubes up through numerous types of photographic flash bulbs to large single pulse lamps requiring megawatts of instantaneous power and exceeding the brilliance of sunlight in visible illumination. Special units employed in military recognizance were not available for commercial applications at mid-20th century because of the Korean war,

Stroboscope flash lamps are produced in many sizes and shapes. Some are made of straight pyrex glass or quartz tubing ranging in length from a few inches to several feet. For compactness the tubing is normally formed into twisted spirals. These vary in size from tilbing in in. internal diameter, with the helix an inch or more long, to in, tubing in helices 4 in in diameter and 12 in. long. Rare gases or mixtures of gases and mercury vapour are commonly employed at pressures ranging from a few millimetres

are made of a special alloy to minimize vaporization and sputtering of the metals and thus prevent blackening of the tube walls

Lamps yielding high peak intensities required in photographic work are normally operated by connecting the electrodes to a condenser charged to a notential less than the breakdown voltage of the gas An external electrode consisting of a wire wiapped about the tubing is used to trigger the discharge. Triggering is accompanied by applying to the wire a pulse of potential rising to many thousands of volts in a fraction of a microsecond. In the rapidly changing field ions and electrons are formed in the gas and sufficient conduction is produced to cause the condenser to discharge through the tube Peak current values range from a few hundred amperes to several thousand depending upon the size of the lamp. kind of gas and its pressure, and electrical constants of the circuit

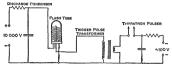


FIG 2 -- DISCHARGE CIRCUIT FOR HIGH-INTENSITY FLASH LAMP Opention of Discharge Line (Line ) FOR HIGH-INTERSITY FLASH LAMP Opention of Discharge Line (Line ) and the Company of the Co duce renetitive flashing

A typical discharge circuit for operating high-intensity flash lamps is shown in fig 2. In this arrangement, which is typical of a laboratory arrangement for studying the discharge, the charge from an auxiliary condense; is sent through the primary of a special type of transformer to produce a high voltage pulse for the external trigger electrode. Single flashes are caused by closing a switch; multiple flashing may be produced by means of a thyratron pulser.

The effective resistance of the arc formed in the gas when discharge occurs is defined as the ratio of arc potential to current flowing at the instant of its peak value. Potential and current measurements are made by means of oscilloscopes using carefully synchronized sweep. The arc resistance varies nearly inversely with the current in a particular lamp. Low intensity discharges have resistances of a few ohms. At several thousand amperes the

resistance values are much lower.

FIG 3 -- OSCILLOSCOPE TRACES OF

FLASH DISCHARGE IN ARGON

These blots are taken from photographs of synchroscope traces. The soops evere jie released by trigger pulse which initiates the discharge. Several successive pulses were used to get traces of current, potential and light responses. These are then photographs of the several successive pulses were used to get traces of current, potential and light responses. The service of the several several services are the services of the se ensitive to short wave infra-red radi-ation at about .85 µ, and filters were used to get the light curves. The ordinates do not represent correct relative intensities in the three spectral regions

Typical values obtained in a laboratory study of a medium intensity flash discharge tube are given by way of illustration A quartz tube with gas column 17 mm. long and 4 mm. in diameter was filled with pure argon at a pressure of 75 mm Hg This was pulsed 15 times per second using a 2 µf. capacitor charged from 1,200 to 3,000 v. Maximum current values ranged from 250 to 1,000 amp Effective arc resistances varied from 4 ohms at the low current value to 1.85 ohms at 1,000 amp. (See fig. 3)

The duration of the light flash is always longer than that of the current pulse For the argon flash tube just described onerated at 3,000 v. capacitor potential, the time taken for the current to rise to its half-maximum value was about 0.8 usec. The current decayed to its half value m 5 µsec and the total current pulse lasted 12 µsec Corresponding values of the visible light pulse produced was 3 µsec. for half-intensity rise, 14 µsec for the light to decrease to one-half its peak value, and the slowly decaying afterglow lasted for 40 µsec

Spectial observation of the induston as a function of time during the flash period is carried out by means of multiplier phototuber and a synchroscope. Results show that most of the intense
hight is a true continuum exhibiting closely the characteristics of
a black body radiator. Maximum intensity occurs at a wave length
of about 5,000 A. Superimposed on this continuum are spark lines
emitted by ions of the gas. These lines are very strong early in
the flash at the time of the current peak. As the light decays the
spark lines disappear and only atomic spectral lines are observed
in the later stages of the flash. The process of excitation and
ionization is of a thermal nature and electron temperatures of
12,000 K and highe are found. The highly energized gas
plasmas of these discharges resemble the states of matter observed in the attrospheres of the sum and other star.

It has been established that the mean intensity of the visible hight flash entitled by a given tube increases approximately as the square of the energy supplied by the condenser. This holds for slow flashing rates in which the tube is ventilated and the envelope is not excessively heated. For infin-red light the relationship is nearly a linear dependence. The mechanism of production of the most intense part of the continuous spectrum is believed to be due to retardation and another infinitely and the state of the continuous spectrum is believed to be due to retardation and atom (Brohmstrikhing) entitled by electrons for exception of excitation is often referred to as arising from "free-free" collisions of electrons and ions.

The rapid conversion of energy from electrical form to radiation in the high current are produces uddeen changes in gas temperature. Shock waves are generated by the flashes and luminous friends are observed passing through the gas of a side tube connected to the discharge. This method of generating shock impulses has been employed in the detailed study of shock waves at low gas pressures. In the operation of high intensity lamps sharp audible clicks are heard accompanying the breakdown discharges.

The glass wall of the flash tube is subjected to rapidly changing temperature gradients due to violent gaseous bombardment. Continued operation at high temperatures result in crazing of the inner surface of the well. This consists of a maze of very fine cracks which decreases the life of the tube Release of foreign gas from the glass rises the voltage at which the discharge occurs and leads to estatic triggering. This effect determines the maximum value of power which can be supplied to a particular type of flash tube to ensure constancy of output and nessonable life. Flash tubes of high power ratings are made of quants and are cooled with a forced light power ratings are made of quants and are cooled with a forced

The efficiency of conversion of electrical energy to radiation is remarkably high in stroboscope lamps operated in properly designed circuits. With low circuit resistance and neglipible inductance 90% of the energy stored in the condenser can be converted into energy of ionization and excitation of the gas. Both short wave length and long wave length addiations are trapped within the glass envelope. The amount of ultra-violet and of infrared radiation transmitted depends upon the material used in the tube walls

A large portion of the light is in the blue and near ultra-violet spectral regions and while this is very effective for photographic purposes it can cause severe injury to the retina of the eye. Workers subjected to prologost preptitive flashing of these sources developed eye strain and migraine headcates even when protected by goggles. Special protective devices must be provided to minimize the harmful effects produced by intense radiations from high power flash bulbs.

BRILDORAFIY.—J. F. Crowley, "Intermittent Illumination in Industry," The Illuminating Engineer, pp. 189–117. (Aug.—Spt.), 1923); H. E. Edgerton and K. J. Germésbausen, "The Stroboscope and High-Boyel Molion Future Channes as Research, Entimements Am Binder Company of the Comp

man and W. H. Walhau, "In-expensive Stochoscope for High Speed Photography," Review of Scientific Institute 14, 1273—275, (1983), G. Wandted, "Schobscope Equipment," Beginnering, vol. 125, no. 6, pp. 462-462 (1943), R. C. Patne, "Simple Strobescope for Moving Manager," Electionis, vol. 17, no. 13, pp. 154-160, (1944), R. W. Walder, "Strobescope," Journal of Scientific Institute (1944), Ph. S. Walder, "Strobescope," Journal of Scientific Institute Institute 13, 13-13 (1941), A. E. Clawford, "Electronic Strobescope," Aircraft Production, 1941, A. E. E. Patron, 1941, P. Power Englisher, 1941, 37-124 (1942), The Charlett Production, 1941, 1942, 1942, 1942, 1943, 1944,

STRODE, RALPH (h. 150-1400). English schoolman, was probably a native of the West Midands. He was a fellow of Merton college, Oxford, before 1366, and famous as a teacher of logic and philosophy and a writer on educational subjects. He belonged, like Thomas Aquinas and Bonaventura, to that "School of the Middle" which mediated between realists and nominalists Besides his Logica, which has not survived, he wote Consequenties, a treatse on the syllogism, and Objectiones or Scholastica militia, a series of "Formal exercises in scholastic diaectics."

He had some not unfriendly controversy with his colleague John Wychffe, against whom he defended the possession of wealth by the clergy, and whose doctrine of predestination he attacked. Strode is also associated with John Gower in Chaucer's dedication of Troyluss and Cryseyde, and Strode himself, according to the 15th-century Vetus catalogus of fellow of Merton, was a "poeta nobilis"

John Leland and John Bale confirmed this testimony, and L Gollancz suggested the identification of the Phaniasma Radulphi attributed to Strode in the Venus catalogus with the beautiful 14th-century elegiac poem The Pearl. If this be true, Strode wrote also Cleamess, Patence, and Sir Gawayne and the Green Kmight. From 1375 to 1385 this Strode or another of the same name was common sergeant of the city of London; he died in 1387.

STRODE, WILLIAM (1598-1645), English parliamentarian, second son of Sik William Stoode, of Newham, Devenshire (a member of an ancient family long established in that county, which became extinct in 1897). He was admitted as a student of the Inner Temple in 1614, matriculated at Exeter college, Oxford, in 1617, and took the degree of bachelor of arts in 1619. He was returned to parliament in 1624 for Beeralston and represented the borough in all succeeding parliaments until his death. He from the first threw himself into opposition to Charles I and took a leading part in the scene of March 2, 1629, when the Speaker, Sir John Finch, was held down in the chair. (See HOLLES, DENZH HOLLES.)

Proscuted before the Star Chamber, he refused "to answer anything done in the House of Parliament but in that House." On May 7, a fresh warrant was issued, and a month later, to prevent his release on bail, he was sent by Charles with two of his fellow members to the Tower. Refusing to give a bond for his good behaviour, he was sentenced to imprisonment during the king pleasure, and was kept in confinement in various prisons for II years.

In Jan. 1640, in accordance with the king's new policy of moderation, be was bherated; and on April 13, took his seat in the Short Parhament, with a mind embittered by the sense of his wrongs. In the Long Parliament, which met on Nov. 3, 1640, he was the first to propose the control by parliament over ministerial appointments, the militia and its own duration; supported the Grand Remonstrance of Nov. 7, 1641; and displayed a violent

zeal in pursuing the prosecution of Strafford actually proposing that all who appeared as the prisoner's counse! should be "charged as conspitators in the same treason" He was included among the five members impeached by Chailes of high treason on Jan 3, 1642 He opposed all suggestions of compromise with Charles, urged on the preparations for war, and on Oct 23, was present at the battle of Edgehill In the prosecution of Laud he showed the same relentless zeal as he had in that of Strafford, and it was he who, on Nov 28, 1644, carried up the message from the commons to the lords, desiring them to hasten on the ordinance for the archbishop's execution Strode did not long survive his victim He is mentioned as having been elected a member of the assem-

order of parliament was accorded a public funeral in Westminster abbey The body was exhumed after the Restoration Clarendon speaks of Strode as a man "of low account and esteem" who gained his reputation by his accidental association with those greater than himself, but to his own party his "insuperable constancie" gave him a title to rank with those who had deserved best of their country at a time when the liberties of England hung in the balance

bly of divines on Jan 31, 1645 He died Sept 9, 1645, and by

STROMNESS, a small burgh and fishing port on the island of Mainland (Pomona), county of Orkney, Scotland Pop (1951) 1,503 Area 712 ac It is situated on the west side of a wellsheltered bay opening off Hoy sound. Many of the houses are within tidal limits and are furnished with quays and jetties. The harbour admits vessels of all sizes There is an egg-packing station, and eggs are exported to the Scottish mainland. The neighbourhood suffered much damage from the great storm of Jan 1953

Stromness is a centre for visiting the magnificent scenery of the west coast of Mainland, including Black craig (400 ft ) and the Hole of Row, a natural arch carved out by the ocean At the southern edge of the bay of Skaill lies the prehistoric village of Skara Brae (q v)

STRONG, LEONARD ALFRED GEORGE (1896-

), British author and journalist, was born March 8, 1896, at Plympton, Devon, and received his education at Brighton college and at Wadham college, Oxford, where he was awarded his bachelor's degree in 1920 His first work was in verse (Dublin Days, The Lowery Road, Difficult Love) and showed the influence of William Butler Yeats His first novel was Dewer Rides (1929), a story laid in Dartmoor; later books included The Jealous Ghost (1930), The Garden (1931), The Open Sky (1939), Travellers (1945) and Trevannion (1948) Strong published several collections of short stories and also stories for children His critical works include Sacred River, An Approach to James Joyce (1951) For 12 years he taught English and classics at Summer Fields,

Oxford In 1938 he became a director of a publishing house STRONG ROOMS: see SAFES, STRONG ROOMS AND VAULTS STRONGYLION, a Greek sculptor His bronze figure of a horse, representing the wooden horse of Troy with the Greek heroes inside and looking forth, was set up on the Acropolis of Athens late in the 5th century B.C. Other works of Strongylion were a figure of Artemis at Megara, a group of the Muses, and an Amazon which was greatly admired by the emperor Nero.

STRONTIANITE, a mineral consisting of strontium carbonate SrCO3. It takes its name from Strontian in Argyllshire, where it appears to have been known as far back as 1764, but it was not recognized as a distinct mineral until later, when the examination of it led to the discovery of the element strontium. It crystallizes in the orthorhombic system and is isomorphous with aragonite and witherite. Distinctly developed crystals are, however, of rare occurrence; they are usually acicular with acute pyramid planes and are repeatedly twinned on the prism. Radiating, fibrous or granular aggregates are more common. The colour is white, pale green or yellowish brown. The hardness is 3.5 and the specific gravity 3.7. The mineral occurs in metalliferous veins in the lead mines of Strontian in Argyllshire, abundantly in veins in calcareous marl near Münster and Hamm in Westphalia, in limestone near Barstow, San Bernardino county, California, and in geodes at Schoharie, N.Y.

It is used for producing red fire in pyrotechny and for refining

(CLF.X)

STRONTIUM, a metallic element (symbol Sr. atomic weight 87 63, atomic number 38), belonging to the alkaline earth family of elements in group two of the periodic table. It composes about 00010% of the igneous rocks and about 02% of the entire crust of the earth It is distributed in small quantities in many different rocks and soils Its principal sources are strontianite, SrCO3, and celestite, SrSO;

William Cruikshank, in 1787, first detected the existence of the element in the strontianite found at Strontian in Argyllshire The metal was isolated in 1808 by Sir Humphry Davy, who electrolyzed a mixture of the moist hydroxide or chloride with mercuric oxide, using a mercury cathode. It was obtained in a state of purity by A Guntz and Roedeser by heating the hydride in a vacuum to 1.000° C It may be obtained in the form of sticks by the "contact cathode" method, in which a cooled iron rod, acting as a cathode, just touches the surface of a fused mixture of potassium and strontium chlorides and is raised as the strontium collects on it Because calcium and barium, which it resembles closely, occur in much greater abundance, strontrum is not produced in commercially important quantities and has no uses,

There are four isotopes of the element, their mass numbers, in the order of abundance, are 88, 86, 87 and 84 Artificial radioactive isotopes with mass numbers 85, 87 and 89 have been prepared The distribution of electrons in the levels and sublevels of the strontium atom 15 1 s2, 2 s2, 2 p6, 3 v2, 3 p6, 3 d10, 4 s2, 4 p6, 5 s2

Properties.-Strontium, as usually produced by electrolysis, is a soft, slightly yellow metal which greatly resembles calcium The pure metal has a silvery white colour. It is malleable and ductile and acts as a good conductor of electricity Other physical properties are listed below.

Atomic radius

2 14 A. 1 13 A. Ionic radius Ionization potential (gaseous element) 1st electron 561 v. and electron 10 08 W Single electrode potential (between metal and molal solution of Si \*\*ion) 2 80 V 757±1° C. Melting point Boiling point Density 26 g per cubic centimetre

The chemical properties of strontium are similar to those of calcium and barium, in keeping with its position in the periodic table, where it is above barium and below calcium. Generally speaking, its base-forming characteristics are somewhat less pronounced than those of barrum but more pronounced than those of calcium. In its compounds, the element has a valence number of +2. As indicated by its atomic radius, ionization potential and single electrode potential, the atom of strontium easily loses the two electrons in the 5 s level when it reacts with nonmetallic elements, thus forming the Si\*ton The element is an active re-It reacts readily with water to form hydrogen and the hydroxide, Sr(OH). It ouddzes rapidly when exposed to the air and buins brilliantly when heated in air, oxygen, tholonie, the vapour of bionaine or the vapour of sulphur With oxygen, the element forms biomine or the vapour of sulphur With the monoxide, SrO, and the peroxide, SiO

Compounds.—Compounds of strontium are not so extensively used as those of calcium or barum The solubilities of the salts of the ment, generally speaking, are intermediate with respect to the

solubilities of the corresponding salts of calcium and basium.

The hydride, SrH<sub>2</sub>, obtained by Guntz on heating strontium amalgam in a current of hydrogen, is a white solid, which readily decomposes water in the cold and behaves as a strong reducing agent The monoxide or strontia, SrO, is formed by strongly heating the mirate, or commercially from the hydroxide which is produced by heating the sulphide or carbonate in superheated steam (at about 500-60° C) It is a white powder which resembles lime in its general character By heating the powder in the electric furnace, H. Monssan succeeded in obtaining crystals of the oxide. The compound readily slakes with water, and the aqueous solution yields a crystalline hydrated hydroxide It is used in the extraction of sugar from molasses, since it combines with the sugar to form a soluble saccharate, which is removed and then decomposed by carbon dioxide. A hydrated peroxide, approximating in composition to SrO<sub>2</sub>.8H<sub>2</sub>O<sub>3</sub> is formed as a crystalline precipitate when alkah is added to an aqueous solution of a strontum salt containing hydrogen peroxide. If all the solutions are above 50° C, and concentrated, the anhydrous peroxide results, Strontum fluoride, StF.3 is obtained by the action of hydrofluoric acid on the carbonate, or by the addition of potassium fluoride to strontum chloride solution Strontum chloride, StCl, 6H.0, is obtained by dissolving the carbonate in hydrochloric acid or, commercially, by fusing the carbonate with calcium chloride and extracting the melt with water. It crystallizes in small colourless needles and is easily with water II Cybaillacks in Stalla colouries needles and is easily solible in water, the concentrated aqueous solution dissolves bromme and nodme readily By concentrating the aqueous solution between go -130°C to by passing hydrogen chloride into a saturated aqueous solution, a scond hydrated form of composition, SiCl; 2H,O, corresponding with dihydrated barrium and iadmin chlorides, is obtained The anhydrous chloride is formed by heating the hydrated chloride in

a current of hydrogen chloride

Strontism valbhide, StS. is formed when the carbonate is heated to Strontum sulphule, SiS, is formed when the cathonate is heated to tedness in a stream of hydrogen sulphule. It phosphoresces slightly when pure Strontum sulphule, SrSO., found in the mineral kingdom as celestite, is formed when sulphurie and or a soluble sulphule is added to a solution of a strontum salt. It is a colourless solid, which temperature, it is appreciably soluble in concentrated sulphuric acid
When boiled with alkaline carbonates, it is converted into strontum

carbonate

carbonate nutrade, Sr.Nn, is formed when strontium amalgam is heated to redness in a stream of introgen or by igniting the oxide with magnesium. It is readily decomposed by water, with hieration of ammonia Strontium nutrate, Sr(NOIn), is obtained by dissolving the acrbonate in disulte intin each if reystallizes from water (in which it is soluble) in monoclinic prisms which approximate in composition to  $Sr(NO_d)_3 4H_2O$  It is used in pyrotechny for the manutacture of red

Strontium carbide, SrCe, is obtained by heating strontium carbonate with carbon in the electric furnace II resembles calcium carbide, decomposing rapidly with water, giving acetylene Strontium carbonate, SrCO<sub>3</sub>, found in the mineral kingdom as strontianite, is formed when a

STCOs, found in the mineral kingdom as strontaints, is formed when a solution of a carbon dioxide when nested above constraints and the strong carbon dioxide when nested above constraints are solved to the strong carbon dioxide when nested above constraints are solved to the strong carbon dioxide when the strong carbon dioxide s

In the usual schemes of analysis, strontium is separated, along with In the usual scenes of analysis, stomatin is separated, adong war-calcium, barium, magnesum and the alkah metals, by making use of the fact that none of these ions is precipitated by sulphide ion in either an acidic or an alkaline solution. After the precipitation of all other positive ions by the sulphide ion, calcium, strontium and barium are precipitated as carbonates in the presence of ammonium ion precipitated as Carbonates in the presence of amountain or precipitate is then dissolved in acetic acid, and, in the usual procedure, barium is then separated by precipitation as the chromate, leaving

barum is then separated by precipitation as the chromasi, leaving structure and calcium ions in solution Strontium non can then be separated from calcium by the addition of a dilute solution of sulphate ion which, because of the considerably greater solution of sulphate ion which, because of the considerably greater solution of sulphate ion which possible of the sulphate in the sulphate in the sulphate is supported by the sulphate in the sulphate in the sulphate is supported by the supported by the sulphate is supported by the supported by the sulphate is supported by the sulphate is supported by the sulphate is supported by the supported by the supported by the supported by the sulphate is supported by the supported b

don, 1943

STROPHANTHUS, a genus of plants of the family Apocynaceae, deriving its name from the long twisted threadlike segments of the corolla, which in one species attain a length of 12 to 14 m. The genus comprises about 28 species, mainly tropical African, extending into South Africa, with a few species in Asia, from eastern India to the Philippines and China. Several of the African species furnish the natives with the principal ingredient in their arrow poisons—S. hispidus and S. kombe being probably most frequently employed.

Both S hispidus and S. kombe have hairy seeds with a slender threadlike appendage, terminating in a feathery tuft of long silken hairs, the seeds of the former being coated with short appressed brown hairs and those of the latter with white hairs; but in the species used at Delagoa bay and called umtsuli the threadlike appendage of the seed is absent. The natives pound the seeds into an oily mass, which assumes a red colour, portions of this mass being smeared on the arrow immediately behind the barb.

Under the name of strophanti semma, the dried ripe seeds of Strophanthus, freed from awns, are official in the British and many other pharmacopeias. The seeds must be mature. They are about in long, in broad, greenish fawn, covered with flattened silky hairs and oval-acuminate in shape. They are almost odourless but have an intensely bitter taste. The chief constituent is a white microcrystalline glucoside, known as strophanthin, freely soluble

in water and alcohol, but not in chloroform or ether, and melting at about 173° C It constitutes about 50% of the mature cotyledons of the mature seed. The resin is contained in the husk and occurs in the alcoholic tincture of strophanthus

Pharmacology -The drug has no external actions Taken interritarinacology—The drug has no even a actions from the instance and in the repetition of large doses, to produce some gastric unitation. As ordinarily administered, the drug acts on the heart before influencing any other organ or tissue. It is almost certain that strophanthus acts directly on no other cardiac structure than the muscle fibre. No action can certainly be demonstrated either upon the vagus nerves or upon the intracarduc nervous ganglia. The muscular force is increased in a very marked degree. A secondary consequence of this is that the diastole is prolonged, and the pulse thus rendered less frequent. If the heart is beating irregularly the drug tends to make it. more regular. In fatal cases of strophanthus possoning death is brought about by the airest of the heart in systole, ie in a state of tetanic spasm from overstimulation. Strophanthus markedly ruses the blood pressure, but this action is almost entirely the result of the increased force of

STROPHE, a term in versification which properly means a tuin, as from one foot to another, or from one side of a chorus to the other (Gr στροφή, "a turn") Hence, the song of a chorus during one turn or figure of a dance, and thus a collection of various prosodical periods combined into a structural unit When the strophe is answered by another unit of identical scansion (called an antistrophe) and accompanied by a third of some-

what different structure (epode), the three form a period STROSSMAYER, JOSEPH GEORGE (JOSEP JURAJ STROSSMAJER) (1815-1905), Croatian bishop and politician, was born at Esseg in Croatia-Slavonia on Feb 4, 1815. He became lecturer on theology at Djakovo, chaplain to the Austrian emperor and director of the Augustinian body at Rome. In 1840 he was consecrated bishop of Djakovo, with the official title bishop of Bosnia, Slavonia and Sirmium. He fostered the growth of Slavonic nationalism in Croatia-Slavonia, in Dalmatia and among the Slovenes of south Austria, aiding the Ban Jellacic in his campaigns against Hungary (1848-49) and subsequently becoming a recognized leader of the opposition to Hungarian predominance. (See Croatia-Slavonia) Besides being foremost among the founders of the South Slavonic academy in 1867, and of Agram university in 1874, he helped to reorganize the whole educational system of Dalmatia and Croatia-Slavonia He built a palace and cathedral at Djakovo, founded a seminary for the Bosman Croats, presented the South Slavonic academy with a gallery of valuable pictures and published collections of national songs and tales. He also aided Augustin Theiner, then librarian at the Vatican, to compile his Vetera monumenta Slavorum meridionalium historiam illustrantia (Rome, 1863) Strossmayer died on April 10, 1905. He was a count of the Holy Roman empire and a bishop of the pontifical throne.

STROUD, a town in the Stroud and Thornbury parliamentary division of Gloucestershire, England, 9 mm. S. of Gloucester by road. Pop. of urban district (1951) 15,977. Area 4 4 sq.mi The town hes in the Stroudwater valley, at the junction of several deep narrow valleys, near the Cotswolds It is on the disused Thames-Severn canal and has long been a centre for cloth manufacture, particularly broadcloth, and dyeing, but many former woollen mills are now used for the manufacture of other goods, and engineering has become important. The Elizabethan town hall has been restored

STROUDSBURG, a borough of eastern Pennsylvania, U.S., the county seat of Monroe county; on Broadhead creek, opposite East Stroudsburg (q.v.). It is on federal highways 200 and 611 and is served by the Lackawanna and the Pennsylvania railways. Pop. (1950) 6,361; (1940) 6,186; (1930) 5,961; federal census Stroudsburg is a summer resort 3 mi. W. of the Delaware water gap and 15 mi. from the heart of the Pocono mountains. It has various manufacturing industries. A number of colonial houses still stand, notably the Jacob Stroud mansion (1760) which served as a refuge at the time of the Wyoming massacre. The borough was laid out in 1806.

STROZZI, the name of an ancient and noble Florentine family, which was already famous in the 14th century. Palla Strozzi (1372-1462) founded the first public library in Florence in the monastery of Santa Trinita. Filippo Strozzi il Vecchio

(1436-1491), son of Mattee and of Alessandra Macnigh, began to build the beutiful Strozei place in Florence Another Flippo Stroze. (1488-1538), who, although marued to a Medict, opposed the hegemony of that house and was one of the leaders of the rising of 1527. On the final overthrow of the republic in 1530 Alessandro de' Medica attempted to win over Flippo Stroze, but Strozei had no faith in the tyrant and retired to Vennec After the murder of Alessandro he undertook the leadership of a band of republican eciles with the object of re-entering the city (1537), but third packed feated and captured and put to the torture, he committed succide. His son Leone (1515-1524) was a distinguished admiral in the service of Pracea and fought against a distinguished admiral in the service of Pracea and fought against The Strozei palace, which belonged to the family until 1907, was becouched for will to the Italian nation.

See A Bardi, Filippo Strozzi (Florence, 1894), B Niccolmi, Filippo Strozzi (Florence), C Guasti, Le Carte Strozziane (Florence, 1884-91)

STRUCTURAL DRAWING: see Drawing, Engineering

STRUCTURAL ENGINEERING. The term structural engineering came nto accepted use in the United States duming the 19th century, in relation to the particular branch of evil engineering which was concerned with bridge building A ta later date the term came to be used more frequently in connection with the great development of steel-framed and reinforced concrete buildings in that country, and it is mainly in this connection that the term has been accepted and used throughout the world

From the brief survey in this article of the development of structural practice, it will be seen that the most fundamental change has not been in the use of mild steel, or, in fact, in the use of any relatively new material, but in the intelligent application in the design of structures of a rapidly extending knowledge good of mechanics and of the scientific use of construction materials. Hence there is a general tendency to give a wider significance to the term structural engineering and to set no arbitrary limits either to the materials employed or to the nature of the structures in which they are embodied.

Structural engineering embraces the design and construction of all those vital structural parts of buildings, and other substantial erections, in which a knowledge of the strength and nature of the materials used and of the relevant principles of the science of mechanics are the controlling factors. See also the articles on Accurractural and Burness.

Early Development of Structural Practice .-- While the more modern developments of structural engineering have been largely coincident with and dependent upon parallel developments in the production and use of iron, steel and Portland cement, the development of the science of mechanics and of the theory of elasticity have occupied a much longer period of time. Until the middle of the 18th century constructional practice of all kinds had been chiefly governed by the common traditions accepted in the various crafts. This practice was subject to the losses, faults and checks to which knowledge so acquired and held is peculiarly hable. The high state of development of the science of stereotomy or jointing of stone work should, however, be noted, particularly as applying to stone arches, vaults and domes. It arose out of the construction needs of the great cathedrals of the middle ages, The great era of bridge building, which may be said to have been initiated by the erection of the second bridge over the Thames at London by the French engineer Labelye in 1749, and by the successful completion of William Edwards' third bridge at Pontypridd in 1755, continued for the remainder of that century, and may be credited with the establishment of a new era in constructive ability and knowledge. At later dates notable bridges were erected by Robert Mylne, Thomas Telford and John Rennie, which carried this aspect of structural design to an advanced stage

Use of Cast Iron.—In England in 1755, the use of cast iron in construction had been advocated by John Smeaton, and by the end of the century much experience had been acquired in the production of a uniform and reliable material and in the possibilities of its use in buildings. "The most striking use of the metal probably occurred in the construction of arched bridges, where cast-iron voussoirs were employed in the place of stone: the first bridge of

this kind was completed at Coalbrookdale in 1776 (Much conidence was shown in this type of bridge construction and Renne prepared designs for a cast-iron bridge of 450 ft. span over the Menia straits) At a still later date the cast-iron units were made in longer sections and botted together, so that they were called upon to resist tensile forces and the sections of the ribs approximated to cast-iron beams of curved outline

Meanwhile, the use of cast-iron in the construction of factory buildings in the north of England was developed, first in columns to support timber beams, and later in the substitution of cast-iron beams for timber. At the commencement of the right century, a building was designed by Boulton and Watt and crected in Man-chester, in which cast-iron beams were supported on cast-iron columns, while the floors consisted of brick arches supported on be bottom flanges of the beams and brought to a level surface by rough concrete Buildings of this type were erected with little change for a long period. The principles underlying this form of construction were at first little understood, but such men as 5 in constitution which is the constitution of the constitution

Use of Wrought Iron and Steel.—The great improvements in the manufacture of wrought iron, which followed upon the introduction and development of the pudding furnace and the rolling mill by Henry Cort toward the end of the 18th century, let to its increased use in construction, while the investigations into the strength of acti-tron referred to above probably stimulated the more effective use of wrought iron, the nature of which approximated more closely to the ideal elastic material conceived by the mathematicians and physicists. Only the simplest sections were rolled in the solid, beams.

were rotted in the sount, beams.
In 1847 Ferdmand Zores produced a small rolled joist or I-section, the form being decided upon after consultation with French ton, the form being decided upon after consultation with French ton, the state of the sound to the sound at the Fars exhibition in 1854 and the sarry small rolled joint were largely used in France as the basis of fire-resisting floor construction, but while they were obviously of value in other forms of construction, the I-section came very slowly into general use The first steel-joint section to be produced in England was rolled by Dorman and Long in 1855. The Harper building in New York city built in 1854 was the first one to have wrought-iron beams set in masonry walls as lateral supports.

Cheap and reliable mild steel became available through the introduction of the Bessemer and Siemens-Martin processes of production but prejudice and early difficulties in manufacture delayed its use. As late as 1877 in England board of trade regulations prohibited the use of mild steel in bridge constitution. In the construction of the Forth bridge (1880-90) mild steel was, however, employed and the success of this venture constitutes a remarkable tribute to the skill of the structural engineers at that date and a testimony to the fitness and rehability of this material for bridge work and general constructional use. The extended use of steel for structural purposes was assisted and guided by the introduction of standard forms and dimensions, and by uniform specifications The American Society of Civil Engineers, founded in 1852, in co-operation with the steel manufacturers contributed immensely to the development of standard formulas. In 1894 the Carnegie-Phipps company of Pittsburgh, Pa, published a handbook of standard shapes with information and formulas as to their structural properties. These remained standard for years and were basic for many subsequent handbooks published American cities, where skyscraper construction started, building laws were passed giving effect to the conclusions of these early developments. In England specifications were issued by the British Engineering Standards association (formed in 1904), and the passing of the London County Council (General Powers) Act of 1909, provided the first authoritative regulations for the control of the design of steel-framed buildings

Development of Framed Construction.—In the construction of various kinds of framed structures iron was being used to

a considerable extent by the middle of the 19th century, thus the ings on city sites were rapidly recognized both by the land-owner technique of this form of construction was being steadily developed In some of the larger structures pin joints were used, but these were gradually discarded in England and the simpler riveted joint adopted. Of this latter type of construction Tuelier's lattice girder bridge (1868) consisting of 300 ft. spans over the Mersey at Runcorn is a good example

At a somewhat earlier period, similar developments in framed construction were taking place in America, where road bridges were being erected to meet a great demand. The majority of these were constructed in timber alone, or in timber and iron, but the well known forms of Howe truss (1830) and Pratt truss (1844) which were developed in this connection represented substantial progress in the design of framed structures. At a later date, the development of the wire rope by Robling, applied in the construction of the great suspension bridge at Brooklyn, indirectly influenced the introduction and perfection of the lift or elevator, which became, and is now, so vital an equipment of all tall build-

While a considerable amount of iron was used in the construction of buildings until well into the latter half of the 19th century, the construction of normal types was based on the assumption that the walls constituted the chief supports for transmitting structural loads to the foundation; also, since the thicknesses of these walls were regulated by building by-laws-which were based upon tradition and custom rather than upon scientific conclusion-the height to which buildings could be economically carried was limited, owing to the thick walls necessary to conform with the bylaws Moreover high building possessed no great advantage without lifts The first passenger elevator equipped with automatic safety devices was installed in 1856 by Elisha G Otis in a New York store In this the hoist tope was wound and unwound from a steam-driven drum to raise and lower the car

The Crystal Palace buildings, erected by Paxton for the 1851 Exhibition in Hyde Park, were not usually claimed as one of the early examples of iron-framed buildings, yet the structure was remarkable in having foreshadowed and established a principle adopted in the modern steel building, in which the walls do not transmit any important portion of the structural load to the foundation. It was, however, the developments which took place in America at a later date which were to influence most markedly the progress of this form of construction throughout the world In the year 1883, during a period of unusual building activity in Chicago and following an extensive fire in that city, W. L. B Jenney designed a building of 10 storeys that is the forerunner of all high buildings. Afterwards two storeys were added, making the building 12 storeys, proving the soundness of the original calculations This building, the Home Insurance building, is the first of all skyscrapers It was finished in x885. While it is true that L. S. Buffington, a young architect in Minneapolis, had thought of steel skeleton structures as early as 1880, it remained for Mr. Jenney to put the problem to practical test There is, however, some controversy regarding who should get credit for the first skeleton construction building

Skeleton Construction.-The Home Insurance building was designed with relatively thin outer walls, the dead load of which is placed on a framework of iron concealed inside the masonry and used to transmit the weight to the foundation. The framework was made of cast fron columns, and wrought fron I-beams, the beams being bolted to the columns with angle iron brackets. At the suggestion of the Carnegie-Phipps Steel company, rolled Bessemer steel beams, then being first produced, were used above the fifth floor. Cast-iron columns were used to the top since plates and angles of steel, of which the later steel columns were built up, had not yet been rolled. The term skeleton construction was later applied to all buildings of this type. Besides the development of the steel framework, the elevators, the use of Portland cement, another factor of great importance in the creating of skyscrapers was the invention of hollow tile in 1871 by Balthaser Kreisher, which solved both the dead-weight and the fire protection problem.

The advantages to be derived from the erection of high build-

and the building-owner; site values were enormously increased and much greater accommodation became available on a restricted area The adoption of skeleton construction also led to speedier erection, since, on the completion of the steel framing, the building of walls and the construction of the floors could proceed

simultaneously on several floor levels As confidence in the type of building increased, higher and yet higher structures were erected, and since most of them were relatively slender and were frequently built on sites that afforded poor foundations, the use of piles and of the caisson-already adopted by the bridge builder to ensure sound foundations-increased and developed Improved practice in the construction of foundations became fundamentally important in the further growth of this type of building, and many ingenious and effective developments occurred, including combined foundations for two or more columns, and also cantilevered foundations, by means of which the actual foundation construction for the external or boundary columns could be kept within the limits of the site. (See article on FOUNDATIONS )

Protection from Fire.-Early experience showed the very complete destruction by fire of iron and steel buildings in which the distortion of the framework, under the effects of excessive heat, resulted in the collapse of the metal framework and walls The importance of fire protection is now generally recognized and the vital parts of steel buildings are required to be protected by terra-cotta, hollow tile, cement concrete or other fire-resisting materials In America a definite limit of height is generally set by the building regulations for the control of non-fireproof buildings, but if adequate and ample fire-protection of the structural fabric is provided in the permanent construction, no arbitrary limit is set to the height in some American cities; in others there are height limitations It is necessary, however, to provide, for all high buildings efficient warning, fire-checking and fire-fighting equipment, such as stand-pipes and extinguishers, especially at heights beyond the scope of the local fire-fighting equipment. The work of the various Fire Assurance companies and, more recently, the effective research and investigations of the National Board of Fire Underwriters, has influenced fire-protection, assisted in the improvements of constructional methods, and helped to render these improvements rapidly effective. In Great Britain, structural practice and consequent building developments have been somewhat different from those of America Very high buildings have not been favoured for a variety of seasons which are referred to elsewhere in this article One of the arguments that was used in the past against high buildings was the difficulty of dealing with fires at great heights Experience in America, however, has proved that adequate provisions can be made to meet such emergencies.

Wind Pressure,-There are obvious dangers associated with tall structures, which arise chiefly from the effects of wind pressure upon the exposed elevated faces Stability of the structures as a whole is now generally obtained by a combination in the building of rigidity and weight. While the steel frame in itself is sufficiently rigid to reduce distortion under wind pressure to a negligible amount, in all calculations the rigidity of the walls is taken into consideration, as it is a considerable factor in resisting distortion. The necessity for maintaining a rigid form of frame which would resist distortion under side pressure has led to the development of the braced structure and of the structure with rigid connections. Both these types demand of the designer a knowledge of the most advanced sections of mechanics and structural engineering. Much experimental research upon problems associated with tall structures has been carried out in the universities of America and by American engineers, from which satisfactory bases of design have been developed or theories verified. The progress of framed construction in tall buildings has enabled such a high degree of achievement to be reached. that careful experiments upon one of the tallest buildings recently erected in America have fully demonstrated that, even in the strongest gales, the little vibration that occurs is of no consequence in such structures.

Electric welding, to replace riveting, is still in the experimental

is provided by the riveted structure, two objects are being sought. the elimination of noise and the saving in steel that would result from not needing such heavy angles at the connections

Corrosion .- During the later development of skeleton construction considerable attention was given to the dangers which might ause from the corrosion of important parts of these steel structures In the earlier days of steel construction applied to buildings, insufficient care was given to the protection of hidden and maccessible parts, and connections and members were often so designed and fabricated that protection was difficult to apply A few failures have occurred owing to corrosion, but the recent demolition of some of the earliest tall buildings in America has demonstrated that, with reasonable care, the life of the ordinary type of steel-framed building may be practically indefinite if the work is properly done. At the same time the investigation has led to the recognition of the value of concrete as a suitable and effective encasing material for the protection of steel Reliable and durable protective paints have been produced and are now in wide use for the treatment of steel framework to be enclosed in masonry They should be freely applied in at least two coats to all parts where actual encasing in solid concrete is not specified Some hopes are entertained that a solution of the problem of corrosion will be found in the production of non-corrosive steel. having the necessary structural properties and yet economical in

Building Regulations,-The extent to which the adoption of suitable building regulations has assisted in the development of efficient and economical methods of construction has varied in different countries. In Great Britain, the type of local by-law which has generally been in force has lagged seriously behind the best accepted modern practice and has often acted as a deterrent to such development. In relation to the construction of walls the regulations have had a restrictive effect since they have compelled the erection of exceptionally thick walls. In relation to other parts of buildings such as roofs, floors and columns these by-laws are usually madequate and arbitrary and, while they may be of a character to prevent the erection of unsafe structures, they have not tended to encourage the adoption of better forms of construction

The first and the most outstanding regulations to govern steel building construction in Great Britain were embodied in the London County Council (General Powers) Act of 1909, and are usually referred to as the L.C.C. Regulations for Steel-Framed Buildings. These regulations, while containing some peculiar features and restrictions, had a marked effect upon the development of this form of construction and there has since been a steady increase in the number of buildings erected in accordance with them At present, practically all large buildings erected in London, apart from reinforced concrete structures, are designed and erected as steel-framed buildings.

In consequence of the manner in which the L.C C. regulations were framed, they applied only to new buildings in which the main structure was to be of steel, while buildings in which steel was combined structurally with other materials were still subject to the older regulations. This lack of co-ordination has tended to discourage forms of composite construction which, for smaller buildings would often have produced more economical results. Under the London County Council (General Powers) Act 1926 eftorts are being made to remove these and other anomalies.

In the United States a much closer relation has been established between regulation's and practice, and many thorough revisions of local building codes, particularly in their effect on steel construction, have been undertaken during the last twenty years in American cities. The general methods of procedure and supervision adopted by authorities in the United States are more elastic in practice than in Great Britain, so that the regulations do not tend so much to discourage the best available methods offered by the engineers and contractors; the system in vogue is indeed equivalent to a continual revision of the regulations, thus encouraging constant progress and improvement,

In this connection the investigations carried out by the Bureau

state While no additional strength or rigidity is necessary than of Standards in Washington, D.C., and by various professional bodies have proved most valuable, the results of such investigations-conducted under practical and exhaustive conditions-being incorporated in the various building codes when approved and accepted by the responsible and representative professional institutions

Reinforced Concrete,-The adoption and development of construction in reinforced concrete has followed the lines common to steel work, since the theoretical basis is almost identical, and the production of suitable specifications and regulations has been the product of similar efforts. Reinforced concrete buildings are usually of the framed type of construction, consisting of pillars and beams, as in steel work, but with the wall and floor panels continuous between columns and beams, so that the concrete enclosing the reinforcing steel is continuous and the structure is monolithic in character. All the intersections of beams and columns are thus rigid connections and the rigidity of such structures is one of their main features. In recent years the study of elasticity has been closely followed in its application to reinforced work, where the straining of one member is definitely communicated through the rigid continuation to the adjoining members Hence the designer of reinforced concrete must have an unusually thorough structural training if he is to comprehend and provide successfully for all the variations of stress to which a reinforced structure is subject. The development of the theory of indeterminate structures involving rigid connections has been a natural consequence A later type of construction dispenses with beams and uses slabs and mushroom-headed piliars.

Reinforced concrete reached an established position as a constructional method in England when a joint committee, under the auspices of the Royal Institute of British Architects, considered and reported on the subject, first in 1907 and later in 1911. The report gave advice and guidance upon this form of construction in the absence of local regulations. As early as 1900 American engineers had developed the technique of reinforced concrete to a high degree

In 1915 the London County Council, using the authority vested in them under the clauses of the L.C C (General Powers) Act 1909, made regulations for the control of buildings erected in reinforced concrete While, in view of later developments and scientific investigation, these regulations are seen to be faulty, they were accepted at the time as a real help to the architect. builder and engineer, because at that time there was little general recognition of the more intricate problems involved in its use. The regulations include data for the practical design of beams, slabs, columns, foundations and walls, and a specification of materials and minimum strengths under test. These regulations now are in need of revision, because of the great advance in knowledge concerning this work. In the United States various changes have been made in the early rules with the result that more adequate requirements are in force

Owing to the experience gained in actual design and construction and to the greatly extended investigations which have been conducted into the properties of this new material, reinforced concrete appears not only low in maintenance cost, but is of satisfactory permanence. In addition it possesses fire-resisting qualities. Contradictory data, however, indicate that more knowledge of the action of concrete under various conditions is necessary before definite conclusions can be drawn. Owing mainly, perhaps, to the severely classical character of the normal architectural training, concrete cannot be said to have attained the same pre-eminence as a material for architectural expression as it has in construction However, some interesting, though perhaps exceptional, schemes have been produced by the so-called "modernist" architects and structural designers. (See also Con-CRETE and FERRO-CONCRETE.)

Structural Engineer and Architect.-It is recognized that structural engineering developed in its initial stages as a specialized branch of civil engineering, and its most prominent developments took place in connection with those pioneering ventures of mankind in the furtherance of which the skill and ability of the civil engineer is of paramount importance. Later developments, however, especially in countries where industrial and commercial carried out on April 28, Brandt suffering first conditions are now more stable, have resulted in establishing conditions in which the work of the structural engineer is, in nature and quality, much more closely related to that of the architect It follows, therefore, that as a knowledge of the theory and practice of structural engineering becomes more established and widespread, it will become more difficult to distinguish clearly between the work of the architect and that of the structural engineer in regard to the design and construction of tall fireproof buildings

There are at present, in all countries, numbers of architects who have prepared themselves to undertake responsibility both for architectural design and structural engineering in relation to all the forms of building in which they practise, the combination being most frequently found in continental countries. In Great Britain, where the private architectural practice still predominates. the employment of a structural engineer as a consultant, or as a specialist, appears to be the normal procedure. In view of the general recognition of the advantages of specialization, and of the difficulties inherent in scientific construction, there is little doubt that the structural specialist will remain a distinct and important person among those who are responsible for the design of future huldings

Building Skyscrapers in the United States.-The great demand for tall buildings that started at the end of the last century produced a new form of organization to handle their construction In the past the work was done on a divided contract where work was parcelled out to various contractors who worked under the supervision of the architect who had designed the Then, due to the magnitude and complication of the building work and the overburdening of the architect, the general contractor appeared, who was prepared to undertake the building of a skyscraper under a general contract in which he agreed to deliver the completed building on a given date. The contractor became a promoter, a financier, a buyer of materials, a large employer of labour, and principally an organizer who could combine all building trades and functions under a centralized management. The architect usually, therefore, became responsible only for architectural and structural design.

(F E D , J L. M.; W. A St.) See Col W A Starrett, Skyscrapers (1928)

STRUENSEE, JOHAN FREDERICK, COUNT (1737-1772), Danish statesman, was born at Halle on Aug. 5. His father, subsequently superintendent general of Schleswig-Holstein, was a rigid pietist, but young Struensee, who settled down in the '60s as a doctor at Altona, revolted against his father's narrow creed and became a fanatical propagandist of the doctrines of the encyclopaedists. In 1768 he became court physican to Christian VII and rapidly gained authority in affaus.

For a time Struensee kept himself discreetly in the background, but he soon grew impatient of his puppets He dismissed the heads of departments, and abolished the Norwegian stadholderships. Henceforth the cabinet, with himself as its motive power, was to be the one supreme authority in the state. He then began to reform the administration and the law without regard to national customs and predilections Between March 29, 1771, and Jan 16, 1772-the ten months during which he held absolute sway-he issued no fewer than 1,069 cabinet orders, or more than three a day. In order to be sure of obedience he dismissed wholesale without pension or compensation the staffs of all the public departments, substituting nominees of his own.

The general ill will against Struensee, which had been smouldering all through the autumn of 1771, led to a conspiracy against him, headed by Rantzau-Ascheburg and others, in the name of the queen-dowager Juliana Maria. On Jan. 17, 1772 Struensee, E. Brandt, the unhappy king's keeper, and Queen Caroline were ar-rested, and "the liberation of the king," who was driven round Copenhagen by his deliverers in a gold carriage, was received with universal rejoicing The interrogation of Struensee began on Feb. 20, and on Feb. 22 he confessed that he had been Queen Caroline's lover On April 25 he and Brandt were condemned first to lose their right hands and then to be beheaded; their bodies were afterward to be drawn and quartered. The sentences were

BIBLIOGRAPHY -Ehe Salomon Francois Reverdil, Struensee et la cour Biutiogariv.—Elis Salomon François Reverdil, Stransise et la cour de Copenhagur rojo-1772 (Prinz, 1838), kari Wittik, Straemez (Legiong, 1879), Peter Eliward Holm, Danmar-Norges Histori, vol. vol. Corolino-Afachilde et le Conte Straene (C Planis, 1887), Robert Nibbet Bam, Scaudanuva, cap xv (Cambridge, 1905), William Henry William, A Queen of Tears (London, 1944), Georg Fredench von Jensen-Tusch, Der Verichworung geger die Komgin Karoline Mathilde und die Geffen Struener und Brandt (Calping, 1854)

STRUTHERS, a village of Mahoning county, Ohio, USA on the Mahoning river, 5 mi SE of Youngstown; served by the Pennsylvania and the Pittsburgh and Lake Erie railways (1950) 11,941 and was 11,739 in 1940 Struthers is a residential and industrial suburb of Youngstown, with large steel and iron works and various other manufacturing plants

STRUTHIONID AE: see OSTRICH

STRUTT, JEDEDIAH (1726-1797), British inventor and manufacturer, was born at South Normanton, Derbyshire, on July 28, 1726 He was educated at a country school, with a view to becoming a farmer, but he showed mechanical aptitude and in 1740 was apprenticed to a wheelwright at Findern near Derby During the time he was serving his apprenticeship, he inherited the stock on a farm at Blackwell near South Normanton While he was occupying the farm, his brother-in-law, William Woollatt, brought to his notice the unsuccessful efforts to produce ribbed as well as plain goods on the stocking frame, and he invented Strutt's Derby 1ibbing machine

Patents were taken out by Strutt and Woollatt in 1758 and 1750. Strutt then started a factory with Woollatt at Derby, and in 1762 took in Samuel Need as a partner. In 1768 Richard Arkwright (q v ) consulted Need as to the possibilities of his cotton-spinning frame Strutt at once realized its value, and was able to solve one or two minor difficulties which had interrupted the smooth working of the new mechanism. The firm of Arkwright, Strutt and Need started their first cotton mill at Nottingham with horse power.

Later works were erected at Cromford and, about 1780, after Strutt dissolved the partnership with Arkwhight, he built himself the mills at Belper and Milford. Shortly before this Strutt had made the discovery, which revolutionized the manufacture of calico, that cotton could be used throughout in its making. To house the machinery for this new invention the first fireproof mill in England was built at Derby In order to be near his work, Strutt built, from his own designs, Milford house, near Belper, where he lived until 1795, when ill health compelled him to return to Derby. He died there on May 6, 1797.

His eldest son, William Strutt (1756-1830), designed the calico factory at Derby He studied the house-heating problem and invented the Belper stove. He also devised a self-acting spinning mule, which, however, was not a great success. He was a fellow of the Royal society.

William Strutt's son, EDWARD STRUTT (1801-1880), was for some time M.P. for Derby, and in 1856 was raised to the peerage with the title of Baron Belper of Belper His political views were greatly influenced by Jeremy Bentham and James and John Stuart Mill. In later life he was considered an authority on such subjects as education, free trade and law reform. Like his father, he also was a fellow of the Royal society

STRUVE, FRIEDRICH GEORG WILHELM (1793-1864), German astronomer, made a systematic survey of the whole available sky for the discovery and measurement of visual double stars. Born at Altona on April 15, 1793, he attended the University of Dorpat, and was appointed to a professorship of astronomy and mathematics in 1813. He was summoned by Emperor Nicholas I of Russia in 1835 to superintend the building of the Pulkowa observatory, near St Petersburg; he became its director in 1839. He died on November 23, 1864.

Struve was a highly skillful observer. The catalogue in which his results were published, Mensurae Micrometricae, is one of the classics of double star astronomy. (W. W. M)

STRYCHNINE, an alkaloid discovered in 1818 in St. Ignatius's beans (Strychnos Ignatii); it also occurs in other species of Strychnos; e.g., S. Nur vomica, S. colubrina, S. Ticuté, and is from 1680 till 1724. He died at Hackney on Dec 11, 1737. He generally accompanied by brucine (dimethoxy strychnine) Strychnine crystallizes from alcohol in colourless prisms, practically insoluble in water, and with difficulty soluble in the common organic solvents Its taste is exceptionally bitter. It has an alkalme reaction, and is a tertiary monacid base

In Medicine.-The British Pharmacopoesa includes Easton's Syrup, syrupus ferri phosphatis cum quinina et strychnina, and Strychninae hydrochloridum which is much more soluble than strychnine. From it is prepared hquor strychnmae hydrochlorida The United States Pharmacopoeta contains strychmnae sulphas.

As regards its physiological action, strychnine enters the blood as such, being freely absorbed from mucous surfaces or when given hypodermically In small doses it acts as a bitter, increasing the secretion of gastric ruice. The specific effects of the drug, however, are upon the central nervous system. It excites the motor areas of the spinal cord and increases their reflex irritability Small doses increase the sensibility of touch, sight and hearing; large doses cause twitching of the muscles and difficulty in swallowing; while in overdoses violent convulsions are produced. The cerebral convolutions remain unaffected, but the important centres of the medulla oblongata are stimulated. Not only is the respiratory centre stimulated but the vasomotor centre is acted upon both directly by the drug and indirectly by the convulsion and asphyxia. Ordinary doses have no effect upon the temperature but in overdose the temperature rises during a convulsion. Strychnine is partly detoxified in the liver and partly excreted unchanged by the kidneys

In collapse following severe haemorrhage and arrest of the heart or respiration during chloroform narcosis an intramuscular injection of the hydrochloride may indirectly stimulate the cardiac action.

Toxicology.--/The symptoms of strychnine poisoning usually appear within twenty minutes of the ingestion of a poisonous dose, starting with stiffness at the back of the neck, twitching of the muscles and a feeling of impending suffocation. The patient is then seized with violent tetanic convulsions. After a minute the muscles relax, and the patient sinks back exhausted, consciousness being preserved throughout. Tetanus (q v.) resembles strychnine poisoning, but the development of the symptoms in tetanus is usually much slower, death rarely occurring within 24 hours.

In treating strychnine poisoning, antidotes such as charcoal or egg white should be administered promptly. Emetics should be avoided as they tend to precipitate convulsions. The patient should be kept quiet and protected from external stimuii. The convulsions can be best controlled by intravenous barbiturates or by ether. Artificial respiration may be necessary.

STRYJ, a town of U.S.S.R. formerly in the province of Stanislawow, Poland. Pop. (1930) 30,682. It is an important railway junction and a centre for the oil fields and the agricultural area of the province. Mineral gas is produced in the neighbourhood. The town is on the Stryj river. Soviet troops occupied Stryj in 1939; it was conquered by axis forces in 1941 and incorporated into U.S.S.R. in 1945.

STRYPE, JOHN (1643-1737), English historian and biographer, was born in Houndsditch, London, on Nov. 1, 1643. He was the son of John Strype, or van Stryp, a member of a Flemish family settled in Strype's Yard in Petticoat Lane, as a merchant and silk throwster. The younger John was educated at St. Paul's school, and at Jesus college, and Catherine Hall, Cambridge. In 1670 he became perpetual curate of Theydon Bois, Essex, and subsequently received the curacy of Leyton and a sinecure living in Sussex. He was lecturer at Hackney

was buried in the church at Levton

was buried in the clutter at Leycon The most impulse of Thomas The most impulse of Shyperboxis are the Memorials of Thomas The most impulse of the Each Soc, 3 vol (Oxford, 1885–1854), and in 2 vol with notes by P. Baines (London, 1835); Life of the Lenn of Sir Thomas Smith (1993). It is and control to the state of the Sir Thomas Control to the Control of the Sir Thomas Control of The most important of Strype's works are the Memorials of Thomas

torian, boin at Biala, near Bielsko, Teschen, Silesia, on March 7, 1862, became a professor at Graz in 1892 and was appointed professor of art history at the University of Vienna in 1909. He wrote numerous works on art, dealing especially with oriental influences on western art His works include. Byzantische Denkmaler, 1-3 (1891-93), Hellenistische und koptische Kunst in Alexandria (1902); Koptische Kunst (1903); Die bildende Kunst der Gegenwart (1907); Die Baukunst der Armemer und Europa (1918); Ursprung der christlichen Kirchenkunst (1920); Krisis der Geisteswissenschaften (1923); Der Norden in der bildenden Kunst Europas (1926); Die altslavische Kunst (1929); The Work of Clemens Holzmeister (1931); Assatische Miniaturmaleres (1932), Aufgang des Nordens (1936). He edited Early North European Church Art and Wood Architecture (1925). He was director of the first Institute for the History of Art in Vienna He died in Vienna on Feb. 2, 1941.

STUART, ARABELLA (1575-1615), daughter of Charles Stuart, earl of Lennox, younger brother of Lord Darnley and of Elizabeth, daughter of Sir William Cavendish and "Bess of Hardwick," was (by strict pedigree) next in succession to James VI. of Scotland to the thrones of England and Scotland, after Queen Elizabeth I. She became the centre of the intrigues of those who refused to accept James as Elizabeth's successor. Suitors for her hand included Henry IV. of France, the earl of Northumberland, and Esmé Stuart, duke of Lennox. In 1590 a scheme was formed of marrying her to Ranuccio, eldest son of the duke of Parma, who was descended from John of Gaunt, and of raising her with Spanish support to the throne She was regarded with suspicion by Elizabeth and closely guarded at Hardwick by the dowager countess of Shrewsbury. In 1602 the queen's suspicions were increased by the discovery of a plot to marry Arabella to Edward, eldest son of Lord Beauchamp, who as grandson of Edward Seymour, earl of Hertford, and of Lady Catherine Giey, was heir to the throne after Elizabeth according to Henry VIII.'s will. According to other accounts the intended husband was Thomas Seymour, a younger son of the earl of Hertford. Arabella planned an escape from Hardwick with the aid of her chaplain Starkey, who after its failure committed suicide In December she wrote secretly to Lord Hertford proposing her marriage with his grandson, but the latter immediately informed the council. In February 1603 another attempt at escape failed, and she was then transferred to the care of the earl of Kent at Wrest House. Arabella was received at the court of James I. and treated with favour, and she showed her fidelity to James by revealing a communication made to her by the conspirators in the Main and Bye Plots, in which her name had been used without her sanction. Every effort, however, was made to prevent her marriage. In December 1609 her plan to escape with Sir George Douglas to Scotland, apparently with a view of arranging a marriage with Stephen Bogdan, pretender to Moldavia, was discovered, and she was arrested. She was, however, granted a pension of £1,600 a year by James. In 1610 she was married secretly in despite of the King's prohibition to William Seymour, younger brother of Edward, and grandson of Lord Hertford. They were imprisoned, Arabella at Lambeth and her husband in the Tower. In 1611 she was placed in charge

of the bishop of Durham She escaped on June 3, 1611, and suc- Frankin's attack on "Stonewall" Jackson's Corps At Chancelceeded in boarding a ship bound for Calais. Her husband had also effected his escape and was sailing towards the French coast Arabella was captured and brought back to the Tower, where she spent the rest of her unhappy career She sank into melancholy, and, according to some accounts, insanity, and died on or about Sept 25, 1615 She was buried in the tomb of Mary Queen of Scots in Henry VII's chapel in Westminster Abbey

See also The Life and Letters of Arabella Stuart, by E T Bradley (1889), which supersedes the Life by E Cooper (1866); and Lives by M Letuse (1913), and B C. Bradley (1913).

STUART, GILBERT (1755-1828), American artist, was born at North Kingstown (RI) on Dec 3, 1755 He studied at Newport (RI) with Cosmo Alexander, and went with him to Scotland, but returned to America after Alexander's death, and obtained many portrait commissions. In 1775 he went to England, and became a pupil of Benjamin West in 1778. His work, however, shows none of the influence of West, and after four years Stuart set up a studio for himself in London. He painted George III and the future George IV, and in Paris he painted Louis XVI, and his success was no less great in Ireland After five years he left Iteland for his native land in order to paint Gen Washington, who was said to be the only person in whose presence Stuart found himself embairassed His first portrait Stuart felt was a failure; but Washington sat to him again, the result being the "Athenaeum" head on an unfinished canvas, showing the left side of the face. This remains the accepted likeness of Washington, of whom he also painted a full-length for Lord Lansdowne; of each of these portraits he executed many replicas Among his portraits are those of Presidents Washington, John Adams. Thomas Jefferson, James Madison, James Monroe and John Quincy Adams, and John Jay, Governor Winthrop, Generals Gates and Knox, Bishop White, Chief Justice Shippen, John Singleton Copley, Sir Joshua Reynolds, Benjamın West, Lords Clinton, Lyndhurst, and Inchiquin, Sir Edward Thointon, Mme. Patterson-Bonaparte and Horace Binney. Stuart's original colouring and technique, and his meight into character, make him not only one of the few great American artists, but one of the greatest portrait-painters of his time. He settled at Boston in 1805, and died there on July 9, 1828.

See George C. Muson, Life and Works of Gilbert Stuart (1879).

STUART, JAMES EWELL BROWN (1833-1864), American soldier, was born in Virginia on Feb 6, 1833 and entered West Point military academy in 1850 In 1859 Stuart, while staying in Washington on official business, was sent to assist Col R. E Lee in the suppression of the John Brown raid on Harper's ferry. Two years later when Virginia seceded from the Union Stuart resigned his commission in the United States army to share in the defence of his State. He had resigned as a ligutenant but he was at once made a colonel. With the scantiest of formal training his regiment was mustered into the Confederate army, and assigned to Joseph Johnston's force in the Shenandoah valley. At the first battle of Bull Run, Stuart distinguished himself by his personal bravery Later in the year 1861 he was promoted brigadier-general and placed in command of the cavalry brigade of the Army of Northern Virginia. Just before the Seven Days' battle (qv) he was sent out by Lee to locate the right flank of McClellan's army, and not only successfully achieved his mission, but rode right round McClellan's rear to deliver his report to Lee at Richmond. In the next campaign he had the good fortune, in his raid against Gen. Pope's communications, not only to burn a great quantity of stores, but also to bring off the headquarters' staff document of the enemy, from which Lee was able to discover the strength and positions of his opponents in detail. Stuart, now a majorgeneral and commander of the Cavalry Corps, was present at the second battle of Bull Run, and during the Maryland campaign he brilliantly defended one of the passes of South mountain (Crampton's gap), thus enabling Lee to concentrate his disseminated army in time to meet McClellan's attack At Fredericksburg Stuart's cavalry were as usual in the flank of the army, and his horse artillery rendered valuable service in checking

lorsville Stuart was specially appointed by Lee to take over command of the II Army Coips after Jackson had been wounded. The next campaign, Gettysburg, was preceded by the cavalry battle of Brandy station, in which for the first time the Federal Cavalry showed themselves worthy opponents for Stuart and his men. The march to the Potomac was screened by the Cavalry Corps, which held the various approaches on the right flank of the aimy, but at the crisis of the campaign Stuart was absent on a raid, and although he attempted to rejoin Lee during the battle, he was met and checked some miles from the field. Very shortly after the opening of the campaign of 1864 Stuart's corps was drawn away from Lee's army by the Union cavalry under Sheridan, and part of it was defeated at Vellow Tavein on May 10, and Stuart himself was killed

See Life by H. B. McClellan (1885).

STUART, JOHN McDOUALL (1815-1866), South Australian explorer, was born at Dysart in Fifeshine, Scotland, in 1815, and arrived in the colony about 1839 He accompanied (aptain Sturt's 1844-1845 expedition as draughtsman, and between 1858 and 1862 he made six expeditions into the interior, the last of which brought him on July 25 to the shores of the Indian ocean at Van Diemen's gulf, at the mouth of the Adelaide river He died June 5, 1866

STUBBS, WILLIAM (1825-1901), English historian and bishop of Oxford, son of William Morley Stubbs, solicitor, of Knareshorough, Yorkshire, was born on June 21, 1825, and was educated at the Ripon Grammar school and at Christ Chuich, Oxford, where he graduated in 1848, with a first class in classics and a third in mathematics He was elected a fellow of Trinity college in the same year, was ordained priest in 1850, and held the college living of Navestock, Essex, from 1850 to 1866. In 1862 he was appointed librarian at Lambeth, and in 1866 regius professor of modern history at Oxford. He held this chair tell 188.4 Many of his lectures were published in book form, including Seventeen Lectures on the Study of Mediaeval and Modern History, etc (1886, 3rd ed. 1900), Lectures on European History (1906), Germany in the Early Middle Ages (1908); and Germany in the later Middle Ages (1908) Stubbs aimed at the organization of a school of history in Oxford after the German model, but his lectures were thinly attended and he gave up the idea

As a historian Stubbs was eminent alike in ecclesiastical history, as an editor of texts and as the historian of the English Constitution In 1858 he published his Registrum sacrum anglicanum, which sets forth episcopal succession in England, and he edited with A. W. Haddan, vol iii. of Councils and Ecclesiastical Documents covering the History of the Anglo-Saxon Church (1878). He edited for the Rolls series 19 volumes of editions of the chronicles, among the most notable of which are the Gesta Regum of Wilham of Malmesbury (1867); the Gesta regis Henrici II. (1867); Roger Hoveden's Chronica (4 vols., 1868-71); the Memorials of St Dunstan (1874); The Historical Works of Ralph Diceto (1878) and The Historical Works of Gorvase of Canterbury (1879-90) The prefaces to these volumes contain some bulliant sketches of character.

His most famous work is his Constitutional History of England (3 vols., 1873, 75, 78, French trans. 1907), preceded by the Select Charters, and other Illustrations of English Constitutional History from the Earliest Times to the Reign of Edward I., in 1870. The appearance of the Constitutional History, which traces the development of the English Constitution from the Teutonic invasions of Britain till 1485, is a landmark in the study of mediaeval English history, and has not been superseded

In character Bishop Stubbs was modest, kind and sympathetic, ever ready to help and encourage serious students, generous in his judgment of the works of others, a most cheery companion, full of wit and humour. His wit was often used as a weapon of defence, for he did not suffer fools gladly. He died on April 22, 1901. In 1859 he had married Catherine, daughter of John Dollar, of Navestock, and had a numerous family.

Sec Letters of William Stubbs, Bishop of Oxford, edit. W. H. Hutton (1904).

for decorative or ornamental features such as cornices, mouldings, blick or stone work is coarse, a finer kind is used for decorative springs can be unhooked and twisted to tighten the grip

purposes (See Plaster-Work )

STUCLEY (or STUKELY), THOMAS (c 1525-1578), English adventurer, son of Sir Hugh Stucley, of Affleton, near Ilfracombe, a knight of the body to King Henry VIII was supposed to have been an illegitimate son of the king. He was a standardbearer at Boulogne from 1547 to 1550, entered the service of the duke of Somerset, and after his master's arrest in 1551 a warrant was issued against him, but he escaped to France, and served in the French aimy. He was sent by Montmorency with a letter of recommendation from Henry II of France to Edward VI On ais airival he pioceeded on Sept 16, 1552, to reveal the French plans for the capture of Calais and for a descent upon England. which had, according to his account, been the object of his mission to England. Stucley was imprisoned in the Tower for some months A prosecution for debt on his release in Aug 1553 compelled him to become a soldier of fortune once more, but he returned to England in Dec 1554 in the train of Philibert, duke of Savoy. He mairied an heiress, Anne Curtis, but in a few months had to return to the duke of Savoy's service From 1558 onward he seems to have been engaged in buccaneering, and although Elizabeth was compelled to disavow Stucley, who surrendered in 1565, his prosecution was merely formal

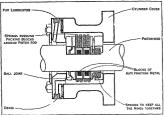
Stucley was then engaged by Sir Henry Sidney in Ireland, then by Bertrand de Salignac Fénelon, the French ambassador in London, and then by Philip II of Spain, but he fell into disgrace at Madrid. But he commanded three galleys, under Don John of Austria at the battle of Lepanto, and exploits restored him to favour at Madrid. On March 2, 1572, he was at Seville, offering to hold the narrow seas against the English with a fleet of 20 ships In four years (1570-74) he is said to have received more than 27,000 ducats from Philip II. Wearied by the Spanish king's delays he sought assistance from Gregory XIII, who aspired to make his illegitimate son, Giacomo Buoncompagno, king of Ireland He set sail from Civitavecchia in March 1578, but put into Lisbon, where he was to meet his confederate, James Fitzmaurice Fitzgerald, and to secure better ships before sailing for Ireland There he was turned from his purpose by King Sebastian, with whom he sailed for Morocco. He commanded the centre in the battle of Alcasar on Aug. 4, 1578, and was killed.

There is a detailed biography of Studey, based chiefly on the English, Venetian and Spanish state papers, in R. Simpson's edition of the 1605 play (School of Shakespeare, vol. 1 [1878]), where the Studey ballads are also printed.

STUDEBAKER CORPORATION, THE, incorporated under the laws of the state of New Jersey on Feb 14, 1911, at that time acquiring the assets of the Studebaker Brotheis Manufacturing company, formed in 1868, and the Everitt-Metzger-Flanders company, organized in 1908. The Studebaker Brothers Manufacturing company succeeded the firm of H and C. Stude-baker, established in 1852. In March 1935, a reorganization of the capital structure was effected and a new company bearing the same name (The Studebaker corporation) was organized under the laws of the state of Delaware. (H. E. DA)

STUFFING BOX is a device to prevent leakage by a piston or ram or spindle as it passes into a cylinder sustaining pressure, This applies to steam engines, air compressors, some kinds of pumps, hydraulic machinery, many stop valves, throttle valves, and water fittings. The main element in each instance is the gland, which is forced along by a thread, or by two or more screws pressing its flange. A chamber surrounding the rod or spindle contains the stuffing or packing, and this becomes compressed around the rod to form a nonleaking joint. Big glands have the nuts of the holts driven in unison by a gear to produce equable tightening all around the circle. A packing commonly used is hemp, though to withstand heat asbestos mixtures are chiefly employed, and are charged with graphite so as to give a constant lubicating effect. Metallic packings have largely superseded any kind of fabrics, the stuffing box containing an arrangement of white-metal

STUCCO, a kind of plaster used for the covering of walls, or pads, with spings to compress them around the rod, the steam pressure further assists in making a tight joint. The drawing etc, or for ceilings. The stucco used as an exterior covering for shows the Lancaster and Tonge packing, in which the encircling



SECTION OF LANCASTER STUFFING BOX SHOWING METALLIC PACKING WHICH PRESSES ANTI-FRICTION BLOCKS AROUND THE PISTON-ROD AND PREVENTS THE ESCAPE OF STEAM

STUFFINGS OR FORCEMEATS. These are used puncipally to give extra flavour to certain flesh foods and vegetables, to bring out the flavour of others, and as additions to some dish such as jugged hare, in the form of forcemeat balls or quenelles Bread, crumpled, moistened and seasoned, is the foundation of many forcemeats A simple US formula is 2 cups dry bread crumbs to 1/2 cup hot water, 1/2 teaspoon salt, 1/4 teaspoon pepper, sometimes varied by the substitution of milk or stock (especially chicken stock) for water A plain English recipe calls for 4 oz. bread scraps to half the amount of suet, one egg, salt, pepper and some form of seasoning, e g, parsley or mixed herbs. Either recipe may be elaborated by adding chopped onion, sage, nutmeg or ground nuts Chestnut, mushroom, oyster and potato forcemeats are good for poultry, minced giblets being often added Fruit stuffings are especially good for strong-flavoured birds like duck and goose.

STUKELEY, WILLIAM (1687-1765), English antiquary, was born at Holbeach, Lincolnshire, on Nov 7, 1687 His principal work, an elaborate account of Stonehenge, appeared in 1740, and he wrote conjously on other supposed Druid remains, becoming familiarly known as the "Arch-Druid" He died in London on March 3, 1765.

STUMPF, CARL (1848-1936), German psychologist and philosopher, was born at Wiesentheid, Bayaria, April 21, 1848, He studied first at Wurzburg under Franz Brentano, and later at Gottingen under Rudolf Lotze He was greatly influenced in his philosophy and psychology by these two men, and remained loyal to them He was appointed to the chair of philosophy at Wurzburg (1873), Prague (1879), Halle (1884), Munich (1889) and finally Berlin (1894) where he was professor of philosophy and director of the psychological laboratory. In 1900 he founded the phonogram-archivs, which consist of a collection of phonograph records of primitive music. In 1907-08 he was rector of Berlin university. In 1921 he reached the age limit, and retired from active teaching

In 1921 he reached the age limit, and retured from active teaching His chief publications included. Uebe den spychologische IUrjeung der Raumworstellung (1873), Tonhyschologise (1883-90); "Ueber den Begriff der mathematischen Wahleschenchkeit," 3th bayr Ak (1893); Ueber Leb und Seele (1867), Beiträge zur Akustia und Manheusen-Prychol. (1899), "Exactingung und psychoske Funktionen," Abh pr. Ak. (1906), "Car Entiellung der Wissenschaften," Abh. pr. Ak. (1906), "Embergen und psychoske Funktionen," Abh pr. Ak. (1906), "Embergen und psychoske Funktionen," Abh. pr. Ak. (1906), "Die Struktur der Vokalo," Sitz. p. Ak (1918), Die Sprachlaute "experimentellphomen (1906), See also B Rand, He Clastical Psychologists (1913); Stump's autobiorynsphy in K. Schmidt, Die Philosophie der Gegenwart in Schriederschlangen (1924), (II. S. Lie Philosophie der Gegenwart in Schriederschlangen (1924), (II. S. Lie Philosophie der Gegenwart in Schriederschlangen (1924), (II. S. Lie Philosophie der Gegenwart in Schriederschlangen (1924), (II. S. Lie Philosophie der Gegenwart in Schriederschlangen (1924), (II. S. Lie Philosophie der Gegenwart in Schriederschlangen (1924), (II. S. Lie Philosophie der Gegenwart in Schriederschlangen (1924), (II. S. Lie Philosophie der Gegenwart in Schriederschlangen (1924), (II. S. Lie Philosophie der Gegenwart in Schriederschlangen (1924), (II. S. Lie Philosophie der Gegenwart in Schriederschlangen (1924), (II. S. Lie Philosophie der Gegenwart in Schriederschlangen (1924), (II. S. Lie Philosophie der Gegenwart in Schriederschlangen (1924), (II. S. Lie Philosophie der Gegenwart in Schriederschlangen (1924), (II. S. Lie Philosophie der Gegenwart in Schriederschlangen (1924), (II. S. Lie Philosophie der Gegenwart in Schriederschlangen (1924), (II. S. Lie Philosophie der Gegenwart in S

STUMPP, JOHANN (1500-1576), write on Swes hatory and topography, was born at Bruchsal (near Carlsruhe) in 1500 and died at Zunch in 1576 Herudicel theology at Standard and the Carlsruhe in 1576 Herudicel theology at Standard and assigned to the parsh of Bubkon (and Lanch Zench). He coon, however, adopted the Protestant fath, and assigned to the parsh of Bubkon (most of his parishones following him) aromanded at Bubkon (most of his parishones following him) aromanded to the control of the standard for the paster till 1543. Thereafter he removed to Standard manham, butter till of the standard for 
TV (1556)

TV (1556)

STUDA, in architecture, a specific type of Buddhist religious building, consisting of a solid mass of masonry, built above a receptacle containing a sacred relic. In India it is commonly called a tope (qv) Although the origin of the stupa was probably the more primitive tumulus, or mound of earth over a grave, its development in historic times was toward greater and greater height and richness of treatment Outside of Thète and China, a profile generally contical and of gieat height was developed, as in the famous gilded example in the centre of the Shwe Dagon, in Rangoon The Thietan from, developed to a great degree of beauty and richness in China, has a bulbous silhouette, wideen near the top than at the bottom.

STURDEE, SIR FREDERICK CHARLES DOVE-TON (1859-1925), Butish sailor, was born at Charlton, Kent, on June 9, 1859, and entered the navy in 1871. He was promoted heutenant (1880), commander (1893), captain (1899), real-admiral (1908), vice-admiral (1913), admiral (1917) and admiral of the fleet (1921) He saw service in Egypt (1882) and in Samoa (1899), when he was in command of the Anglo-American force He was assistant director of naval intelligence to the Admiralty (1000-02) and chief of staff, Mediterranean Fleet (1005-07) and Channel Fleet (1907) In 1910 he became rear-admiral of the first battle squadron, and commanded the 2nd cruiser squadron (1912-13) During the World War Sturdee was made chief of the war staff in Nov 1914 As commander-in-chief in the south Atlantic and Pacific, he led the squadron which won the battle of the Falkland islands (Dec 8, 1914), and he was in command of the 4th battle squadron when it took part in the battle of Tutland He was created KCB in 1913, KCMG in 1916, and a baronetcy was conferred on him in 1916, with the title "of the Falkland islands" From 1018-21 he was commander-in-chief at the Nore He died on May 7, 1925.

STURDZA or STURZA, the name of an ancient Rumanian family, of unknown origin, which probably came from Trebizond and settled in Moldava. The Sturdza family has been long and intunately associated with the Government first of Moldava and afterwards of Rumana Its members belong to two man divisions, which trace their descent respectively from John (Loan) or from Alexander (Sandu), the sons of Klück Sturdza, who lived in the ryth century, the founder of the family.

I. To the first division belongs Michael Strupza. (1795–184), prince of Moldsviar from 1844 to 1849. A man of liberal education, he established the first high school, a kind of university, in Jassy. He brought scholars from foreign countries to act as teachers, and gave a very powerful stimulus to the educational development of the country. In 1844, he decreed the enancipation of the gypaies. Until then the gypaies had been treated as slaves and owned by the Church or by private land-owners, they had been bought and sold in the open market. Michael Sturdan also attempted the secularization of monastic establishments, which their endowments for national purposes. Under his rule the internal development of Moldavia made immense progress; toads were built, industry developed, and Michael is still rariefully remembered by the people.

See Michel Stourdsa et son administration (Brussels, 1834), Michel Stourdsa, ancien prince regnant de Moldavie (1874); A. A. C. Sturdza, Règne de Michel Sturdza, prince de Moldavie 1834-1849 (1907).

2 GREGORY [Gigorie] STURDA (1821—1921), son of the above, we deducted in France and Germany, became a general in the Ostoman army under the name of Müklis Pasha, and afterwards attained the same rank in the Moldavan army. He was a candidate for the Moldavan throne in 1859, and subsequently a prominent member of the Russophil party in the Rumanian pailament. He worde Loss fondamentales de l'unwors (Paris 1891).

3. John [Ioan] Sturzza, prince of Moldava (182-1828), was the most famous descendant of Alexander Sturdza Immediately after the Greek revolution, Prince John Sturdza took an active part in subduing the 100mg bands of Greek Efetairists in Moldava, he transformed the Greek elementary schools into Rumainau schools and laid the foundation for that scientific antional development which Prince Michael Sturdza continued after 1834 In 1838 the Russians entered the country and took Prince Iohn prince The ded in exile

4 DFMFINITIS [Drumtine] STUREAR (1833-1914), Rumanian statesman, was born in 183 at Jassy, and educated there at the Academa Michaileana. He continued his studies in Germany, took part in the political movements of the time, and was private secretary to Prince Cuzz. Demetrius afterwards turned against Cuzz, joined John Bratlanu, and became a member of the so-called Liberal Government. In 1899 he was elected leader of the party in succession to Brathanu and was four times prime mimister He died at Buchailest on Oct 21, 1914. (M. G.)

STURE, STEN, commonly called the Younger (1492—1520), succeeded his father Svante (d. 1512) as regent of Sweden. His regency was wrecked by the feud between the Sture and Trolle families, and his own personal feud with Gustaf Trolle, who invoked the aid of Christian II of Demmark. The war with Denmark was begun in 1516 and resumed in 1518, and in 1520 cull-united in the battle near Borgerund on Lake Aarunden (Jan. 19) At the very beginning Sture was hit by a bullet and his peasant levels field to the wild mountainous regions of Trovelen where they made a last desperate but unsuccessful stand. The mortally-wounded regent took to his sledge and posted towards

STURGE, JOSEPH (1793-1789). English philanthropast and politicans, was the son of a farmer in Gloucestenbire, and settled in 13:2 in Birmingham, where he died on May 14, 1859. Its life was given to agitation for the abolition of slavery, into to the bettement of the conditions of the liberated slaves, and lastly to the cause of peace and arbitration. He was one of the founders in 1855 of the Morning Star, a paper established in the peace interest, a Quaker; and a friend of the Charitsts

Stockholm, but expired on the ice of Lake Malar two days later

See Henry Richard, Memoirs of Joseph Sturge (London, 1864) John (Viscount) Morley, Life of Richard Cobden (London, 1881)

STURGEON (Aciponser), a small group of fishes, of which some 20 species are known, from European, Assatic and North American rivers The distinguishing characters of this group are dealt with in the article Fishins Most of them pass a great part of the year in the sea, but pendically ascend large rivers, some in spring to deposit their spawn, others later in the season for some purpose unknown; a few are confined to fresh water. None occur in the tropics or the southern hemisphere By a decree of Edward II. Enclish sturesons are the property of the king.

Sturgeons are found in the greatest abundance in the rivers of southern Russia, more than 10,000 fish being sometimes caught at a single fishing station in the fortinght of the upstream migration, and in the fresh waters of North America In Russia the fisheries are of immense value. Early in summer the fish migrate into the rivers or towards the shores of fresh-water lakes in large shoals for breeding purposes. The own are small and numerous The growth of the young is rapid. After the sturgeon attains the growth of the young is rapid. After the sturgeon attains attain great age, and won Buer claimed that observations made in Russia indicate that the Hausen (A. hao), may attain an age of between 200 and 200 years. Sturgeons ranging from \$6 to 1 it it in length are by no means searce, and some species grow to a much larger size. Sturgeons are ground-feeders. The more important species are.

1. The common sturgeon of Europe (A sturio) occurs on all

the coasts of Europe, but is absent from the Black sea. It is not rare on the coasts of North America. It reaches a length of 12 of t., and is always caught singly, or in pairs. The four of its snout varies with age (as in the other species), being much more blunt and abbreviated in oid than in young examples. There are

11-13 bony shields along the back and 29-31 along the body.

2. A. guldenstadtis is one of the most valuable species of the rivers of Russia; it inhabits the Siberian rivers also, eastwards

as far as Lake Baikal. It attains the same size as the common sturgeon, and abounds in the rivers of the Black and Caspian seas.

ers of the Black and Caspian seas, 3 A stellatus occurs in abundance in the rivers of the Black sea and of the Sea of Azov. It has a long and pointed snout, like seatch that the sterlet, but simple barbels THE of the sterlet in the



the sterlet, but simple barbels The common sturgeon (acipenwithout fringes. Though growing SER STURIO)

only to about half the size of the preceding species it is of no less value, its flesh being more highly esteemed and its caviare and isinglass fetching a higher price.

4. The sturgeon of the great lakes of North America (A. rubicundus) has been made the object of a large industry at various places on Lakes Michigan and Erlo. The sturgeons of the lakes are unable to migrate to the sea, but those below the Falls of Nigarar are great wanderers.

5. A. have is recognized by the absence of osseous scutes on the mout and by its flattened, tape-like barbels. It is one of the largest species, reaching the length of 24 ft., and a weight of 2000 Ib. It inabilist the Caspian and Black easa, and the of Azov, Its flesh, caviare and air bladder are of less value than those of the smaller kinds.

The steriet (A. ruthenus) is one of the smaller species, which inhabits both the Black and Caspian seas.

The family Acienseridae includes one other genus, Scaphirhynchus, the shovelhead or shovel-need sturgeon, distinguished by the long, broad and flat snout, the suppression of the spiracles, and the union of the longitudinal rows of scales posteroriy. All the species are confined to fresh water. One of them is common in the Mississippi and other rivers of North America, the other three occur in the larger tures of eastern 42.

three occur in the larger nvers of eastern Asia.

STURGEON BAY, a city of northeastern Wisconsin,
U.S.A, on the narrow peninsula (there 8 ml. wide) between
Green bay and the main body of Lake Michigan. The county
seat of Door county. It lies on Stutgeon bay (an inlet of Green
bay, connected with Lake Michigan by a ship canal) and is served
by the Ahnapee & Western railroad (freight only) and lake
steamers. Pop. (1950) 7/654; (1940) 5/439. The peninsula is a
region of great natural beauty, and the city is a summer resort and
trading centre. The annual cherry crop amounts to about 3,000,
tating the control of the county of the county of the county
start fish batchery in the city and other industries. The city was
incorporated in \$83.

STURGIS, RUSSELL (1836-1909), American architect and art critic, was born in Baltimore county, Maryland, on Oct. 16, 1836. He graduated from the Free Academy in New York (now the College of the City of New York) in 1856. He studied architecture under Leopold Eidlitz and then for two years in Munich. In 1862 he returned to the United States. He designed the Yale University chapel and the Farnham and Durfee dormitories at Yale, the Flower Hospital, New York, the Farmers' and Mechanics' Bank, Albany, and many other buildings. After 1880 he did comparatively little professional work. He was in Europe in 1880-84. For a short time after his return he was secretary of the New York municipal civil service board. He was president of the Architectural League of New York in 1889-03. was first president of the Fine Arts Federation in 1895-97, and was a member of the National Society of Mural Painters, the National Sculpture Society, the National Academy of Design, and the New York chapter of the American Institute of Architects. He lectured on art at Columbia University, the Metropolitan Museum of Art in New York, the Peabody Institute of Baltimore and the

Art Institute of Chicago. He edited A Dictionary of Architecture and Building (3 vols, 1501-02) and the English version of Wilhelm Luckke's Outlines of the History of Art (2 vols, 1594), and he wrote European Achitecture (1595), How to Indige Architecture (1595), The Appleatation of Sculptine (1594), The Appleatation of Sculptine (1595), A Study of the Artist's Way of Working in the Various Handleroffst and Arts of Design (2 vols, 1595) and an unfinished History of Architecture (1596 et seq.). He died in New York Feb. 11, 1594

STURGIS, a city of Michigan, U.S.A. The population was 7,786 in 1950, 7,214 in 1940 and 6,950 in 1930.

It is in a nich agricultural region, and has a large number of diversified manufacturing industries. The city has a commissionmanagement.

STURGKH, CARL, COUNT (1859-1916), Austrian politician, was born at Graz on Oct. 30, 1859, of an ancient Styrian family. In 1891, he entered the Reichsrat as representative of the constitutional landed proprietors, achieving some prominence as a keen opponent of universal suffrage. He was from Feb. 10, 1909 to Nov. 3, 1911 minister of education, and a zealous advocate of the humanistic education traditional in the gymnasia. On Nov. 3 he became prime minister, and formed a cabinet with-out regard to nationality. Owing to the incessant parliamentary obstruction, however, Sturgkh prorogued parliament indefinitely on March 16, 1914, with an announcement that "Parliaments were only means to an end, and where they failed, other means must be employed," So on the outbreak of World War I, Austria was without a parliament, and the decisions lay with its few rulers alone. Sturgkh was one of the committee of five ministers who decided on the ultimatum to Serbia. He refused to convoke parliament, and as a protest against this the Social Democrat, Friedrich Adler, assassinated him in a Viennese restaurant on Oct. 21, 1916 (see Austria, Empire of)

STURM, JACQUES CHARLES FRANÇOIS (1802-1851), French mathematician, of German extraction, was born at Geneva on Sept. 29, 1803, and spent most of his life in Paris. In 1839 he discovered the theorem regarding the determination of the number of real roots of a numerical equation included between given limits, which bears his name. (See Equatrons, Tracory or.) He was elected to the Académie des Sciences in 1836, was professor in the Ecole Polytechnique in 1849, and finally succeeded Poisson in the chair of mechanics in the Faculté des Sciences in Paris. He ded in Paris on Doc. 18, 1855.

His works, Cours d'analyse de l'école polytechnique (1857-68) and Cours de Mécanque de l'école polytechnique (1861), were published posthumously.

STURMER, BORIS VLADIMIROVICH (1849-1917), Russian politician, was of German origin. His father was captain of a fire brigade at Tula. He studied at the University of St. Petersburg (Leningrad). He started his career in the chamberlain's department of the imperial court. When in 1892 the Government rejected the candidate nominated to the presidency of the executive board of the Tver zemstvo, Sturmer, whose name was on the list of the Tver gentry, was appointed to this office. It was the first case of a president being appointed instead of elected. In 1804 Sturmer was appointed governor of the Novgored, and later of the Yaroslavl province. In Jan. 1916, he was made prime minister. He was opposed in liberal and patriotic circles. Accusations of connections with Germany were brought to the Duma by Milyukov and resulted in Sturmer's resignation in Nov. 1916. After Sazonov's dismissal Stürmer took the portfolio of foreign affairs. He was arrested after the revolution, and

died in prison in Sept. 1927.

STURM VON STURMECK, JACOB (1489-1553), German statesman and reformer, was born at Strasbourg on Aug. 70.

489. He was educated at the universities of Heddelberg and Freiburg, and about 1517 he entered the service of Henry of Withelbach, provost of Strasbourg (d. 1552). He soon became an adherent of the reformed electrines, and a member of the town council in 1524. He was responsible for the policy of Strasbourg during the Peasants' War; represented the city at the diet of Speyer in 1526 and at subsequent diets. He took part in the con-

ference at Marburg in 1529; but when the attempts to close the breach between Lutherans and Zwinglians failed, he presented the Confessio tetrapolstana to the Augsburg duet of 1530. As the representative of Strasbourg Sturm signed the "protest" which was presented to the diet of Spires in 1529, being thus one of the original "Protestants" Owing largely to his influence Strasbourg toined the league of Schmalkalden in 1531. In Feb. 1547 the citizens were compelled to submit to Charles V Sturm obtained for his native city some modification of the Interim issued from Augsburg in May 1548. He died at Strasbourg on Oct. 30, 1553. See H. Baumgarten, Jakob Sturm (Strasbourg, 1876), A. Baum, Magistrat und Reformation in Strassburg bis 1529 (Strasbourg, 1887). STURNIDAE: see Starling

ŠTURSA, JAN (1880-1925), the leader of the modern school of Czech sculpture, was born at Nové Město in Moravia. In 1899 he entered the Academy of Fine Arts at Prague as a pupil of Myslbek His early works manifest the influence of the symbolic literature of that period, but by 1905-7 he had already attained an individual expression in such works as "Puberty (1905), "The Melancholy Girl" (1906) and "Primaveia" (1907). A journey to Italy in 1907 was the opening of a new epoch in his creative work. His admiration for femininity is manifested in "Eve" (1908, State Gallery, Munich), "Hetaira" (1909), "Messalina" and the monumental representation of the dancer "Sulamith Rahu" (1911), now in the gallery at Venice. He interpreted the opposite feminine type of intellectuality in the monument to Hana Kvapilova (1912), the Czech actress. During the same period Stursa produced the group of statuary for the pylons of the Hlavka Bridge at Prague. In 1916 he was appointed professor at the Academy of Fine Arts in Prague, and in this period of his artistic maturity he created the "Wounded Man," He produced a number of portrait busts, the most noteworthy being "President Masaryk." He died in Prague on April 28, 1925 STURT, CHARLES (1795-1869), English explorer, born in

Bengal Having landed in Australia with his regiment (the 39th), he started on a first expedition (1828) discovering the Darling river, while a second made known the existence of Lake Alexandrina. From his third journey (1844-1845), in which terrible hardships had to be endured, he returned quite blind, and he never altogether recovered his sight. He was appointed surveyor-general of South Australia in 1833, and subsequently chief secretary until 1856 when responsible government was introduced. Sturt died at

Cheltenham, England, on June 16, 1869

STURZO, LUIGI (1871-), Italian priest and political organizer, promoter of the Christian Democratic movement in Italy. Born at Caltagirone, Sic, on Nov. 26, 1871, he studied at the Gregorian university, Rome, and became professor of philosophy and sociology in his native town. On the outbreak of World War I he went to Rome as secretary of Azione Cattolica (Catholic Action) In 1919 he founded the Partito Popolare and became its first political secretary. Sturzo and his party based themselves on papal encyclicals concerning the social order and advocated reforms of a radical nature, especially in agriculture; the majority of the party's adherents were peasants.

At the elections of Nov. 1919 the newly founded Partito Popolare secured for seats and became a dominant force in politics, if not with the Giolitti cabinet certainly during the subsequent Bonomi cabinet After the Fascist "march on Rome" several Popolari entered the first Mussolini cabinet, but soon he and his party joined the opposition. In 1923, however, the Vatican, subjected to pressure from Mussolini, withdrew its support from Sturzo in an attempt to reach some understanding with the Fascists Sturzo's party had by now much shrunk as an outcome of Fascist electoral methods. He resigned the leadership in 1923 and left Italy in Oct. 1924. Sturzo spent his 20 years of exile first in London and after the outbreak of World War II in the U.S. His party in Italy was driven underground, but after the overthrow of Fascism many of his ideas re-emerged in the Christian Democratic party, headed by Alcide de Gasperi and other followers of Sturzo's who revered him as the father of their ideas. He returned to Italy after the war and was made a senator for life in 1952.

(1939), Italy and the Coming World (1945) and numerous other work not translated into English

STUTTGART, capital of Wurttemberg-Baden, Germany Pop including suburbs (1950) 497,677. Stuttgart seems to have originated in a stud (Stuten Garten) of the early counts of Wurttemberg, and is first mentioned in a document of 1229 In its early history it was overshadowed by Cannstatt. Ever at the beginning of the 19th century it did not contain 20, 000 inhabitants, and its real advance began with Kings Frederick and William I. Few of its principal buildings are older than the 19th century They illustrate the revival of the Renaissance style Of the churches in the city the most interesting are the Stiftskirche, with two towers, a fine specimen of 15th-century Gothic: the Leonhardskirche, also a Gothic building of the 15th century; and the Hospitalkırche, restored in 1841, the clossters of which contain the tomb of Johann Reuchlin. A large proportion of the most prominent buildings are clustered round the Schlossplatz. Among these are the new palace, a structure of the 18th century, finished in 1807; the old palace, a 16th-century building, and the so-called Akademic, formerly the seat of the Karlschule, where Schiller received part of his education, and now containing a library. On or near the Schlossplatz also are the new courts of justice; and the central railway station

The art collections of Stuttgart are numerous and valuable. The museum of art comprises a picture gallery, a collection of casts of Thorvaldsen's works and a cabinet of engravings. The library contains many thousands of printed volumes and manuscripts, including one of the largest collections of Bibles in the world. The technical high school, which after 1899 possessed the right to confer the degree of doctor of engineering, practically enjoys academic status and so does the veterinary high school.

Stuttgart is the centre of the publishing trade of south Germany. Its other manufactures include machinery, pianos and other musical instruments, cotton goods, linen, gloves, rubber, jewellery, chocolate, lamps, cigars, furniture, leather, paper, colours and chemicals. The Daimler-Benz factory for aircraft engines, trucks, and tanks, the Bosch plant for electrical equipment, and the important railway yards made Stuttgart an object of air raids during World War II.

STUYVESANT, PETER (1592-1672), Dutch colonial governor, was born in Scherpenzeel, in Southern Friesland, in 1502. He studied at Francker, entered the military service in the West Indies about 1625, and was director of the West India Company's colony of Curação 1634-44. In April, 1644 he attacked the Por-tuguese island of Saint Martin and was wounded; he had to return to Holland, and there one of his legs was amoutated Thereafter he wore a wooden leg ornamented with silver bands. In May, 1645, he was selected by the West India Company to supersede William Kieft as director of New Netherland. He arrived in New Amsterdam (later New York) on May 11, 1647, and was received with great enthusiasm. In response to the demand for self-government, in Sept , 1647, he and the council appointed-after the manner then followed in Holland-from 18 representatives chosen by the people a board of 9 to confer with him and the council whenever he thought it expedient to ask their advice.

The leading burghers were, however, soon alienated by his violent and despotic methods, by his defence of Kieft, and by his devotion to the interests of the company; the nine men became the centre of municipal discontent, and a bitter quarrel ensued. In 1650 the states-general suggested a representative government to go into effect in 1653, but the company opposed it; in 1653, however, there was established the first municipal government for the city of New Amsterdam modelled after that of the cities of Holland. Stuyvesant also aroused opposition through his efforts to increase the revenues of the company, to improve the system of defence, and to prevent the sale of liquor and firearms to the Indians, and through his persecution of Lutherans and Quakers. to which the company finally put an end. In 1650, he came to an agreement with the commissioners of the united colonies of New England at Hartford upon the boundary between New Netherland fter the war and was made a senator for life in 1952.

and Connecticut, involving the sacrifice of a large amount of
His books include Haly and Fascismo (1927), Church and State
territory. On Long Island, during Stuyvesant's rule, Dutch in4.88 STYLE

fluence was gradually undermined by John Underhill Stuyve- mental brain-work" must always have a leading place sant's dealings with the Swedes were more successful. With a force of 700 men he sailed into the Delaware in 1655, captured Ft Casimir (Newcastle)-which Stuyvesant had built in 1651 and which the Swedes had taken in 1651-and overthrew the Swedish authority in that region. He also vigorously suppressed Indian uprisings in 1655, 1658 and 1663

In March, 1664, Charles II granted to his brother, the duke of York, the territory between the Connecticut river and Delaware bay, and Col Richard Nicolls with a fleet of 4 ships and about 300 or 400 men was sent out to take possession. Misled by instructions from Holland that the expedition was directed wholly against New England, Stuyvesant made no preparation for defence until just before the fleet arrived. As the burghers refused to support him, Stuyvesant was compelled to surrender the town and fort on Sept 8 He returned to Holland in 1665 and was made a scapegoat by the West India Company for all its failings in New Amsterdam, he went back to New York again after the treaty of Breda in 1667, having secured the right of free trade between Holland and New York He spent the remainder of his life on his farm called the Bouwerie, from which the present "Bowery" in New York city takes its name He died in Feb 1672, and was buried in a chapel, on the site of which in 1799 was erected St Mark's church.

See Bayard Tuckerman, Peter Stuyvesant (1893), in the "Makers of America" Series, and Mrs Schuyler Van Rensselaer, History of the City of New York in the Seventeenth Century (1909)

STYLE. It is desirable to insist at the outset on the dangers of a heresy which found audacious expression towards the close of the 19th century, namely, that style is superior to thought and independent of it Against this may be set at once one of the splendid apophthegms of Buffon, "Les idées seules forment le fond du style." Before there can be style there must be thought, clearness of knowledge, precise experience, sanity of reasoning power. A confusion between form and matter has often confused this branch of our theme. Even Flaubert, than whom no man ever gave closer attention to the question of style, seems to dislocate them For him the form was the work itself "As in living creatures, the blood, nourishing the body, determines its very contour and external aspect, just so the matter, the basis, of a work of art imposes, necessarily, the unique, the just expression, the measure, the rhythm, the form in all its characteristics" This ingenious definition seems to strain language beyond its natural limits If the adventures of an ordinary young man in Paris be the matter of L'Education sentimentale it is not easy to admit that they "imposed, necessarily," such a "unique" treatment of them as Flaubert so superlatively gave. They might have been recounted with feebler rhythm by an inferior novelist, with bad rhythm by a bad novelist and with no rhythm at all by a police-news reporter What makes that book a masterpiece is not the basis of adventure, but the superstructure of expression. The expression, however, could not have been built up on no basis at all, and would have fallen short of Flaubert's aim if it had risen on an madequate basis. The perfect umon is that between adequate matter and an adequate form. We will borrow from the history of English literature an example which may serve to illuminate this point. Locke has no appreciable style; he has only thoughts. Berkeley has thoughts which are as valuable as those of Locke, and he has an exquisite style as well. From the artist's point of view, therefore, we are justified in giving the higher place to Berkeley, but in doing this we must not deny the importance of Locke. If we compare him with some pseudo-philosopher, whose style is highly ornamental but whose thoughts are valueless, we see that Locke greatly prevails. Yet we need not pretend that he rises to an equal height with Berkeley, in whom the basis is no less solid, and where the superstructure of style adds an emotional and aesthetic importance to which Locke's plain speech is a stranger. At the same time, an abstract style, such as that of Pascal, may often give extreme pleasure, in spite of its absence of ornament, by its precise and pure definition of ideas and by the just mental impression it supplies of its writer's power and placidity of mind. But whether in the abstract or concrete style, what Rossetti called "funda-

When full justice has been done to the necessity of thought as the basis of style, it remains true that what is visible, so to speak, to the naked eye, what can be analysed and described, is an artistic arrangement of words. Language is so used as to awaken impressions, and these are roused in a way peculiar to the genius of the individual who brings them forth. The personal aspect of style is therefore indispensable, and is not to be ignored even by those who are most rigid in their objection to mere ornament Ornament in itself is no more style than facts, as such, are thought In an excellent style there is an effect upon our senses of the mental force of the man who employs it D'Alembert said of Fontenelle that he had the style of his thought, like all good authors In the words of Schopenhauer, style is the physiognomy of the soul in the Renaissance phrase, it is mentis character All these attempts at epigrammatic definition tend to show the sense that language ought to be, and even unconsciously is, the mental picture of the man who writes

To attain this, however, the writer must be sincere, original and highly trained. He must be highly trained, because, without the exercise of clearness of knowledge, precise experience and the habit of expression, he will not be able to produce his soul in language. Nor can anyone who desires to write consistently and well, aftord to neglect the laborious discipline which excellence entails. He must never rest until he has attained a consummate adaptation of his language to his subject, of his words to his emotion. This is the most difficult aim which the writer can put before him Perfection is impossible, and yet he must never desist from pursuing perfection

> "If all the pens that ever poets held Had fed the feeling of their masters' thoughts, And every sweetness that inspired their hearts, Their minds, and muses, on admired themes If all the heavenly quintessence they 'still From their immortal flowers of poesy, Wherein, as in a mirror, we perceive The highest reaches of a human wit-If these had made one poem's period, And all combined in beauty's worthiness Yet should there hover in their restless heads One thought, one grace, one wonder, at the least Which into words no virtue can digest."
>
> —Marlowe, Tamburlaine the Great

Flaubert believed that every thought or grace or wonder had one word or phrase exactly adapted to express it, and could be "digested" by no other without loss of clearness and beauty It was the passion of his life, and the despair of it, to search for this unique phrase in each individual case Perhaps in this research after style he went too far, losing something of that simplicity and inevitability which is the charm of natural writing. The greatest writing is that which in its magnificent spontaneity carries the reader with it in its flight; that which detains him to admire itself can never rise above the second place Forgetfulness of self, absence of conceit and affectation, simplicity in the sense not of thinness or poorness but of genumeness-these are elements essential to the cultivation of a noble style. Here again, thought must be the basis, not vanity or the desire to astonish. We do not escape by our ingenuities from the firm principle of Horace, "scribendi recte sapere est et principium et fons.

Of the errors of style which are the consequences of bad taste, it is difficult to speak except in an entirely empirical spirit, because of the absence of any absolute standard of beauty by which artistic products can be judged. That kind of writing which in its own age is extravagantly cultivated and admired may, in the next age, be as violently repudiated; this does not preclude the possibility of its recovering critical if not popular favour. Pethaps the most remarkable instance of this is the revolt against Ciceronian prose which occurred almost simultaneously in several nations toward the middle of the 16th century and in England is best represented by Lyly in his celebrated Euphues. Montaigne in France and Castiglione in Italy, by their easiness and brightness, their use of vivid imagery and their graceful illumination, marked the universal revulsion against the Ciceronian stiffness. Each of these new manners of writing fell almost immediately into desuecame into vogue (Joseph Addison, Jacques Bossuet, Giovanni Vico, Samuel Johnson) In the 19th century admiration of the ornamental writers of the 16th and 17th centuries revived A facility in bringing up before the memory incessant analogous metaphors is the property, not merely of certain men, but of certain ages, it flourished in the age of Giovanni Marini and was welcomed again in that of George Meredith A vivid concrete style, full of colour and images, is not to be condemned because it is not an abstract style, scholastic and systematic. It is to be judged on its own ments and by its own laws. It may be good or bad, it is not bad merely because it is metaphorical and ornate The amazing errors which lie strewn along the shore of criticism bear witness to the lack of sympathy which has not perceived this axiom and has wrecked the credit of dogmatists. Yet that particular species of affectation which encourages untruth, affectation, parade for the mere purpose of producing an effect, must be wrong, even though Cicero be guilty of it

be wrong, even inougn Licero ne guilty of a See Walter Pater, An Evroy on Style (1889); Walter Raleigh, Style (1897). Antoine Albalat, La Formation dis style per Faissimilation mont, Le Problème du style (1923). J Middelton Muity, Per Problème of Style (1923); H W. Fowlet, A Dictionary of Modern English Unage (1926)

For style in architecture, etc , see Periods of Art

STYLOBATE, in architecture, the upper step of a Greek temple on which the columns test, also applied to all three steps STYLOPS, the name of a genus of insects belonging to the order Strepsiptera allied to the beetles. The order is distributed over most parts of the world, but numbers less than 200 species. The males are minute, black or brown insects with branched antennae and vestigial mouth parts the forewings are reduced to clublike scales but the hind wings are large and fanlike. They are seldom seen and lead a very brief life. The females are mostly degenerate sachke parasites that live partly protruding from the bodies of bees, wasps or leafhoppers and other insects. The young larvae are minute and known as triungulins, which hatch within the parent and probably escape on to flowers, etc., where they await the presence of a host. On finding the latter they bore their way into the body, change into legless maggots and pupate there, in most species, the males alone subsequently emerge. The presence of these parasites frequently induces structural and other changes in their hosts including the acquisition of characters pertaining to the opposite sex (parasitic castration),

STYRENE, also known as vnyl benzene or phenyl ethylene is a hydrocrabon known to sedence from 1839 and occurring to a limited extent naturally in crude xylene and in storax balsam (onental sweet gum). Styrene produced synthetically was introduced commercially in the United States in 1937. It is now produced in greater quantities than any other synthetic aromatic hydrocarbon, the 1945 production being about 400,000,000 lb. The raw materials used for the production of styrene are ethylene derived from crude oil (or natural gas) and benzene obtained from coal. These products are combined to form ethyl benzene from which the styrene is obtained by catalytic dehydrogenation. The crude product is purified by distillation.

Styrene has the structure CoH5.CH.CH2. It is a water-white hauid having a molecular weight of 104 14, a specific gravity of 0.904+, a refractive index of 1.5439, a boiling point of 145.20 C, and a freezing point of -30.63°C. Styrene has a sweet, penetrating aromatic odour that makes it desirable for certain types of perfume Chemically its reactive double bond permits polymerization reactions (see POLYMERIZATION) which are utilized in the manufacture of plastics and of synthetic rubber. It is chemically reactive with halogens, hydrogen halides and many other compounds Polymerized styrene (polystyrene) is one of the major mexpensive thermoplastics. It is a rigid plastic having excellent electrical and optical properties, good water and chemical resistance and good mechanical strength. It can be produced in a wide range of colours. Styrene is a major ingredient of GR-S synthetic rubber. Along with butadiene it had to share the tremendous burden of the demand for synthetic rubber during World War II

STYRIA, a province of Austria, seized by Germany during the

tude, and the precise and classic mode of writing m another form are chilors of 1938, covering 6,716 sq ml, is distinguished for its came into voque (Joseph Addison, Jacques Bessuet, Giovania scenery and muneral wealth It is divided into Upper Styna, Voq. Samuel Johnson). In the right century admiration of the temperatures of the right and right centures revived A and Min-Mul, and Lower Styna, the region of the middle Mur affacility in bringing up before the memory incessant analogous and the headwaters of the Raab Upper Styna north of the Eans metaphors is the property, not merely of certain me, but of ter, tam ages, it flourished in the age of Giovanni Marini and was welter the property of the state of the st

Despite the mountainous character little of the soil is unpoductive, only 8% of the area long classed as harren land Forests cover 45% of at sproductive area, cultivated land 20% and the remainder is good grassland. In Upper Styra cultivation favours the fertile glacul moranes and alluvial fens of the stream terraces and haims, rye, oats and buckwheat being the most common cereals though wheat, barley and make are also grown. In addition potatoes, flax, hemp and ioot crops are important. Dow-Styria under more favourable conditions of soil and climate produces wine, fruit and hops. Calle bueding is a flourishing activity supported by the breeding of draught horses in the marshy basins, pigs and poulity thrive in Lower Styra while sheep are on the increase everywhere, large numbers of game of vanous kinds are also to be found on the highlands of

The Erzberg iron mines have been worked from the Roman period and yeld nearly the whole of the Austran production Signal supplies about 50% of Austran lignite production. In addition there are important deposits of magneste, e.g., at Trieben, while other mineral resources include graphite, aluminium, salt, marble and building stone The Tertiary basin of Lochen and Dinauki, near coal and iron supplies, is the centre of the iron and steel undusty, Graz (q v), the administrative, religious and intellectual capital, is also the commercial centre of the province. In the Styram Salckammegut around Aussee, near Giava at the spas of Gleichenberg and Tobelhad and in the Semmening district of Mutzauschlag, an increasing revenue is derived from tourists. Styria is richly endowed with water power, notably in the valleys of the Enns. Mur and Murz.

The population in 1939 was 1,120,146, equivalent to 167 persons per sq m1, but it is very unevenly distributed. In the more remote highland region of Upper Styria isolated houses or small villages are the rule, the inhabitants of villages and districts having often united in co-operative agricultural groups. Settlements in the valleys are small and strung like beads along the river courses They are markets for the neighbouring mountain valleys and often busy manufacturing centres, but apart from Graz few towns exceed 10,000 inhabitants. The population is mainly German in speech with Slovene intermixture in the southeast, and Roman Catholic in faith Despite a mountainous situation, the early fame of its metallic wealth attracted notice, from Roman times onward, and it has been traversed by most of the migratory peoples of whom the Slavs left the strongest imprint. Under Charlemagne it became part of the duchy of Carinthia, obtained separate existence as the mark of Styria in 1056, passed to the Habsburgs in the late 13th century and was annexed by Adolf Hitler in 1938

See also Austria and K Kochl, Steirisch Land und Leute (Graz, 1923); Otto Reicher, Die Steiermaik (Beilin, 1938).

STYX, a stream near Nonacris in Arcadia, Paus , viii, 17, 6 ff, where see Frazer's commentary, the modern Mavro Nero (Black Water). It was thought to be virulently poisonous and capable of dissolving any vessel it was put in, save one made from the hoof of a horse. From the time of Homer, Styx (The Hateful) is one of the rivers of the underworld, generally its boundary, and the gods, if they swear by it, dare not break their oath In Hesiod (Theogonia, 383 ff.) the nymph Styx, daughter of Ocean. with her children (Power, Might, Victory and other abstractions) helps Zeus against the Titans, and is therefore honoured by him. If a god does break the oath, he is insensible for a year and then banished for nine years; mortals on occasion might take this oath, and in either case it would seem to have involved dinking the water (Hestod, op. cit., 783 ff.; Herodotus, vi, 74) We may suppose that the oath was really an ordeal; the water was a magical poison, perhaps originally fatal only to perjurers.

SUAKIN, a seaport of the Anglo-Egyptian Sudan on the Red sea. It is a coraline islet connected with the suburb of El-Kef on the mainland by a causeway and a viaduct. Access is gained to the harbour by a winding and dangerous passage more than 2 mi, long, terminating in a deep oval-shaped basin several acres in extent, and completely sheltered from all winds. Suakin is superseded by Port Sudan (qv), a harbout 36 mt to the north At Suakin, as at Massawa, traders were attracted by an island site which protected them from the Arabs The mainland belonged in the middle ages to the Beja (q v ), but in 1330 Ibn Batuta found a son of the amir of Mecca reigning in Suakin over the Beja, who were his mother's kin. Makrızi says that the chief inhabitants were nominal Moslems and were called Hadarib The amir of the Hadaub was still sovereign of the mainland at the time of J. L. Burckhardt's visit (1814), though the island had been seized in 1517 by the Turks under Selim the Great. Mohammed Ali after the conquest of the Sudan leased Suakin from Turkey. This lease lapsed with the pasha's death, but in 1865 Ismail Pasha 1eacquired the post for Egypt It has always been the place of embarkation for Sudan pilgrims to Mecca Legitimate commerce, rapidly growing before the revolt of the Mahdi (1881), was greatly crippled during the continuance of the dervish power, though the town itself never fell into their hands. The port is connected by railway with the Nile valley joining that route at Atbara 300 mi. west of Port Sudan.

SUARDI, BARTOLOMMEO (c. 1455-c. 1536), Italian painter and architect, frequently called Bramanton, was burn in Milan, the son of Alberta Suarch. He executed paintings containing portrats of celebrated personages for the Vatican. In 1508 he was engaged in Rome. Bramante d'Urbino taught him architecture, and had his assistance in the execution of the interior of the church of San Satiro, Milan. In 1525 Bramantino was appointed architect to the court by Duke Francis (II) Sforza

Bartolommeo Suardi has been confused with a certain Bramantino da Milano, of whom Vasari makes frequent mention. The Bramantino of Vasari, if he existed at all, worked for Pope Nicolas V between 1450 and 1455.

See A della Croce, Le Rovine di Roma (Milan, 1875) (from the sketch book of Suardi in the Ambrosiana Library at Milan).

SUAREZ, FRANCISCO (1548-1617), Spanish theologian and philosopher, was born at Granada on Jan 5, 1548, and educated at Salamanca. Influenced by the Jesuit John Ramirez he entered the Society of Jesus in 1564, and after teaching philosophy at Segovia, taught theology at Valladolid, at Alcala, at Salamanca and at Rome successively. After taking his doctorate at Evora, he was named by Philip II principal professor of theology at Coimbra. Suarez may be considered almost the last eminent representative of scholasticism. In philosophical doctrine he adhered to a moderate Thomism. On the question of universals he endeavoured to steer a middle course between the pantheistically inclined realism of Duns Scotus and the extreme nominalism of William of Occam. In theology, Suarez attached himself to the doctrine of Luis Molina, the celebrated Jesuit professor of Evora, and endeavoured to reconcile his view with the more orthodox doctrines of the efficacy of grace and special election. This mediatizing system was known by the name of "congruism."

Suiace is probably more important, however, as a philosophical jurist than as a theologian or metaphysical. In his extensive work Tractatus de legibus ac deo legislatore (reprinted, London, 1679) he is to some extent the precursor of Grotius and Samuel Putendorf. Grotius spakes of him in terms of high respect. Suarerefutes the divine right of kings—doctrines popular in England

and to some extent on the continent.

In 162, at the instigation of Pope Paul V, Suares wrote a treatise dedicated to the Christian princes of Europe, entitled Defensio catholicae fide centra anglicance sectae errores. This was directed against the each of allegiance which james! a trancied from his subjects. James caused it to be burned by the common hangman, and forbade its perusal under the severest penalties, complaining bitterly at the same time to Philip III that he should harbour in his dominions a declared enemy of the throne and majesty of kings. Suares lived a very humble and simple life.

He died after a few days' illness on Sept 25, 1617, at Lisbon
The collected works of Suarez have been printed at Maina and
Lyons (1630), at Venuc (1740-517), at Besançon (1856-63) and
in the collection of the Abbé Migne His life has been written
by Emile Deschamps (Vita Pr. Suaresis, Perpugan, 1671). The
helf modern authorities are K Wenner's Prina Suarez u dae
Scholastik der letten Jahrhunderte (Regensburg, 1861) and
Stockt's Geschichte der Philosophia des Mittellaters, in, 631 sea

SUBCONSCIOUS, in psychology, means anything that is neither in the focus nor in the margin of consciousness (that is, does not receive attention, and so cannot be recognized in the actual experience of the moment), but which nevertheless must be assumed to be influencing us in some way, as a disposition, etc See Abnormal Psychology, Psychology, Unconscious, with bibliographies

SUB-DOMINANT, in music, the 4th degree of the diatonic scale, as F in the scale of C. (See Harmony)

SUBIACO (anc Sublaqueum), a town of Italy, picturesquely situated on the Anio, 1,339 ft. above sea level. Pop (1951) 9,201 (commune). It was so called from its position under the three artificial lakes constructed in the gorge of the Anio in connection with the aqueduct of the Anio Novus, which had its intake at the lower end of the lowest of them (the Simbruina stagna of Tacitus) On the banks of this lake Nero constructed a villa, in the remains of which was found the beautiful headless statue of a youth kneeling, now in the Museo delle Terme at Rome The lakes ceased to exist, the last dam being washed away in 1305 In 494 St Benedict retired as a hermit to a cave (Sacro Speco) above the lakes of the Anio In 505, probably, he founded the first of his 12 monasteries The church dedicated to Ste. Scholastica, St Benedict's sister, was erected in 981 In 1053 it was restored and a campanile built, which still exists, and in the middle of the 13th century the church was rebuilt in the Gothic style Other buildings grew up round it. the closster on the right is a fine Romanesque arcaded court with twisted columns and Cosmatesque (13th cent ) mosaics, the south side by Lorenzo Cosmati, the other three sides by his sons (c 1227-1243) See BENEDICTINES.

Arnold Pannartz and Conrad Schweinheim, two German ecclesastics, set up here the first printing press in Italy, issuing an edition of Donatus (1464), followed by one of Cicero (1465) and of Lactantius (1465). Copies of the Lactantius, of the Augustine of 1467, printed not here but in Rome, and of other rare incunabula are preserved here. Still more interesting is the monastery of the Sacro Speco, higher up the hill. The Grotta des Pastori has frescoes of the 9th century, while the Sacro Speco, or cave of St Benedict, contains frescoes of the 13th, and so does the lower church, the latter having been in part repainted in the latter half of that century by an unknown master Conxolus The upper church contains scenes from the life of Christ by a Sienese master of the end of the 14th century, to whom is also attributable a remarkable fresco of the triumph of death and some 15th-century work, and in the chapel of St. Gregory a portrait of St. Francis of Assisi (who was perhaps here in 1218), probably painted before 1228, as it lacks the halo and the stigmata. The whole group of buildings is constructed against the rocky sides of the gorge, part of it on massive substructions

The town contains various buildings constructed by Pius VI, who as cardinal was commendatory abbot of Subiaco II is crowned by a mediaeval castle constructed originally by Gregory VII. (T. A)

SUBJECT: see TERM; JUDGMENT; LOGIC.

SUBJECTIVISM, a philosophical term, applied in general to all theories which hay stress on the purely mental sides of experience, opposed to objectivism. In the narrowest sense subjectivism goes to the logical extreme of denying that mind can know objects at all (cf. SOLTESIM, IDEALISM)

SUBLEYRAS, PIERRE (1699-1749), French painter, was born at Uzès (Gard) in 1699 He gained the grand prix and west to Italy in 1792. His first important work was "Christ's Visit to the House of Simon the Pharisee" (Louvre, engraved by Subleyras himself), ordered by the canons of Ast, which made his repu-

Cardinal Valenti Gonzaga next obtained for him the order for "Saint Basil and the Emperor Valens" (small study in Louvre), which was executed in mosaic for St. Peter's Benedict XIV and all the princes of Rome sat to him, and the pope himself commanded two great paintings-the "Marriage of St. Catherine" and the "Ecstasy of St Camilla"-which he placed in his private apartments. Subleyias shows greater individuality in his curious genre pictures, which he produced in considerable numbers (Louvre) In his illustrations of La Fontaine and Boccaccio his true relation to the modern era comes out; and his drawings from nature are often admirable (See one of a man draped in a heavy cloak in the British Museum ) He died in Rome on May 28, 1749 His wife was a celebrated miniature painter, Maria Felice Thibaldi

SUBLIMINAL SELF. The phrase owes its wide currency to the writings of F W H. Myers, especially to his posthumous work Human Personality and its survival of Bodily Death. In the stricter usage the phrase stands for an hypothesis which seemed to its author to bring almost all the strange facts he observed under one scheme of explanation. But the phrase "Subliminal Self" is now often used by those who do not fully accept Myers's hypothesis, as a convenient heading to which to refer all the facts of many different kinds that seem to imply subconscious or unconscious mental operations. It is the stricter sense that here concerns us

In the speculations of Schopenhauer and of Eduard von Hartmann, the "Unconscious" played a great part as a metaphysical punciple explanatory of the phenomena of the life and mind of both men and animals. But with these exceptions, the philosophers and psychologists of the 19th century showed themselves in the main reluctant to admit the propriety of any conception of unconscious or subconscious mental states or operations. The predominant tendency was to regard as the issue of "automatic" nervous action or of "unconscious cerebration" whatever bodily movements seemed to take place independently of the consciousness and volition of the subject, even if those movements seemed to be of an intelligent and purposeful character. This attitude towards the subconscious is still maintained by some of the more strictly orthodox scientists; but it is now very widely accepted that we must recognize in some sense the reality of subconsciousness or of subliminal pyschical process. The conception of a limen (threshold) of consciousness, separating subconscious or subliminal psychical process from supraliminal or conscious psychical process, figured prominently in the works of G. T. Fechner, the father of psycho-physics, and by him was made widely familiar. In the last half century, there has been accumulated a mass of observations which establish the reality of processes which express themselves in purposeful actions and which bear all the marks from which we are accustomed to infer conscious cognition and volition, but of which nevertheless the subject or normal personality has no personal knowledge.

Among the commonest and most striking of such manifestations is the "automatic writing" which a considerable proportion of normal persons are capable of producing. A person who has this power may sit absorbed in reading or in conversation, while his hand produces written words or sentences, of which he knows nothing until he afterwards reads them. In some cases the matter so written states facts previously known to the subject but which he is unable to recollect by any voluntary effort. And in rare cases the matter written seems to imply knowledge or capacities which the subject was not believed to possess either by himself or by his friends Other actions, including connected speech, may be produced in a similar fashion, and in the last case the subject hears and understands the words uttered from his own mouth in the same way only as those from the mouth of another person. "Tabletilting," "planchette-writing," and the various similar modes of spelling out by the aid of a code intelligible replies to questions, which have long been current in spiritistic circles and which, by those who practise them, are often regarded as the operations of disembodied intelligences, seem to belong to the same class of process. In extreme cases the manifestations of such subconscious or (better) co-conscious operations are so fre-

tation and procured his admission into the Academy of St. Luke. quent, exhibit so much continuity and express so clearly a train of thought, purpose and memory, that they compel us to infer an organized personality of which they are the expression; such are the cases of double or multiple consciousness or personality. Very similar manifestations of a "co-consciousness" may be produced in a considerable proportion of apparently normal persons by means of post-hypnotic suggestion; as when suggestions are made during hypnosis, which afterwards the subject carries out without being aware of the actions, or of the signals in response to which he acts, and without any awareness or remembrance of the nature of the suggestions made to him. The more sober-minded of the investigators of these phenomena have sought to display all such cases as instances of division of the normal personality, and as explicable by the principle of terebral dissociation (see HYPNO-11SM), the more adventurous, concentrating their attention on the more extreme instances, regard all such manifestations as instances of the possession and control (partial or complete) of the organism of one person by the spirit or soul of another, generally a deceased person. Myers's hypothesis of the subliminal self was a brilliant attempt to follow a middle way in the explanation of these strange cases, to reconcile the two kinds of explanation with one another, and at the same time to bring into line with these other alleged facts of perplexing character, especially veridical hallucinations (q v), various types of communication at a distance (see Telepathy), and all the more striking instances of the operation of suggestion and of hypnosis, including the exaltation of the powers of the senses, of the memory and of control over the organic processes.

Myers conceived the soul of man as capable of existing independently of the body in some super-terrestrial or extra-terrene realm He regarded our normal mental life as only a very partial expression of the capacities of the soul, so much only as can manifest itself through the human brain. He regarded the brain as still at a comparatively early stage of its evolution as an instrument through which the soul operates in the material world So much of the life of the soul as fails to find expression in our conscious and organic life through its interactions with this very inadequate material mechanism remains beneath the threshold of consciousness and is said to constitute the subliminal self. It is held to be in touch with a realm of psychical forces from which it is able to draw supplies of energy which it infuses into the organism, normally in limited quantities, but, in exceptionally favourable circumstances, in great floods, which for the time being raise the mental operations and the powers of the mind over the

body to an abnormally high level. Abnormal mental manifestations that have commonly been regarded as symptoms of mental or nervous disease or degeneration are by its aid brought into line with mental processes that are by common consent of an unusually high type, the intuitions of genius, the outbursts of inspired poesy, the emotional fervour or the ecstasy that carries the martyr trumphantly through the severest trials, the enthusiasm that enables the human organism to carry through incredible labours Myers's hypothesis thus boldly inverts the dominant view, which sees in all departures from the normal symptoms of weakness and degeneracy and which seeks to bring genius and ecstasy down to the level of madness and hysteria, the hypothesis of the subliminal self seeks to level up, rather than to level down and to display many departures from normal mental life as being of the same order as

the operations of genius. This bold and far-reaching hypothesis has not up to the present time been accepted by any considerable number of professional psychologists, though its author's great literary power has secured for him a respectful hearing.

10 n lm a respectful hearing.

Billindonskry.—See F. W. H. Myes, Human Personality and its
Survival of Boduly Death (1st ed., London, 1903; and ed., phridged and
edited by L. H. Myers, London, 1904). Motion Prince, The Dissociation of a Personality (London, 1906); I. justrow, The Subcomeons
Earl Murchlon (ed.), The Case for and Against Psychical Belle!
(Worcester, Mass., 1927). Helen C. Lambert, A General Survey of
Psycho Phenomena (1918). See also many papers by various hands in
Proceedings of the Society for Psychical Research, especially in part
ktlv, vol. xvila.

SUBMARINE. The submarine first became a major factor in naval warfare during World War I, when Germany demonstrated its full potentialities However, its advent at that time, marked by wholesale sinkings of Allied shipping, was in reality the culimation of a long process of development

Ancient history includes occasional records of attempts at underwater operations in wai fare. The Athenians are said to have under objective to clear the entrance to the harbour of Syracuse during the sage of that city. In his operations against Tyre, Alexander the Great ordered divers to impede or destroy any submarine defenses the city might undertake to build. But in none of these records there a direct reference to the use of submersible apparatus of any kind. There is, howeve, a legend that Alexander the Great himself made a descent into the sea in a device which kept its occumants dry and admitted light.

Not until 1580 does any record appear of a craft designed to be navigated under water. In that year William Bourne, a British naval officer, made designs of a completely enclosed boat which could be submerged and rowed under the surface. It consisted of to be submerged by reducing its volume by contracting the sides through the use of hand vises Although Bourne never built this boat, a similar construction, sponsored by one Magnus Pegelius, was launched in 1605 But the designers made one serious oversight. They failed to consider the tenacity of underwater mud and the craft was buried at the bottom of a river during initial underwater trials. It is to Cornelius van Drebel, a Dutch physician, that credit is usually given for building the first submarine To him is conceded the honour of successfully manoeuvring his craft during repeated trials in the Thames river, at depths of 12 to 15 ft beneath the surface

Van Drebel's craft resembled those of Bourne and Pegelius in that its outer bull consisted of greased leather over a wooden framework. Oars, extending through the sides and sealed with thigh-fitting leather flaps, provided propulsion either on the surface or when submerged. Van Drebel built his first boat in 1620 and followed it later with two others, both larger but emboding the same principles. It is reported that after repeated tests, James I took a trup in one of the larger models and demonstrated its safety. But despite this evidence of royal favour, the craft failed to arouse the interest of the navy in an age when all conception of the possibilities of submanne warrare was still far in the

Submarine boats seem to have been numerous in the early years of the 18th century. By 1727 no fewer than 14 types had been patented in England alone An unidentified inventor, whose work is described in the Gentleman's Magazine of 1747, introduced an ingenious method of submerging and surfacing his submarine. His craft was to have had a number of goatskins built into the hull. each of which was to be connected to an aperture in the bottom He planned to submerge the vessel by filling the skins with water and to bring it to the surface again by forcing the water out of the skins with a "twisting rod." This was the first approach to the modern ballast tank. By that time, ideas were plentiful, some of them fanciful and grotesque but some containing certain practical elements. Lack of full understanding of the physical and mechanical principles involved, coupled with the universal conviction that underwater navigation was impossible and of no practical value, postponed for more than another hundred years the attempt to include a submarine in naval warfare.

In the American Revolutionary War, a submarine was first used as an offensive weapon in naval warfare. The "Turtle," a one-man submersible invented by David Bushnell and hand-operated by a screw propeller, attempted to sink a British man-of-war in New York harbour. The plain was to attach a charge of gunpowder to the ships bottom with a screw and explode it with a tume fuse. After repeated failures to force the screws through the copper sheathing on the hull of H.M.S. "Eagle," the submarine gave up, released the charge and withdrew. The powder exploded without result, except that the "Eagle" at once decided to shift to a berth fatther out to see

Although his name is most often associated with the invention

of the steamboat, Robert Fulton experimented with submarine at least a decade before he sailed the "Clermont" up the Hudson Fulton's "Nauthus" was built of steel, in the shape of an elongated oval It was somewhat smillar in structure to the modern submarine. A sail was employed for surface propulsion and a hand-driven screw propeller drove the boat when submerged A modified form of coming tower was equipped with a porthole for underwater observation since the persocope had not yet been invented. In 1801 Fulton tried to interest France, Britain and the US in his idea, but no nation ventured to spossor the development of the caft, even though his model was superior to any submarine designed up to that time

Development of the submarine boat was held back during all of this period by lack of any adequate means of propulsion Nevertheless, inventors continued resolutely with experiments upon small, hand-propelled submersibles, carrying a ciew of not more than six or eight men On Feb 17, 1864, a Confederate vessel of this type, the "Hunley," sank the "Housatonic," a Federal corvette that was blockading Charleston harbour. This is the first recorded instance of a submarine sinking a warship The "Hunley" accomplished the feat by using a torpedo suspended ahead of her how as she rammed the corvette Interest in improvement of the submaine was active during the period of the American Civil War, but the problem of a suitable means of propulsion continued to limit progress. Steam was tried and finally in 1880 an English clergyman, Garrett, successfully operated a submarine with steam from a coal-fired hoiler which featured a retractable smokestack. During the same period, a Swedish gun designer, Nordenfelt, also constructed a submarine using steam and driven by twin screws His ciaft, which could submerge to a depth of 50 ft, was fitted with one of the first practical tornedo tubes

Meanwhile, electric propulsion machinery had proved its utility in many fields In 1886 an all-electric submarine was built by two Englishmen, Campbell and Ash Their boat was propelled at a surface speed of six Roits by two 50-bp electric motors operated from a roo-cell storage battery. However, this craft suffered one major handricap—its batteries had to be recharged and overhauled at such short intervals that its effective range never exceeded 86 mit.

Antedating the efforts of Nordenfelt were the experiments of J. P. Holland of New Jersey, who launched his first boat in 1875. Although his early models embodied features that were discontinued as development progressed, many of his initial idea, perfected in practice, came into later use. Outstanding in importance was the principle of submergence by water ballast and the use of horizontal rudders to dive the boat

Not until 1895, however, did Holland, in competition with Nor-denfelt, finally receive an order for a submarine from the United States government. The vessel, named the "Plunger," was propiled by steam on the surface and by electricity when submerged. The original craft was redesigned frequently during construction and was finally abandoned altogether in favour of a newer model then building in the Holland shippard. This was Holland's ninth submersible, but it was the first to be delivered to the U.S. government. It was delivered in 1900 and was the basic design of all submarines to follow.

Simon Lake, who began building submarines in 1894, designed them primarily with peacetume uses in mind. His vessels could travel about the sea bottom and had an air lock which permitted a passenger in a diving helmet to emerge from the hull to walk about and explore In fact, Lake used his extensively in commercial salvaging operations. His first model, the "Argonaut, Jr." was solely an experimental one. It was built of two layers of yellow pine with a sheet of canvas between them and was operated by band

It was followed in 1807 by the "Argonaut," a cigar-shaped hull of ft long and powered by a 30-h p, gasoline engine This craft could submerge to the bottom of a lake or river and roll along the bottom on three wheels. For navigating, the wheels could be raised and carried in packets in the keel. In 1898 the "Argonaut" travelled under its own power through heavy November storms from Norfolk to New York and was thus the first submarine to

navgate extensively in the open sea. In 1006 Lake built the "Protector" and sold it to Russa. After it had successfully passed various severe tests there, Lake built a number of submerables on contract for the Russang sovenment. Thus, the fundamental principles of construction and operation of submarine boats had been determined and demonstrated before the outbreak of World War I. By that time, too, internal-combustion engines, both gasoline and diesel, were available for use as practical power plants. The invention of the peiscope had maternally increased the feasibility of underwater navigation. And the primary weepon of the publication of the peiscope had maternally increased the feasibility of the desired for use. Thus, the publication of t

Construction.—When the submarine rests on the surface, so thit of it is seen above the water that it has the appearance of being longer and more slender than it really is Actually, the modern fleet-type submarine is approximately 1:2 ft long with a superstructure deck tapering almost to a point, both fore and aft, from its greatest width of approximately is ft amidship

The personnel aboard the fleet-type submarme ranges in number from 66 to 76 Officers number from 6 to 8 and men from 60 to 70 Beneath the superstructure deck as the all-welded hull (actually two hulls). To understand the construction of a submarine, the conditions under which the vessel operates below the surface must first be appreciated. The submarine must at all times be water-tight, otherwise, self-destruction would deault. Construction as therefore on the basis of the fabrication of a series of watertight containers into one large watertight cylinder by means of water-tight points. The containers must be pressure vessels, that is, watering. The pressure vessels, being subject to mechanical actions (leverage), must be secured to each other by one common strength member (the keel) as well as by watertight connections foulkheads).

In the double-hull type of submarine, the pressure hull is haside the outer hull; between the two hulls are the water and the fuel oil tanks. On US submarines the double-hull construction extends from the after bulkhead of the forward torpedo room to the forward bulkhead of the after torpedo room. The pressure or mner hull extends from the forward bulkhead of the forward turn tank to the after bulkhead of the after trum tank. Above the hull is buult a nonwatertight superstructure which forms the main deck, for use when surfaced

The topside nonwatertight superstructure deck extends the length of the ship The space between this deck and the pressure hull is used as locker space for stowing anchor gear, lines and other equipment that is not damaged by immersion in water Ready ammunition in watertight boxes easily accessible to gun crews is also kept in the superstructure. The ship's small boat is stowed in the superstructure on special cradles. The deck is perforated on either side with circular holes along the entire length to prevent air pockets from forming within the superstructure when it becomes flooded. A watertight tower, known as the conning tower, extends upward through the superstructure amidships. The top of the conning tower is used as a bridge when on the surface, but when submerged the control of the boat is maintained either from the conning tower or from a compartment directly below it known as the control room. Periscopes operated from the conning tower extend above the bridge and are used for making observations when submerged

The modern feet-type submarine is built to withstand the pressure of a head of sea water, consistent with requirements as pressure by battle experience and with naval specifications. The pressure is measured in actual submergence tests from the surface of the water to the axis of the vessel through its pressure hull.

Individual compartments are air tested for tightness only, to a pressure of 15 lb per square inch Wateright bulkheads are designed structurally and strengthened through reinforcements to withstand the pressure at the previously mentioned test depths.

The total pressure that the hull must withstand is actually the

navigate extensively in the open sea. In 1906 Lake built the differential piessure between the interior hull pressure and the "Protector" and sold it to Russia. After it had successfully passed external head of water at a given depth

Armaments.—To pedo tubes are the main oftensive and deiensive aimament of the submarine. A total of ten 2x-in tubes is usually carried, six forward and four aft. The tubes can be fired electrically or by hand when surfaced or submerged. The condition of the tube is indicated by the topredo ready lightly

The 5-IN 25-cal deck gun is a dual-purpose gun. It is so mounted as to be used effectively against surface craft and arcraft. Two guns may be carried, if one gun is carried it is located abact of the conning tower. However, this is used only in emergency or when the taget is not considered worthy of expending a torpedo. Light anti-aircraft guns (40 mm and 20 mm) are mounted forward and aft of the conning tower. They are principally anti-aircraft weapons, but may be used against surface craft. In addition to the armament described above, the fleet-type submarine carries other small arms and pyrotechnics. Chief among these are machine guns and submachine guns. During World War II submarines also carried mines which could be discharged from the torredo tubes.

The submanne is essentially a torpedo vessel, launching its torpedoes while submerged or surfaced. The size of its torpedo and the number of tubes gradually increased, until by mid-soft century the 11-in. torpedo was being launched from 6 torpedo tubes forward and 4 aft, the submarine carrying 24 torpedoes. The tubes are horizontal fore and aft and can be loaded from within the submarine The tube is fitted with doors at either end so that the inner door can be opened when the outer door is closed and vice versa. The torpedoes are dischaged by air pressure either by remote control from the conning tower or at the tubes by operating personnel.

Subdivision.—A modern submarine contains, in addition to the mechanisms required to operate it on the surface, a multitude not operating machinery and tanks which enable it to drive, surface and proceed submerged. Although it so not of the most compared to the most compared to the submarine and proceed submerged. Although its one of the most compared vessels afloat, it is designed and arranged along simple and logical lines, and in spite of the seeming confusion of valves, lines and apparatus, everything in the submarine is situated to ensure the maximum of speed and efficient such as the submarine is situated to ensure the maximum of speed and efficient speed and efficient such as the submarine is situated to ensure the maximum of speed and efficient speed speed efficient speed and efficient speed speed and efficient speed speed speed and efficient speed efficient speed sp

The modern fleet-type submatrne consists of a superstructure and a hull surrounded for the most part by varrous fuel and water ballast tanks The pressure hull, designed to withstand the sea pressure, houses most of the ship's machinery and provides the living quarters for the officers and the crew. It is divided into eight watertight compartments, separated by pressure builkheads provided with waterlight pressure-ressing doors. The minth compartment, the coming tower, in the shape of a cylinder placed on its side, is located above the control room and connects with the control room through the access hatch

The compartments in turn are divided by means of the platform deck into upper and lower sections which contain the spaces housing the vanous equipment and providing the necessary facilities for the submarine's officers and crew.

Exterior.—The exterior view of the submarine presents a very low silhouette, primarily because the vessel is designed to have a low positive buoyancy to permit quick submergence and normally is two-thirds submerged as it rides on the surface

The extenor hull has a cylindrical shape which gradually tapers of from the middle both forward and sit, giving a cigar-shaped appearance. The superstructure deck, called the main deck, excels virtually from the tip of the bow to near the stern. The deck is generally level. Beginning about the midship section it rises gradually in the direction of the bow to a height of approximately 12 ft. above the water line. The freeboard of the after end of the man deck is about four feet.

The main deck is attached to the exterior hull by means of the framing and rounded sides. Limber holes in the sides allow sea water to enter all hollow spares in the superstructure and the deck when diving, and drain off when the submarine is surfacing. The midship section of the main deck is occupied by the conning tower, which is surmounted by the bridge deck, with perscope shears, periscope, radio compass loon and madra gear.

The after section of the bridge deck contains the ship's pelorus, one anti-aircraft gun and ammunition ready lockers. The forward part of the bridge is similarly equipped with anti-aircraft guns and ammunition lockers

The forward section of the main deck houses the capstan, marker buoy, forward escape and rescue hatch, cleats, hydrophone, forward torpedo loading hatch and radio antenna The after section of the deck contains the 5-in 25-cal gun, galley access hatch, after engine 100m access hatch, after torpedo loading hatch, and escape hatch, marker buoy and capstan

The bow is equipped with six torpedo tube shutters, three on the port and three on the starboard side, and also the bow diving planes. The underside of the hull contains ballast tanks, flooding ports and underwater sound heads

The after end of the ship on the underside is equipped with the four stern torpedo tubes two to a side, port and starboard screws, the diving planes and the rudder

Tanks.-In a submarine, the principal ballast is water. Therefore, the arrangement of the tanks built into the ship establishes the points at which water ballast may be concentrated It is the arrangement of these tanks that makes possible controlled diving and surfacing and the maintenance of diving trim at any depth The arrangement of the tanks with respect to the centre of buoyancy establishes the lever arm for maintaining fore-and-aft balance and athwartship stability.

The water ballast tank groups consist of four groups, which are further subdivided into ten tanks. There are three fuel ballast tanks divided into A and B sections which are connected through limber holes in the vertical keel plating. The fuel ballast tanks normally carry fuel oil. When not being used as fuel ballast tanks

they may be used as main ballast tanks

In addition to the above-named water ballast tanks, there are the normal fuel oil tanks, collecting tank, expansion tank, clean fuel oil tank, main sump tanks, reduction gear sump tanks, freshwater tanks, emergency fresh-water tanks, battery fresh-water tanks and sanitary tanks The main ballast tanks are water ballast tanks They are designated as main ballast tanks because they account for the greater percentage of the water ballast normally carried. They have as their primary function the destroying or

restoring of positive buoyancy The main ballast tanks are located between the pressure and outer hull and are separated by light athwartship bulkheads. These tanks are provided with flood openings located at the lowest point

possible on the outer hull.

All main ballast tanks have hydraulically operated vent valves. Sea water is admitted to each ballast tank through flood ports, located in the bottom of the tank near the keel. Air is vented out of the tank as the water is admitted through the vent valves located on top of the tank To force water out of the tank when it is desired to surface the submarine, high-pressure air is admitted into the tank, forcing the water back out of the flood valves

For correcting any alteration in the longitudinal distribution of weight, a "trim tank" is fitted at either end of the submarine. They are partially filled in the normal diving condition and connected by a pipe through which water is forced from one to the

other as required.

"Water around torpedo" tanks are fitted below the centre of length of the torpedo tubes and contain sufficient water to fill the spaces around the torpedoes when in the tubes. By their use the torpedoes can be left dry in the tubes and withdrawn for examination. If it is desired to fire a torpedo the tube is closed, the water from around the torpedo tanks is blown into the tube and when the door of the tube is opened no water enters and the weight of the submarine is unaltered. It is necessary to keep a constant check of variations in weight on the submarine to maintain a good "diving trim" at all times.

The fuel oil is the main item for which compensation is needed. The fuel is stored in the normal fuel oil tanks or in the fuel ballast tanks. The fuel tanks are completely filled with oil and are positioned symmetrically transversely and longitudinally. When fuel from a tank is required it is forced to the clean fuel oil tanks and thence to the engines by pumping sea water into the bottom of the tank. The oil passes out through a line at the top of the tank

Air Systems .- The importance of the air systems to a submarine cannot be overemphasized, for virtually every function in the diving and surfacing procedure stems initially from air provided by one or more of the air systems. The main hydraulic system, for example, operates because of the air pressure maintained in the air-accumulator flask, toipedoes are discharged by air; and the main propulsion engines are started by air Air or, more specifically, compressed air, is necessary to surface, submerge, attack and cruise Compressed air together with oxygen is used to revitalize the air in the ship after long periods of submergence Pressure in the boat, a test for tightness, utilizes air,

Compressed air is stored in banks consisting of seven or more flasks with a total capacity of 560 cu ft at 3,000 lb per square inch. It is supplied by two high-pressure air compressors located in the pump room, a cellarlike compartment located directly beneath the control room. Compressed air can be obtained also

from a tender ship from outside connections.

Trim and Drain Systems .- A submarine is designed to dive or surface rapidly under complete control, it must be able to proceed on the surface and to submerge at the desired rate of speed to the depths required. To do so quickly and efficiently, it must maintain fore-and-aft balance and athwartship stability. The chief function of the trim and drain systems is to maintain this fore-and-aft balance by controlling the amount and distribution of water in the various tanks used for this purpose Two motordriven pumps are provided for pumping out the submarine's tanks or bilges, they are capable of pumping against any depth pressure at which the vessel is designed to operate Both deliver or discharge overboard or from one tank to another, as desired They are also capable of pumping certain ballast tanks in case of compressed-air failure

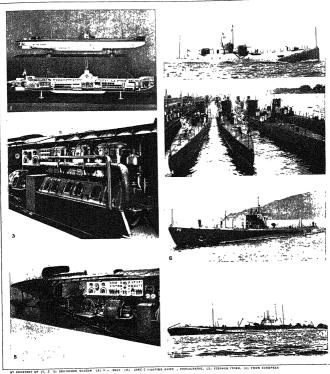
The rudder of the submarine is similar to that of any surface vessel. Under normal operation the steering system has its own source of electrohydraulic power The principal control units are assembled in the steering stand, located in the control room, However, since there is a steering wheel in the conning tower, to allow for every contingency the steering system is so planned that three different methods of steering are available, based on three different sources of hydraulic power-normally used power, hand and emergency. The rudder itself is moved by hydraulic power in all three cases, the only difference between these methods is

in the manner in which the power is developed

Bow and Stern Planes.-The hydroplanes or bow and stern planes, which are actually horizontal rudders, are used for depth and angle control of the submarine when operating submerged They are rectangular in shape and can be turned through 35° sither way. They also are controlled electrohydraulically The after pair when in a neutral position give the submarine a certain stability. The forward pair can be folded into the side of the superstructure which is called the housing. This decreases water resistance and the planes are not subject to additional strain when on the surface The bow planes also assist in submerging the vessel as they overcome the slight amount of buoyancy carried by the submarine, present even in a submerged condition. Hydraulic power is used to tilt the bow and stern planes. Each system (bow and stern planes) has its own power supply system. The control units for diving and rising are assembled in a diving control stand located in the control room. There is a set of controls for stern plane tilting, a set for bow plane tilting and control valves for bow plane rigging. The control panel has diving indicator gauges and motor switches. The planes are operated by enlisted crew members

Periscopes .- The periscope is the eye of the submarine It was invented and developed solely for the purpose of providing a means to view the surface without detection by surface craft While it is primarily simple in principle, actually it is a complicated piece of apparatus. It is probable that all navies of the world have similar instruments with only minor variations

The earliest submarines were built without provision for periscopes and when submerged were forced to grope their way blindly. In 1854 E. M. Marié-Davy, a Frenchman, designed a submarine



# INTERIOR AND EXTERIOR VIEWS OF VARIOUS TYPES OF SUBMARINES AND SUBMARINE MODELS

- 1 Exterior view and longitudinal section of the U-1, the first German U-boat Displacement on surface, 240 tons. Armament one bow torpedo tube; carrying capacity, three torpedos Exped on surface, 11 knots, submerged, 9 knots Built at the Germania Works, Kiel,
- in 1906
- in 1906
  IM S. "Y!" Displacement on surface, 2.525 loss, submerged, 3,600 tons. Armanest four Scin and Scin are typed tube. Seed 5. March 1906
  S. Munich Museum model of the U-1, showing that portion of the engine room containing the 450-hp. patroleum motors used to drive the twin screw which propil the submarine on the surface.
- 4 Fleet of Nazi submarines at home port. The three at the left in the
- first row are occangoing (740 tons, six 21 in torpedo tubes, speed 18% knots) U-45, right, is seagoing (517 tons)
- Munich Museum model of the U-1, showing the aft section of the sub-marine and the electric drive, including one of the 200-h p motors used for propulsion
- USS "Pompano" of the Perch class, launched in 1937 Displacement, 1,330 tons on surface Armament one 3-in, gun and six 21-in, tornedo tubes
- 7. Japanese first class submarine "155" Displacement on surface, 1,650 tons, submerged, 2,100 tons Armament one 4,7-in gun and sight torsed tubes Speed on surface, 21 knots; submerged, 7-9 knots Guilt in 1927

sight tube containing two mirrors, one above the other, held at a 45° angle and facing in opposite directions. These, while providing some degree of sight to the submerged vessel, were faulty at best, and in 1872 pisms were substituted for mirrors.

A U S naval man, Thomas H. Doughty, was the inventor of the original modern periscope, during the American Civil War

The essential function of a perscope is to give the person coming for the submanne a view of the surrounding horizon while his vessel remains submerged. The perscope must be long enough to extend beyond the surface and must deflect the horizontal rays of light first in a downward direction and then horizontally to the eye of the observer. In addition, the past above water must be as inconspicuous and streamlined as possible, in the form of a long narrow that The instrument used on U.S. submannes is of 40-f1 nominal length and 7½-m outer diameter. It is equipped with a tilting head prism capable of elevating the line of sight 74,5% above the horizon and of correcting for the roll or patch of the vessel.

Propulsion Engines.—The first U S submarines utilizing internal-combustion engines for propulsion were powered by 45-hp, two-cylinder, four-stroke cycle gasoline engines produced by the Otto company of Philadelphia, Pa Meanwhile, early British submarines made use of 12-and 16-cylinder gasoline engines.

The inherent hazards accompanying the use of such a highly volatile fuel as gasoline were quickly realized Stowage was a constant problem and handling of the fuel was extremely dangerous Internal explosions were frequent; many of the engines off considerable carbon monoxide fumes creating a menace to personnel.

In the meantime, M.A. N. (Maschinenfabrik Augsberg-Numberg A.-G.) of Germany built and experimented with two-stroke cycle diesel engines for submarine propulsion. However, insufficient progress had been made in metallurgy to provide metals capable of withstanding the greater heat and stress inherent in diesels M.A.N. then turned its efforts toward production of a four-stroke cycle diesel engine capable of developing 1,000 hp. While Inity successful, these engines eventually developed structural west-nesses at the craikcase. Pror to 1920 the engines used in most submarines of all the larger may powers with the exception of Green Britain were foundationed to the exception of Green Britain were foundationed to the complete of t

The need for more powerful engines became apparent with the development of the fleet-type submarne Eventually a 16-cylinder single-acting engine was developed as well as a 9-cylinder double-acting engine. The fact that submarines are both subsurface and surface vessels places definite restrictions upon size, buil design and shape. Total weight is also a factor having considerable bearing on underwater operations. In the first engine-powered submarines the engines were mechanically connected directly to the propeller shafting. However, after testing various types and designs, it became apparent that the disease-lecture drive was the best In this type, the engines were connected only to the generators, which in turn supplied power to the main motors driving the propeller shafting. The generators were also used to charge the storage batteries.

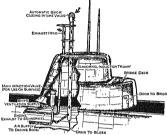
The modern fleet-type submarine is usually driven by four main propulsion diesel enganes, each capable of producing 1,600 h.p. The four main generators each produce 1,100 kw. There are four solv-speed motors, driven by the generators or batteries, each producing about 1,375 h.p. The auxiliary engine us rated at 450 h.p. and drives a 300-kw, senerator.

Batteries.—When submerged the diesels and generators are not used, and power for the motors is supplied by two sets of storage batteries, which are charged by the auxiliary and main generators during surface operations.

Each submarine has two main storage batteries consisting of two groups of 126 cells each. The forward battery is installed below decks in the wardroom country; the after battery is located in the crew's space. Each cell weighs approximately 1,650 lb. Each batters is fitted with an exhaust ventilating system to remove battery gases. The air required to operate this system is supplied through inlets located at opposite ends of each battery well. The free ain in the compartment is drawn through the filling vent connection of each cell. This is necessary in order to eliminate battery

gases and hydrogen which develops when recharging the batterns.

The "Schnorkel" and "Guppy."—In the latter part of World
War II the Germans adopted a radical change in submarine design
known as the "schnorkel"—a Dutch invention The spelling was
reduced by the Americans to "snorkel" and further abbreviated
by the British to "snort." Development of improved sonar (underwaters ound-detecting and ranging equipment) and radar, used by
both aeroplanes and surface craft against axis submarines, forced
the Germans to develop the new device.



SCHEMATIC DRAWING OF THE SCHNORKEL WITH RETRACTABLE PERISCOPES AND MAST SHOWN HERE IN UP POSITION

The schnorkel is a breathing tube which is raised while the submarine is at penscope depth. With the schnorkel in raised position, air for the disesis can be obtained from the surface. This considerably reduces the visible portion of the submarine and also electrical consumption, since the submarine can cruise almost totally submerged on its engines and conserve its battery power for attack and evasive manoeuvres

At the end of World War II the United States navy developed an improved schnorkel and also the upply submarine. The guppy ("greater underwater piopulson power") had the same type hull as that used for the fiele-type submarine of World War II fame. It was 36 ft. long and displaced about 1,800 tons. The only change in the bull was in the superstructure, which was radically changed by reducing the surface area and streamlining every protruding object. The life lines and all guns were removed, the bitts made retractable and the persone shears (supports) enclosed in a streamlined metal fairing. All topside equipment and armament were either removed, made retractable or streamlined. The speed of the new guppy was considerably greater than that of the feet-type boat, and nearly twice that of the old-type sought some process.

Developments After World War II.—The lessons of Nordo War II wrought great changes in submanne construction. Topedoes came to be fired by hydraulic (water) pressure matead of compressed air as previously, eliminating any chance of tellar eliar bubbles escaping to the surface and betraying the submanine's presence.

Hulls were given greater strength for deeper diving that enabled the submarine to pierce depths far below those previously possible Hydraulic mechanisms (oil) were employed extensively throughout the ship for quiet, efficient operation. Radar and sonar coujument increased in efficiency. Torpedoes no longer had to be fired with sharpshooting accuracy; fore-control equipment and homing torpedoes (the torpedo that

seeks its target) eliminated much of the guesswork and chance in firing torpedoes Engines, electrical motors and generators were made more compact

Atomic power became a practical reality to be used for the first time in a submainine projulison plant. Nuclear power was specified to generate steam within the hull of the US submarine "Nautius" as a result of a contract awarded to Westinghouse Electric corporation; and also to generate steam within the hull of the US submarine "Seawolf" as a result of a contract awarded to General Electric corporation. The keel of the "Nautilius" was laid at Groton, Com., in June 1925

Although nuclear power was a radical change in a source of energy, its application to ships was conventional in that steam and turbines had been used in ships, but unconventional in that; it was the first time that US submarines had used steam since the very first unsuccessful submarine, and in that this was the first turbine installation in a US submarine. Steam was to be generated and used to drive steam-turbine generators which in turn duve the propulsion motors and shaft to which the screws are fixed Themeans of propulsion along with greater speed would also give the submarine an advantage of almost unlimited crusing range, a limit probably restricted only by the endurance of the crew and the food the ship can store (H.S.DV.)

SUBMARINE CAMPAIGNS (WORLD WARS I AND II). At the outbreak of World War I in 1914, many people doubted whether the submarine was a senous menace to surface ships, but their confidence was rudely shaken when the British crusers ("Cressy," "Guget" and "Sullej" were torpedoed by the German "U 9" off the Belgan coast with a loss of 1,200 lives It was then clear that the submarine was going to prove a very senous factor in naval warfare and, furthermore, that many British harbons law well within their rudius of action

Boom defenses for Brutsh harbours were practically nonexistent, even in the case of Scapa Flow, the recognized war base for the grand fleet in the Orkney Isles A false alarm of an enemy submanne in the Flow on Sept 1, 1914, caused this anchorage to be abandoned by the fleet in favour of Loch Ewe on the west coast of Scotland, until submanne defenses could be hurriedly placed there

British submarnes were employed patrolling off the Heligoland bight and narrow waters round the coast on the lookout for enemy men-of-war, and U-boats were soon busy attacking the troop transports going to France To meet this attack the Dover patrol was organized, consisting of destroyers and small craft backed up with extensive mine fields

The range and efficiency of the submarine increased rapidly and British boats were employed effectively in waters such as the Baltic and Marmora, which were demed to British and Allied shipping by rifine fields. By June 19; U-boats had entered the Mediterranean and, working from Austran Adriatic ports, became a sention smeace to the Dardanelles and Salonika expeditionary forces.

Up to the end of 1914, the U-boat, though achieving considerable success, was having but little effect on the naval situation, but the sinking of six merchant ships on Jan. 30, 1915, gave an indication of what was to come. On Feb. 2, in regly to the British declaration of blockade of the enemy coasts, Germany published a notice warning all penetral shipping against approaching the coasts of Britain, followed by the celebrated memorandum of Feb 4 pro-diming that after Feb. 18 the waters around Great Britain would claiming that after Feb. 18 the waters around Great Britain would found there would be sunk without regard to safely of passengers or crew and that even neutral shaps would be in danger. The United States pointed out the illegality of this but the protest was directagated.

Antiubmatine Measures.—In Great Britain the state insurance scheme prevented panic and the order in council of March 11,
lonova as the Retalatory order, was issued. Merchant ships were
advised as to what precautions to take, the best procedure to
adopt when attacked and as to the use of wireless telegraphy.
Mine fields were laid to protect shipping routes in the North sea,
the auxiliary patrol was strengthened and various navigational
measures were adopted. In spite of all precautions losses com-

tinued and the range of attack increased, but there was hittle diminution in the flow of trade. Many victuris were claimed by the German mine-laying submarines, which laid their mines close to light vessels and buosy, these mines claimed victimes of all nationalities on the British east and south coast routes. After April to the bugger U-boats operated only in the North's and western approaches, where Scandinavian shipping suffered most severely

The sinking of the passenger ships "Palaba" and "Lustania" in May 1915 with heavy loss of life caused widespread indignation, and following US protests the German government gave orders that large passenger ships were to be spared A further US protest on the occasion of the sinking of the White Star line "Arabic" called forth fresh orders from Germany, and September saw the end of the first campaign in British waters

The 1916 Campaign .- During the winter of 1915-16 the U-boat fleet was increased and Germany decided to sink defensively armed merchant ships without warning, though passenger ships were still to be spared The sinking of the "Sussex," clowded with passengers for Dieppe, F1 , brought further strong protests from the U S president and again Germany gave way However, the Allied blockade bore so heavily on U S commercial interests that feeling against England grew bitter and tension between the U.S. and Germany diminished Encouraged by this, Germany decided to renew its war on commerce, and Scandinavian shipping especially suffered severely The rate of sinkings rose so fast that Adm Sir John (later Earl) Jellicoe took the unusual step of writing to the prime minister directly, calling his attention to the fact that the loss of shipping alone might soon force the Allies to conclude peace He was in consequence appointed first sea lord so that he could devote himself to finding the answer to this problem Tension between the US and Germany again increased because of the depredations of a U-boat off Nantucket During Dec 1916, 167 Allied and neutral ships were sunk and in Jan. 1017 the loss rose to 180 This favourable result led Germany to resume unrestricted wartare, and on Feb 1, 1017, it declared the areas enclosing Britain, France and the Mediterranean to be war zones, adding later the Portuguese Atlantic isles and Archangel Vessels of any nationality or character found in the war zones were to be destroyed without consideration for the lives of those on board

Losses increased rapidly and it appeared that the U-boats would win the war. They were being built faster than they were being destroyed and it was clear that the existing methods of dealing with them were inadequate On Apin! 70, he worst day of the worst month for Great Britain, 12 merchantimen and 8 fishing vessels were sunk One out of every four vessels that left the British Isles that month never returned, but in Apin! 1917 the unstricted war on commerce brought the United States into the struggle and by the end of the year that nation had sent 37 destroyers to assist the Allies

Convoy System.—Some new form of defense was obvously necessary, and the convoy system which had been used in the old French wars was resorted to in spite of strenuous opposition from many quanters because of the great difficulties and inconveniences entailed. It was first employed on the short voyages to France, then for those to Scandinavia, and such was its success that the system was introduced on other routes as soon as secort craft became available. By November the losses were reduced to less than half what they had been in May, and as the losses in shipping decreased the destruction of U-boats increased Scientists and inventors were also at work and the first success with the hydrophone had been obtained on April 23, 1916, when the trawler "Cherio" located the U.C.3 with a hydrophone and beath thanks.

As 1917 progressed, it became increasingly clear that the submanune attack on commerce had been countered. The U-boats failed to impede either the transport of British troops to France or of U.S. troops to Europe and by Oct. 1918 the building of new ships had overtaken the sinkings. Aeroplanes and dirighle balloons were in use for spotting U-boats and for some time the latter had considered the Straits of Dover too dangerous for use.

With the advance of the Allied armies the Flanders bases had to

be abandoned and the U-boats in them blown up

By the end of World War I the British grand fleet possessed a submarine flotilla designed to act with it as a tactical unit, but no opportunity occurred for testing its capabilities in battle. At the Annistice 138 U-boats were surrendered and brought to Harwich

#### WORLD WAR II

Opening Stages.—Conditions at Scaps Flow in 1939 hore an unfortunate issemblance to the conditions in 1941. In 1914 there were no nets, only a few old guns, in 1939 there was only a single line of antisubmarine nets, a few blockships and eight anti-arcraft guns. In each case the fleet had to evacuate the base temporarily for Loch Eve, a great disadvantage which entailed many extra hours steering to the focal points in the North sea and to the Sheland-Norway massage.

The 1914 evacuation was the result of a false alarm of a submarine in the Flow, the 1939 one was occasioned by the sinking of HMS "Royal Oak" by a submarine and the bombing of

HMS "Iron Duke" a week later.

In Aug 1939 Germany had 60 U-boats ready for action The Bittish fleet and coastal command was prepared, but conditions were less favourable to Great Bittain in some important respects than they were nyi4. From the start Erre detared itself a neutral and Bittain was deprived of three valuable bases, Queenstown, Berchaven and Lough Swilly. Italy was obvously going to join Germany, and after the fall of France and Norway all the coast of Europe from the North cape to the Spanish frontier was hostile. This entailed Britain's abandomment of the southwestern approaches to the English channel because of the threat from the arr, a much longer sea passage round the north of Ireland and heavy additional convoy commitments for Scotland and the North sea.

The German U-boats had changed little in size and shape between the wars, but had improved in speed and were able to remain submerged for long periods without suffacing, especially in 1044, when they were equipped with the schnoles. They could go far deeper than before, which was not at first realized by the Isitish, and they were armed with electric torpedoes which had no discharge bubbles and left no track. Great advance had been made by both belligerents in avaition and means of communication, and the mistitution of the British constal command for close and active cooperation with the fleet was to have most important results. The bomber command also played an important part in sea warfare as well as on land

To the British submannes and the aircraft of the coastal command fell the important duty of carrying out the close blockade of Germany's coasts and harbours, England's traditional weapon against continental enemies in all its European wars. This proved an arduous, perilous and most monotonous duty, which extended over a constantly increasing area as Germany overran country after country.

Germany waged unrestricted warfare from the outset, and the British convoy system was in operation from mid-Spt. 1939 as far as the supply of escort vessels would permit. At the start the U-boat attack was connectitated on the focal areas and was countered by surface patrols assisted by spotting aircraft from carriers, but after the sinking of H.M.S. "Courageous" this practice was abandoned. The British occupation of Iceland and the Faerree Islands in 1940 provided new escort and air bases and forestalled their occupation by Germany.

Great Briain had invented the ascir. (Allied Submarine Devices Investigation committee), a great improvement on the hydrophone, as it gave the direction of the U-boat accurately Radar had been invented but was not titled in the Allantic escort vessels uil 1941. HF/DF (high-frequency direction-inding apparatus) was introduced in 1942. The question of convoy escort had received attention before the start of World War II.

In view of the possibility of a German-Japanese attack, Pres. Franklin D. Roosevelt and Winston Churchill had, as early as 7940, agreed on Plan "Rainbow" prepared by their chiefs of staff for joint action if necessary. Under this plan the defeat of Germany was regarded as the first objective and that of Japan as the second. Consequent on the Japanese attack on Pearl Harbor on

Dec 7, 1941, the combined chiefs of staff committee was formed with headquaiters in Washington, D C Great Britain underteok responsibility for the east Atlantic. Mediterranean and Indian occans, and the U S undertook the west Atlantic and the Pacific with the assistance of Australia and New Zealand

Battle of the Atlantic.—At the beginning of World War II, as in 1914, Great Britain was very short of escort vessels, was mediate steps were taken to mass-produce the necessary small craft. The German procedure was to attack convoys at periscope depth by day, or single shape with guafire, and magnetic mines were laid in large quantities, causing many casualties until the simple antitode of degaussing shaps was discovered

Toward the middle of 1940 Germany withdrew its U-boats for use in the Norwegan campaign, thus affording a temporary feel to the convoys, but the overrunning of France and Norway provided Germany with a number of new base. Britain had valued the use of the southwestern approaches, and the occupation of Norway brought the U-boats much nearer to the for-

point of British commerce

In March 1941 there was a change in U-boat tactics Because of their superior speed they found they could attack on the surface at night, but Britain was fitting radar in the escort vessels and in this month it made its first kill. Fear of invasion necessitated a reduction of convoy escorts and this caused the toll of shipping losses to rise considerably, especially as the production of U-boats exceeded sinkings. However, Great Britain increased the coastal command, and new aircraft of greater range enabled the air patrols in focal areas to drive the enemy into the open ocean Germany also produced a better aircraft, the Focke-Wulf, but, because of the lack of co-operation between the navy and the air force, the results were less satisfactory. Though they were attacking as far west as longitude 40°. Great Britain now had new air bases in Iceland and Newfoundland and could provide escorts for food convoys to Halifax, N.S : Gibraltar; and Freetown, Sierra Leone. Germany had to devise some new method of attack.

The Pack Attack.—The new idea was to attack a convoy with a number of U-basts over a short period of time so that, if some boats were discovered and counteratusched by the escorts, other words, they shadowed the convoy and with their superior speed were able to concentrate on it and swamp the secorts. These pack attacks during 1941-43 were made at night. To deal with them the escorts were provided with "escort carriers," small arriers arranged and the secorts were provided with "escort carriers," small arriers, arranged carriers whose planes could search out the surrounding waters by daylight. Escort teams were given intensive training and instruction and they were kept together in units as far as possible, but the ausburst still increased.

U.S. Entry Into the War.—In spite of Plan "Rainbow," the U.S. was unprepared for submarine warfare when Pearl Harbor was attacked it had no convoy organization and lacked escort and arcraft. In Jan. 1942 Germany had so U-boats operating in U.S. coastal waters, causing very heavy losses. By May the U.S. had coastal convoys in operation and an consequence the U-boats shifted their attacks to the Cambbean area.

For a time the coastal convoys had an easer task but the Russian and Malta convoys suffered severely. The Russian convoy route had to be closed for a time, but not before an alternative supply route had been completed by rail through Iran. After the fall of France, with the exception of Spam, both sides of the Mediterranean from Gibrular to Egypt and Turkey were in the hands of the axis powers. Convoys from Malta to Alexandria had to pass through the narrow waters between Sicily and Tunis, "bomb alley" as it was called, where they were exposed to intensive attack from submainies and aircraft. Since May 1940 the Mediterranean had been closed as the supply route to the east, British shipping not only for India and the far east being sent round the Cape of Good Hope, but even that for Egypt, which entailed an extra 12,000 mil. steaming.

Convoys could get through to Malta only at great hazard. Nevertheless, the submannes based on Malta played a decisive part in the North African campaign, preying on the axis convoys supplying the North African armues. Up to the time of the ad-

vance of the 8th army from El Alamein, they and the air and surface craft based on Malta together sank 300,000 tons of shipping The part Malta played in Mediterranean operations was realized by Germany and an intensive attack in Maich 1942 was intended to reduce the island, but vital convoys got through and in spite of heavy losses they and the "magic caipet" kept the island supplied The magic carpet was a submatine ferry service which transported large quantities of essential gasoline and stores of all kinds from Egypt The German forces might have overrun Egypt but for the heavy losses of men and supplies caused by the Malta patrols

With the entry of Japan into the war Japanese submarines oper-

ated in the Indian ocean

The "Black Pit."-Though the whole of the east coast of North America was now Albed territory there was a large area of the North Atlantic which could not be patrolled by the coastal forces acting from Britain, Iceland and North America This area, known as the "gap" or "black pit," had to be crossed by the convoys When Germany decided it was advisable to avoid coastal command on both sides of the Atlantic, U-boat attack, organized and controlled from headquarters in France, was concentrated in this area The plan was to employ packs of up to 25 boats and send them independently to take up positions about 12 to 20 mi apart on a prearranged patrol line in the gap. No convoy could pass through this patiol line without being seen provided the line was complete, and "milch cow" U-boats kept the pack supplied with fuel and stores

The U-boats kept a lookout on the surface until a convoy was sighted The one sighting the convoy immediately dived and later noted its size, course and speed through its periscope. No tornedo was fired, but when the convoy was out of sight the Uboat surfaced and reported by wireless telegraphy to headquarters in France Headquarters picked up this report and repeated it back to the pack for information, together with instructions as to closing and making contact It was the duty of the boat which sighted the convoy to keep touch and report the convoy's move-When a sufficient number of U-boats had been collected, headquarters would order the attack, when the U-boats would get into position and speed in on the surface after dark

These pack attacks were devastating at times and the clisis of the battle of the Atlantic was reached during the foul weather in the early part of 1942. The general situation corresponded closely to the 1917 crisis That crisis was met by adoption of the convov system, but in 1942 there was no new method to be tried The only solution was more and more coastal command aircraft of longer range to reduce the black pit, more and more escort vessels, more research and much more intensive training of the escort groups

March was the crucial month and by April the German efforts began to slacken In May the wolf pack suffered three severe defeats and no further attack developed until September when the Germans tried their new acoustic homing torpedo. These torpedoes inflicted severe damage on the escorts but did not overwhelm them. The convoy was unharmed and the pack suffered considerable loss. This was the turning point of the battle of the Atlantic; the Germans found their losses too heavy and withdrew their U-boats for rearming and better equipment.

The Bay Offensive .- For months in early 1943 there had not been a single sinking in the North Atlantic. Teamwork had beaten the wolf pack attack. As soon as it was certain that the packs had been cleared from that area, Britain turned to the task of sealing off the Bay of Biscay, to prevent their assembling in the North Atlantic again The support groups and the majority of the eastern strength of coastal command were switched over to present a strong barrier against the egress of the U-boats from the bay The acquisition of a new air base in the Azores in 1943 greatly assisted in this, as the Albes thereby obtained full air cover right across the Atlantic The offensive was now in the hands of the Allies, but this "flooding of the bay" was no easy matter. Coastal command was principally concerned close in shore while the surface forces operated farther out, but the Uboats were now provided with strong anti-aircraft armament and, acting in groups of four to provide mutual support, provided tough

opposition to the aircraft

In 1944 the U-boats were able to counter the flooding of the bay temporarily because of the invention of the schnorkel, which enabled them to remain constantly submerged and almost impossible to detect by radar The asdic had once more to be depended on Convoy battles flared up again, but the U-boats sustained heavy losses and in March they were withdrawn in order to prepare for the Allied invasion

The Midget Submarine.—A human torpedo had been invented in Italy which could be navigated by a crew of two men seated astride of it and by means of which they could secure explosive charges under the bottom of a ship at anchor Several of these craft were ready in Aug 1941 and, by infringing the neutrality of Spain, Italy arranged a depot ship off Algeriras from which these craft could attack ships at anchor off Gibraltar These intrend men succeeded in sinking of damaging 14 merchant ships

Germany had prepared almost maccessible bases for its capital ships many miles up the Norwegian fiords In recesses protected from submarines by patiols, mine fields and lines of antisubmarine and antitorpedo nets, berths had been prepared under overhanging cliffs surrounded by high mountains, which rendered the ships immune from bombing attacks by aircraft. In three such berths the "Tirpitz," "Scharnhorst" and "Lutzow" lay secure and able to slip out when required In order to deal with them Great Britain devised, with the utmost secrecy, a midget submarine able to pass under nets and lay powerful explosive charges under the bottom of a ship at ancho: Special crews were trained to man these craft and it was intended to make an attack on the ships early in 1943 with a force of six boats, but the boats and crews could not be got ready in time and the operation was postponed until the autumn The period Sept 20-25 would be favourable as regards duration of darkness and moonlight, and Sept 20 was selected as D-day A photographic unit in Murmansk procured full details of German dispositions and net defenses.

The six boats set out on Sept 11, 1943, each in tow of a submarine, three to attack the "Tirpitz," two for the "Scharnhorst" and one for the "Lutzow" It was a tow of about 1,200 mi, at eight to ten knots' speed, with frequent stops for ventilating, etc and occupied ten days. Bad weather was encountered and several tow ropes were broken. One boat was lost and one had to be scuttled but the remaining four arrived duly at the rendezvous and the tows were cast off Because of defects, one of the submarines had to abandon the attack. It was the only one that returned, but it brought back valuable information. Of the remaining three which carried out their attack on the "Tirpitz," one was sunk by gunfire or depth charges before it got inside the nets. the other two, after hair-raising experiences, placed their charges under the ship and with great difficulty managed to get back out-side the nets before the explosions They were sunk by gunfire when they came to the surface, but their charges exploded under the "Tirpitz" and damaged it so severely that it was unable to take any further part in the wai The crew of four of one boat was rescued and made prisoner, as were the captain and the second in command of the other.

Conclusion .- The U-boats interfered little with the great Allied landings in Europe and Africa. This was a result of the absolute secrecy maintained by the Allies as to time and place selected. the dissemination of misleading information and the strong antisubmarine patrols protecting the convoys. Before the Normandy landing Germany's concentration of U-boats in the channel ports was neutralized by the Anglo-U.S. air and naval offensive

The Allies won the battle of the Atlantic by a narrow margin This was due to: (1) their success in keeping just ahead of Germany in scientific research and invention; (2) perfect co-operation between the air and surface forces as a result of combined training; (3) their long-range shore-based aircraft which Adm Karl Dönitz acknowledged to be the most deadly threat to the U-boat; (4) the intensive training of convoy escorts, and (5) the dogged determination of the merchant navy and the escorting forces,

See Earl Jelucoe, The Crisis of the Naval War (1921), W. D. Puleston, The Influence of Sea Power in World War II (1947). (1947). (R. N. Ba.)

# U.S. SUBMARINE WARFARE IN THE PACIFIC, WORLD WAR II

While the US navy, as a whole, was placed on the defensive by the crippling Pearl Harbor raud in Dee 1911, a vigious and determined oftensive campains against Japan was immediately commenced by US submaines. The effectiveness of this underwater war is indicated in the final compilation of Japanese navul and merchant marine losses, which shows that US submarines accounted for more than half the tonnage destroyed. The nature of operations in the Pacific made the submarine a valuable weapon, both strategically and tactically. The war against Japan was primarily a naval war, with ground and air sway primarily a naval war, with ground and air sway primarily a naval war, with ground and air sway with naval support,

United States naval strategy, from the first, was based on two minoptant atactors in the Japanese economy the empire was de-pendent on great amounts of imports, particularly oil and rubber pendent on great amounts of imports, particularly oil and rubber to turn out sufficient shapping to bring in such raw materials from southeast Asia and the Indies and at the same time carry from southeast Asia and the Indies and of the same time carry of of military operations across the Pacific Accordingly, US. submanines concentrated their attention on stopping sea-borne movement of Languese suppoles and reducine its interchain trainer.

The principal US submarine base in the Pacific was at Pearl Harbor, the submarine fleet there was undamaged in the Japanese raid With the Asiatic fleet, based in the Philippine Islands, was a smaller force of submarines Duning the Japanese advance through the Netherlands Indies and the southwest Pacific islands, submarines from both the Asiatic fleet (crognamed early in 1942 as the 7th fleet and hased on the Australian ports of Brisbane and Fremantle) and the Pacific fleet ranged across the entire theater of operations, taking an early toll of Japanese shipping. After Guam was retaken in Aug 1944, Pacific fleet submarines operated out of that base

In the southwest Pacific area, U.S. submarines offered support to Allied forces, delayed the Japanese advance where possible and metrupted lines of communication Operating far beyond the effective range of surface or aeral support, they carred their determined attacks deep into Japanese home waters. The very knowledge of their presence in areas under exclusive Japanese domination had the effect of slowing up Japan's operations, while their persistent attacks on sea lines brought a ringing score of slipping the present of the communication of the com

During the first year after the war commenced, U.S. submatines accounted for 50,390 tons of Japanese shipping by sinking 134 anaval and merchant ships. In the second year, 1943, the score went up to 384 sinkings for a total of 1,341,963 tons. By this time the U.S. submarine building program was in full swing and in 10,44 U.S submarines sent to the bottom an armada of 492 ships with a total of 2,387,976 tons, not including merchant ships of less than 1,000 tons. Hundreds of these smaller vessels, such as junks, schooners and barges, were destroyed by gunfar from surfaced submarines. With the toll of sinkings mounting, the Japanese found it uncreasingly difficult to seem surple kines over.

found it uncreasingly difficult to keep supply lanes open. By 1045, U.S. submarines had so depleted the Japanese fleets that they managed to sink only 133 ships for a total of 496,879 tons before the war ended. Japanese shipping was hard hit and what was left was confined chiefly to Asistic coastal waters and the protected reaches of the Japan sea At the time of the Oklinava landings, U.S. submarines had completely stopped Japanese sea traffice to the East Indies and Indontina and in the next month they commenced hunting down the last remnants of Japanese sea power in the sea of Japane.

Although the submarine war was directed mainly against supply (unkers, cargo ships, transports, etc.), the U.S. craft went after bigger game whenever possible and sank a total of 189 combat craft, including I battleship, 4 carriers, 4 secont earriers, 5 heavy cruisers, 9 light cruisers and 193 submarines. In this connection, it should be stressed that, while a submarine is always a hunter, the tactical stitution frequently made the submarine the object of

a determined hunt. While 46 US submarines were lost in such attacks, they never accepted the role of the hunted. Always on the submarines were accepted the role of the hunted. Always on the previously mentioned 4, all paneses destroyers, the principal sub-hunters, as well as 60 other secort craft also employed in anti-submarine warfare. As a result, Japanese forces were often hard-pressed for sufficient escort craft to protect their shipping adequately.

At the time U.S. submarines were patrolling various strategic areas in their hunt for Japanese shipping, others were employed in operations more closely connected with the usual concept of naval warfare. In the battle of Michwy, (June 1942), submarines assigned to task force 17 served as socuts to report the advance of the Japanese feets, and the "Nautubus" assisted in the kill of the carner "Soryu". In Aug. 1942 the "Nautubus" and "Argonaut" landed marine raiders on Makin in the Gilbert Islands

In the North Pacific, submarines operated with task force 8 in repelling Japaneses reinforcements for their Aleutana garsisons in the summer of 1942; the "Grunion" and \$5-27 were lost in these operations. The outstanding victory of task force \$8\$ in the battle of the Philippine asc [June 1944] was partly a result of the fact that submarines shadowing the Japanese fleet were able to give Adm Raymond A Spruance advance warning of its thrust into the central Philippine area. In this battle, the "Albacoro" and "Cavalla" sank the Japanese carriers "Taiho" and "Shokaktu", as an overall result, the U.S. navy terminated the effective use of Japanese carrier awation for the rest of the war.

Agan, in the battle for Leyte gulf (Oct. 1944), US submarines succeeded in surprising the heavy 1rst diversion attack force of the Japanese fleet; the "Dace" sank the heavy cruiser "Maya" and the "Datter" sank another, "Atago", while a third of the six cruiser assigned to that force was badly damaged 'The "Datter" was grounded during this engagement and destroyed by U.S. forces,

Special duties assigned to US submarines during the war included reconnaissance, rescue, supply and lifeguard missions, Submarine reconnaissance could be made in waters where other vessels dared not go. Submarine recounsissance could be made in waters where other vessels dared not go. Submarine rescue was effective for the same reason, the final stage of Gen. Douglass MacArthur's excapa from the Philippine Islands before the fall of Corregion's example by submarine. A valuable cargo of gold was likewise removed from the Philippines shortly before the Inanaese invasion.

In the Philippines and Netherland's Indies, submarines were used to supply Allied forces, both before and after the Japanese occupation. Vital medical supplies were taken into Corregidor by submarine before the fall of that fortress, and various guerilla forces in the slands were supplied with arms and other necessities.

The lifeguard activities of submarines commenced on a minor scale, with the occasional chance rescue of the survivors of a ditched plane. As both air corps and navy carrier strikes against the Japanese increased in strength, the problem of rescuing personnel of planes downed in cenny territory became increasingly important and submarine lifeguard vessels were included in the plans for such attacks. In one such assignment, during a raid on Truk, the "Tang" picked up 22 airmen. More than 500 aviators were thus saved from death or capture.

Other activities of submarines included mine laying, charting dangerous or little-known waters and even raids on Japanese soil. Volunteers from the "Barb" once paddled ashore in rubber boats to blow up a Japanese train, and this submarine, as well as others, created havoc and destruction along Japanese coast lines by gun and rocket bombardment of ports, factories, refineries and other installations.

The antisubmarine phase of the Pacific campaign commenced on Dec. 10, 1941, when navy carrier planes sank the first Japanese submarine of the war and, incidentally, the first naval vessel lost by the Japanese to any power. Approximately 120 more Japanese submarnnes were to go down, victim to U.S. navy ships and planes, before a U.S. submarine got the last Japanese submarine and last major Japanese naval vessel to be sunk on Aug. 14, 1945.

Principal participants in the role of sub-sinkers were destroyers and their new World War II offspring, the destroyer escorts, With sonar (electronic underwater detection device) and depth charges, later augmented by hedgehogs (much smaller but power- basic matter from which all other materials have issued It desigful explosive charges dropped in greater numbers than possible nates, accordingly, the "beginning" of all becoming at large and with depth charges), these craft constantly improved their technique of hunting and sinking submarines and were mostly responsible for the score of 63 sunk by US surface craft

The advantage in using hedgehogs was that, unless they actually hit a submarine, they did not explode, whereas the depth charges went off at a predetermined depth and the resulting underwater disturbance hampered further tracking of the target if it was not hit.

Destroyers and escorts usually hunted in groups, with one or more ships tracking the submarine by sonar while another followed a course plotted to intersect the submanne's track, at which point an attack was made In such operations, the destroyer escort "England" was credited with sinking six submarines in a period of two weeks US submarines were also successful in hunting undersea craft with sonar and sinking them with torpedoes A total of 23 submarines went to the bottom as a result of attack by U S. underwater craft: the "Batfish" was credited with sinking three submarines in four days.

Because they usually operated alone and most attacks on them came when submerged, a submarine's sinking generally resulted in the loss of the entire crew. The "Darter," \$-39, \$-36 and \$-27 were stranded and all on board saved, the "Sealion" was bombed but later destroyed by her own crew with a loss of only five men; the badly damaged "Peich" had to be abandoned by her crew. who were captured and imprisoned. In varying numbers, survivors of the "Grenadier." "Sculpin," "Tang." "Tullibee" and S-44 were also taken as prisoners of war by the Japanese. The "Tang" was destroyed by one of her own torpedoes which boomeranged. In the total of 52 submannes lost in wartime operations, the U.S. lost 374 officers and 3,131 men.

No account of submarine warfare in the Pacific could be complete without reference to the part played by British and Netherlands Indies submarines; about 15 of the latter alone participated in the hopeless but heroic campaign against superior Japanese forces in the early months of the war, with heavy losses. Dutch submarines were credited with the first submarine kills of both Japanese naval and merchant vessels Approximately 60 Japanese vessels were sunk by Allied submarines in the southwest Pacific

Command of the original Asiatic fleet submarines was held by Rear Adm. John Wilkes, U.S.N., while the Pacific fleet craft were led by Rear Adm, Thomas Withers. With the organization of the southwest Pacific force, later the 7th fleet, the Asiatic fleet boats came under control of Vice-Adm. Charles A. Lockwood, Jr., until that officer took command of Pacific fleet submarines Seventh fleet submarines were subsequently commanded by Rear Adm. Ralph W. Christie and Rear Adm. James Fife, Jr., U.S.N

SUBMARINE MINES: See MINES (NAVAL). SUBMARINE SIGNALS: SEE FATHOMETER.

SUBMEDIANT, in music, the sixth degree of the diatonic scale, as A in the scale of C. (See HARMONY)

SUBOTICA, a town of Serbia, Yugoslavia. Pop (1948) 112,551. It is the centre of an immense agricultural district, and in the adjoining territory of Puszta Telecska (369 sq.mi.) large herds of cattle are reared. The chief industries are the making of iron articles of furniture, railway trucks and boots. The town was occupied by Hungary during World War il.

SUBSTANCE. The concept of substance is that of a permanent substratum preserved through all changes. The term substance is Latin for the Greek ὑποκείμενον, "that which underlies," as the permanent "basis" of its "accidents" (συμβεβηκότα, e.g., Aristotle, Metaphysics IV., 30, 1025a).

Greek Philosophy.-To set forth this permanent Being which in all transformations remains identical, was conceived by Greek philosophy from first to last as one of its principal tasks. Greek Philosophy is essentially "ontology"; it aims at the determination of "Being as such" ( or \$ or; Aristotle, Metaphysics, 1, 2). In the characterization of this Being lies the difference between the various schools of Greek thought. In the natural philosophy of the Ionians it is first conceived as material Being; substance is the shaken only by the new scientific view of the world, which origi-

at the same time, an immutable unit, a uniform and constant "nature" (μία τις φύσις), which is neither subject to nor affected by becoming

But already in the next phase of Greek Philosophy, Heraclitus and the Pythagoreans replaced this material determination of substance by another type of determination. For them, the permanent consists not in an unchangeable material substratum, but in certain constant proportions which persist in all Becoming The true substance, the "essence" (ovola) of things is not sought in an individual thing, but, according to the Pythagoreans, in Number, this being the principle underlying all measured proportions; according to Herachtus in the immanent law, in the "Logos" that governs all events and retains them within definite limits. Here substance does not lie outside Becoming, but designates a law which pervades all Becoming and gives it its "form" This view forms the transition from the "physical" explanation of things to their "ideal," ie, mathematical and logical, explanation. The logical view of substance was developed by Parmenides and the Eleatic school True "Being" can be grasped only in pure thought. Thinking and Being are one; so, true Being is determinable only by predicates of thought. It is eternal; it is subject to no change of place, it is one and admits of no partition

This idea of logical identity becomes the determining motive in the further development of the concept of substance in Greek philosophy.

The systems of the "younger philosophy of nature" (Empedocles, Anaxagoras, Democritus) attempt to connect and reconcile this motive with the physical explanation of the universe They seek to exhibit within nature itself certain elements which, although themselves incapable of change, produce, by their mutual relationships, the manifold of reality and their changes

Atomism, especially, became of fundamental importance for the further development of the concept of Substance The idea of the absolute oneness of Substance is here abandoned; true substantiality is attributed to atoms which are infinite in number, but simple and indestructible. From the differences of position, shape, arrangement and spatial motion of the atoms results the manifold of sensible phenomena, which accordingly possess only secondary Being; genuine Being is attributable only to the atoms

and to empty space, which is required for their motion The classical systems of Greek philosophy, however, effect a decisive change. Instead of matter, pure form is made the basis of all substantiality. The form (είδος, ίδέα) is the one persistent element; unlike sensible phenomena which always "become" and never "are," it remains the same. Equal things can become unequal; the small, by growing, can become large; but the sdea of the equal, etc., remains what it is and suffers no change (Plato, Phaidon 99 sqq.). Thus, the idea forms that which alone has genuine, constant, true Being (ὅντως ὅν), while empirical objects, in so far as they have Being owe this to their "participation" in ideas. In the system of Aristotle, too, this interpretation of the problem of substance is retained, although he rejects the substantiality of pure ideas as taught by Plato For him, substance is the individual Being composed of "matter" and "form." But the specific function of determination belongs to the form: Logically substance is the ultimate "subject" of all predication, but which cannot be predicated of anything else. All our judgments refer to a Something of which they claim to be true; and this Something is that to which the judgment refers (Aristotle, Categ. V., Metaphysics, 1069a 18). From this "first substance" (πρώτη οὐσία), Aristotle distinguishes the species and genera as "substances of the second degree" (δεύτεραι οὐσίαι) They do not subsist in themselves, but only in the individual beings, the first substances, but they express the most general determinations without which individual beings could not be thought.

Descartes, etc .- The Aristotelian conception of substance determined for many centuries the form of western thought and metaphysics. Mediaeval Scholasticism was in its essence a philosophy of "substantial forms." This fundamental outlook was nated in the 17th century. The establishment of the helo-centric system by Coperincis and Keplei, and of modern dynamics by Galike, deprived the Aristotelian physics, cosmology, and metaphysics, of their foundation. The new concept of substance goes back historically to pre-Aristotelian philosophy, especially to doctrines of the Pythagoreans and of Democritus Substance is now conceived mathematically; it is that which, in all transformations of behomenae, remains unchangeable in manufact.

Thus, the problem of substance, or matter, is supplemented by the problem of motion. For also motion, more conceived as pure translocation, reveals a quantitative constitute, which makes it sometimes guishantial. In this sense, the Galilean doctine of motion is headed by the principal of merita, re, the theorem that the motion of a material point upon which no external forces are working, remains invariant in velocity and direction. Similarly, the mechanics of Descartier series on the principle of the "preservation of motion," se, the assumption that the so-called magnitude of motion, which is measured by the product of mass and in the whole world, through the archange of velocity, which takes place at the impact of bodies, no new quantity of motion can be created nor any existing one be destroyed, there occurs only a change in the distribution.

From this assumption, however, it follows that the world of bodies is a system completely closed in itself and incapable of suffering any interference from the outside. All action of body upon body, all "causality" within the realm of extension, iesis upon mechanical laws, mental, "immaterial" powers cannot act upon bodies, nor increase or diminish the sum total of their momentum. Between the worlds of "external" and "intenal" experience, between "matter" and "consciousness," no kind of transition takes place.

Through this viewpoint, the metaphysical doctrine of substance receives a decisive turn. Descarted edifies substance (Principal philosophies, r. 50) as that type of thing which exists in such a way that it needs no other thing for its existence Accordingly, the concept of substance is applicable only to the Being of God Next to it, there subsists, as relatively independent and mutually irreducible entities, consciousness and the world of bodies. The fundamental problem consists now in determining how these two essentially different substances can enter that kind of commentum which is exhibited in the concrete existence of mar. For main is a whole consisting of "thought" and "extension," of "soul" and "body of the consisting of "thought" and "extension," of "soul" and "body of the consisting of "thought," then metaphysical difference, gives rise to the systems of Spinosism, of Occasionalism, and of the doctrine of monads

Locke and Hume—A new and decause turn is given to the problem by the critical analysis of cognition which starts with Locke and Hume and reaches ats completion in Kant. The characteristic of this turn lies in the fact that the weight of the problem is transferred from the realm of metaphysics to that of epistemology. Substance appears as a "category" as a fundamental compet of pure understanding. That this concept is not derrusole directly from experience, that it cannot be thought as the mere "copy" of a sense-impression, this is emphassized also by Locke

The privilest and sensualist conception of knowledge, which they represent, is thus confronted with the question whether the concept of substance, not being reducible to empirical sources, retains any "objective" significance or is merely "subjective" as a kind of natural illusion of the human understanding. Locke starts with the assumption that true reality belongs only to the simple, sensible "ideas," to the sensations of colour, sound, etc., whereas the understanding cannot create any new reality, but can merely connect these ideas in certain modes with one another. Such a mode of connection is represented by the concept of substance. What the senses deliver individually, is thereby connected; the changing states and properties being united in one "substratum," or "bearer." But the idea of a perisatent thing as "bearer" of the changeable qualities is, in Isself, use portuger, corresponds. Not

adding anything new to the sensible elements in which all our knowledge of reality is rooted, it originates in the mere habit of correlating with one another many such elements on the basis of their regular conjunction, their spatial coexistence.

This correlation, however, is not a real, objectively founded connection We know, for instance, that in the thing commonly called by the name of "gold," a certain density, a certain colour, a certain specific weight, etc., appear regularly in conjunction, but the mecasity of this conjunction, the "ground" for the combination of the various qualities in this, and no other, mode, is not understood. Even if there be such a ground in reality, in must be undersovestable and unntelligable (Locke, Essay of the Human Understanding). The subjective nature of substance is emphasized even more by Hume.

The concept of substance, according to Hume (Treatise on Human Nature), is not reducible to any sense impression, it has, therefore, no positive significance for knowledge, but is merely a product of the imagnature power which combines what is requently together, into one idea and gives it one name. This criticans of the concept of substance refers to the realm of external as well as of internal experience. The supposition that a material stime of the concept of substance refers to the realm of external as well as of internal experience. The supposition that a material thing as such persists even when not perceived is denied objective significance, and the concept of "soul-substance" is rejected and the "I'v declared a mere "bundle of perceptions".

Kant.—Kant's Critaque of Pure Reason takes up the results of Locke and Hume, but it draws from them an entirely different epistemological conclusion. For Kant, too, substance is a pure concept of understanding, a form of connection established by pure thought. But this form of connection cannot be reduced to the emphreial rules of habit and association; it has universal and necessary validity, it is a synthesis a prior. The validity of his synthesis consists in the fact that it is the bass of experience itself. Without the idea of a Something pensisting in the stream of appearances, it would be impossible to establishs and to make intelligible that order of phenomena which we conceive under the name of "experence".

The proof, the "transcendental deduction" of the concept of substance is, accordingly, presented by exhibiting it as a constitutive condition of any possible experience. This implies, on the one hand, that it is indispensable for all experience, for all scientific cognition of nature, on the other hand, that it is designed for use in experience only, that its validity does not refer to "things-in-themselves" but to phenomena. The principle of substance, according to Kant, belongs to the "analogies of experience," ie, to those principles on the basis of which alone it is possible to set a fixed, objective time-relation between phenomena and to conceive them as "nature" coherent in itself and ordered according to universal laws Such an objectivation of time would be impossible without the category of substance. "The persistent is the substratum of the empirical notion of time itself, and it is on its basis alone that all temporal determination is possible For change does not affect time itself, but only its contents, only the concrete events which we conceive as following each other in time. Time itself does not change, but all change occurs in it as the "constant corollary of all Being of phenomena" However, the strictly "empty" time does not constitute any possible object of perception, in order to think of time as constant, as "duration, we must, therefore, presuppose a persistent element within appearance itself and oppose it to all that is merely changeable,

The concept of something persistent is, accordingly "the coadition of the possibility of all synthetic unity of perceptines, is, of experience; and in proportion to this persistent element, all being and all change in time can be viewed only as a modus of the existence of that which remains and persists." (Kritik der reinen Vermunit, and ed. p. p. 25 sept.

Recent Epistemology.—The contrast between Hume's and Kant's conceptions of substance, reappears in the recent epistemology. The further pursuit of the road of Hume leads to empiricism and positivism; the further pursuit of the road of Kant, logical idealism. For notifying the resemblency as devalored in

changing states and properties being united in one "substratum," purcism and posturism; the further purism of the read of Kant, or "bearer." But the idea of a persistent thing as "bearer" of the logical idealism. For positivist epistemology as developed in changeable qualities is, in itself, utterly empty; it represents a Avenarius 'Kriik der reinen Berfahrung (1883-09) and in the mere form of knowledge to which no content corresponds. Not writings of Ernst Mach (Beitrage zur Analyse der Empfindungen,

1886, Die Mechanik in ihrer Entwicklung, 1883, Prinziplien der Warmelehre, 1896), the concept of substance has an essentially biological significance It serves the "coronmy of thought" in-asmuch as it is a means of correlating a multiplicity of experiences, and grung them one name

But the unity of substance is a merely nominal unity What we call material substance is only "a relatively constant sum of sensations of touch and light associated with sensations of space and time" This constancy can never be considered absolute, only

relative, so that the identity of the "thing" is a mere function Critical idealism essentially agrees with this result, but differs from empiricism and positivism in the explanation which it gives. It, too, emphasizes the fact that, the further the sciencial cognition of nature progresses, the more the concepts of things are replaced by concepts of relations. The concept of substance resolves into the concept of function. But the concept of function is not considered as the expression of a mere "togetherness," of experienced facts, but as a genuine achievement of thought. It is the original form of connection as such, and of experience is the The concept of substance is to be replaced ultimately by that of invarance (E Cassiers, Mishance and Pluschian, 1923) [ECT.

SUBSTITUTIONS: See GROUPS.

SUBWAY, a subsurface passage. The term is generally used in the U.S. in connection with urban underground electric transportation to represent a railway operating either in a tube, a steel framework built in an open cut and then covered, or in any other type of tunnel.

(See NEW YORK (CITY): Transportation and Communication;

RAILWAYS, TUBE; and TUNNEL.)

SUCCESSION: see LAW OF SUCCESSION.

SUCCESSION, ORDER OF, IN GREAT BRITAIN. The heir to the king is ins oldest son; thus George II succeeded his father, George II. If the oldest son be dead, the heir is his oldest son; thus George III, his father Frederick being dead, succeeded his grandfather, George II. If there are no sons, a daughter succeeds, in the event of there being more than one daughter, it is assumed that the daughters succeed in order of semonity.

If the king dies without son or daughter the succession passes to the next oldest brother and his offspring; thus William IV followed his older brother George IV, the latter leaving no child, and Victoria succeeded her uncle William IV in preference to her remaining uncles who were unitor to her father.

If the king dies without issue and without brother or sister (they also without issue) the right of succession goes back to the preceding generation—the oldest son or his descendant, or, barring sons, the daughters, in the order of seniority

SUCCESSION DUTY: See LEGACY DUTY AND SUCCESSION

Dury SUCCESSOR STATE, a term applied to a state formed wholly or partly out of another state which has ceased to exist, thus forming a wholly distinct political entity, but inheriting certain obligations (e.g., the repayment of a public debt) in-herent in its origin. As neither Turkey nor Russia has ceased to exist, although their forms of state have changed, the only modern states to which this term can strictly be applied are those which the treaties of St. Germain and Trianon describe as "States to which territory of the former Austro-Hungarian Monarchy is transferred and States arising from the dismemberment of that Monarchy." These states were taken by the authors of the above treaties to be Czechoslovakia, Poland, Rumania and Yugoslavia. East Galicia, which, like these four states, had been recognized as its successor by the Austrian "Liquidierungskabinett" of Oct. 1918, failed to maintain its existence, and the plea of the Austrian republic to be considered a successor state was rejected by the Powers at St. Germain, who affirmed its identity with the old Austria. The successor states were acquitted of moral identity with the old monarchy, and were thus not called on to pay reparations, but were required instead to pay "contributions towards the Allied cost of liberation" on a scale based on prewar taxation. Among other obligations was the signing of the minorities treaties. Italy signed no minorities treaty, but

consented to regulate the financial position of the territories which it had inherited from Austria and Hungary on a basis similar to that taken for the successor states (C A M)

SUCCINIC ACID is an organic compound occurring in amber (3% to 4%). Irom which fossibled gum it is obtained by distillation. It is also found in other resins, in lignites, in fossibled guid in many plants belonging to the Composite and Papaveraceae. It occurs in the animal kingdom, as in the thymus gland of calves and in the spileen of actite.

Chemically, succinic acid, or ethylenesuccinic acid,

#### CO2H CH2 CH2 CO2H.

is a saturated dibasic acid which crystallizes in colourless prisms or plates melting at 186° C and boiling at 235° C. Its vapour readily loses water to form succinic anhydride (I), which crystallizes in plates melting at 120° C.

The acd itself is soluble in water, and its salts with the alkali and alkaline-earth metals are also soluble in water Barrus coinate is piecipitated from aqueous solution by alcohol, ferro succinate is insoluble in water and is sometimes employed in the analytical separation of iron from other metals. When heated with phosphorus trisublidie, sodium succinate vields throbher

Succinic acid is produced during the bacterial fermentation of ammonium tartual or calcium malate. It arises from the oxidation of fats and fatty acids by nitric acid. It may be prepared synthetically from ethylene, CHH, through ethylene dichloride, CHLC(8), ethylene dicyanide or succinonitrile, CHL(8N). The last compound yields the acid on hydrolysis Malcie acid, on wordowlysis Malcie acid, on wordowlysis Malcie acid, on wordowlysis Malcie acid, on wordowlysis Malcie acid, on the succinic acid on reduction with sodium amalegia.

Succupil chloride (formula II) is obtained by the interaction of phosphorus pentachloride and succinic acid. Succume anhydride (formula I), also produced by heating the acid or its salts with acette anhydride or by beating succinity chloride with anhydrous oxalic acid, is employed as an intermediate in colournakun, when it yields two brands of Rhodamine S (see Dvzs. SUNTHETIC) by condensation with dimethyl- or diethyl-meta-aminophenol, NR,C,CH,OH.

Succinimide (formula III), produced by heating succinic anhydride in ammonia, crystallizes in colourless octahedra melting at 185°-126° C. and readily soluble in water This imide when

distilled with zinc dust furnishes pyrrole (q.v.).

Succhronitrile, CN.CH<sub>2</sub>.CH<sub>2</sub> CN, obtained as above and also by electrolysis of potassum cyanoacetate, is a colourless solid melting at 34°-55° C. On reduction with sodium and alcohol it is converted into the ptomaine alkaloid, puttersion (tetramethylenediamme), NH<sub>2</sub> [CH<sub>2</sub>]<sub>2</sub>,NH<sub>3</sub>, and into pyrollidine (tetramethylenediamme), NH<sub>2</sub> [CH<sub>3</sub>]<sub>2</sub>,NH<sub>3</sub>, and into pyrollidine (tetramethylenediamme), NH<sub>3</sub> [CH<sub>3</sub>]<sub>2</sub>,NH<sub>3</sub>,

Methylsuccinic acid or pyrotartaric acid,

# CO<sub>2</sub>H.CH<sub>2</sub>.CH(CH<sub>2</sub>).CO<sub>2</sub>H,

formed during dry distillation of tartaric acid, by heating pyruvc acid with concentrated hydrochloric acid, or by the reduction with sodium analgam of citraconic and measconic acids, is obtained in colourless prismatic crystais soluble in water and melting at 112° C. It forms an anhydride and its sodium salt heated with phosphorus trisulphide yields \$\textit{\textit{methydride}}\$ and its sodium salt heated with phosphorus trisulphide yields \$\textit{\textit{methydride}}\$ and isomeride of ordinary succinic acid, is obtained on hydrolyzing ac-yanopropionic acid, CH<sub>2</sub>(HC(X)).CO<sub>4</sub>H<sub>2</sub>, b. It for cystallizes in prams melting at 12° C and is soluble in water. Unlike ordinary succinic acid, it does not yield an anhydride on heating, but loses carbon dioxide and passes into propionic acid. See T. E. Thorpe, Dictionary of Applied Chemistry, vol. vi (1926).

SUCEAVA or Suczawa, a town of the Bukovina, Rum, on the river Succava. Pop. (1930) 17,101. It was from 1401 the

seat of the metropolitan of Moldavia and until 1565 the capital, its 14th-century church contains the grave of the patron saint of the Bukovina It was many times besieged by Poles, Hungarians, Tatars and Turks, and also suffered in World War I. Near by is the early 17th-century monastery of Dragomirna in the Byzantine style

SUCHET, LOUIS GABRIEL, DUC D'ALBUFERA DA VA-LENCIA (1770-1826), marshal of France, one of the most brilhant of Napoleon's generals, was the son of a silk manufacturer at Lyons, where he was born on March 2, 1770 As chef de bataillon he was present at the siege of Toulon in 1793, where he took General O'Hara prisoner During the Italian campaign of 1796 he was severely wounded at Cerea on Oct 11 Atter serving under Joubert in Tirol in 1797, and also in Switzerland under Brune in 1797-98, he was made chief of staff to Brune, and restored the efficiency and discipline of the army in Italy In Inly 1700 he was made general of division and chief of staff to Joubert in Italy, and was in 1800 named by Masséna his second in command His action contributed to the success of Napoleon's crossing the Alps, which culminated in the battle of Marengo on

In the campaigns of 1805 and 1806 he greatly increased his reputation at Austerhtz, Saalfeld, Jena, Pultusk and Ostrolenka He obtained the title of count on March 19, 1808, married Mile de Saint Joseph, a niece of Joseph Bonaparte's wife, and soon afterward was ordered to Spain. There he was commander of the army of Aragon and governor of the province, which in two years he brought into complete submission. He annihilated the army of Blake at Maria on June 14, 1800, and on April 22, 1810, defeated O'Donnell at Lerida.

Suchet, now a marshal of France, in 1812 conquered Valencia and received the title of duc d'Albufera da Valencia (1812). When the tide set against the French Suchet defended his conquests step by step till compelled to retire into France, after which he took part in Soult's defensive campaign. By Louis XVIII he was made a peer of France, but, having rallied to Napoleon during the Hundred Days, he was deprived of his peerage in 1815. died near Marseilles on Jan. 3, 1826. Suchet left unfinished Mémoures dealing with the Peninsular War; these were printed by St. Cvr-Noguès in 1829-34.

See C H Barault-Roullon, Le Maréchal Suchet (Paris, 1854); Choumara, Considerations militaires sus les mémoires du Maréchal Suchet (1840) See also Bibliography in article Peninsulae War.

SUCKLING, SIR JOHN (1609-1642), English poet, was born at Whitton, in the parish of Twickenham, Middlesex, and baptized there on Feb. 10, 1609 His father, Sir John Suckling (1569-1627), had been knighted by James I and was successively master of requests, comptroller of the household and secretary of state He amassed a considerable fortune, of which the poet became master at the age of 18. He was sent to Trinity college, Cambridge, in 1623, and was later entered at Gray's Inn. He was intimate with Thomas Carew, Richard Lovelace, Thomas Nabbes and especially with John Hales and Sir William Davenant, who furnished John Aubrey with information about his friend. In 1628 he left London to travel in France and Italy, returning, however, before the autumn of 1630, when he was knighted,

In 1631 he volunteered for the force raised by the marquess of Hamilton to serve under Gustavus Adolphus in Germany. He returned in 1632 but during his short service he had been present at the battle of Breitenfeld and served in many seiges. He had a gift for verse that commended him to Charles I and his queen. Said to have been the best card player and the best bowler at court, Suckling says of himself in "A Sessions of the Poets" that he "prized black eyes or a lucky hit at bowls above all the trophies of wit." John Aubrey says that he invented the game of cribbage and relates that his sisters came weeping to the bowling green at Piccadilly to dissuade him from play, fearing that he would lose

According to Aubrey, Suckling was "the greatest gallant of his time." Aubrey adds that because of his reputation as a "gamester both for bowling and cards . . . no shopkeeper would trust him for sixpence, as to day for instance he might by winning be worth

200l and the next day he might not be worth half so much, or perhaps be sometimes minus nihilo '

In 1634 a great scandal was caused in his old circle by a beating which he received at the hands of Sir John Digby, a rival suitor for the hand of the daughter of Sir John Willoughby It has been suggested that this incident had something to do with his beginning to seek more serious society

Under the proclamation of 1632 against absentee landlordism, enforced by the Star Chamber, he retired to his estates in 1635. This leasure resulted in "A Sessions of the Poets" (circulated in manuscript in 1637) and a tract on Socimianism entitled An Ac-

count of Religion by Reason (printed 1646).

As a dramatist Suckling was noteworthy for having applied to regular drama the accessories already used in the production of masques His Aglaura, published in folio in 1638, was produced at his own expense with elaborate scenery Even the lace on the actors' coats was of real gold and silver The play lacked dramatic interest and, according to Richard Flecknoe, seemed "full of flowers, but tather stuck in than growing there." Other plays are The Goblins (1638) and Brennoralt, or the Discontented Colonel (1639, printed in 1646), a satire on the Scots, who are the Lithuanian rebels of the play His play The Sad One was left unfinished at the outbreak of the Civil War

Suckling forthwith raised a troop of 100 horse, at a cost of £12,000, and accompanied Charles on the Scottish expedition of 1639. He shared in the earl of Holland's retreat before Duns, and was ridiculed in an amusing ballad (printed 1656), in Musarum deliciae He was elected for Bramber (1640) to the Long Parhament; and wrote to Henry Jermyn, afterward earl of St. Albans, advising the king to disconcert the opposition leaders by making more concessions than they asked for. In May 1641 he conspired to rescue Strafford from the Tower and to bring in French troops. The plot was exposed, and Suckling fled beyond the seas Aubrey's statement that he took poison in May or June 1642 in fear of poverty is generally accepted Suckling's minor pieces have at times exquisite felicity of expression "Easy, natural Suckling," is Millamant's comment in Congreve's Way of the World (Act IV. Scene 1). Among the best known are the "Ballade Upon a Wedding," on the marriage of Roger Boyle, afterward earl of Orrery, ung, on the maringe of Koger Hoyle, afterward earl of Orrey, and Lady Margaret Howard; "I Prithee, Send Me Back My Heart", "Out Upon It, I Have Loved Three Whole Days Together", and "Why So Pale and Wan, Fond Lover" from Aglaura. "A Sessions of the Poets," describing a meeting of the contemporary versifiers under the presidency of Apollo to decide who should wear the laurel wreath, is the prototype of many later saures.

A collection of Suckling's poems was first published in 1646 as Frag-menta aurea. The so-called Selections (1836), published by Alfied Imgo Suckling, author of the History and Antiquities of Sulfolk (1846-48), with Memous based on original authorities and a portrait after Van Dyck, is really a complete edition of his works, of which W. C. Hazhtt's edition (1874; revised ed., 1892) is little more than a reprint with some additions. The Poems and Songs of Sir John Scuckling, edited by John Gray and decorated with woodcut border and inning. by Charles Ricketts, was artistically printed at the Ballantyne Press in 1896. In 1970 Suckling's works in prose and verse were edited by A Hamilton Thompson. For anecdotes of Suckling's life see John Aubrey's Brief Lives, Clarendon Press ed., vol il, 242.

SUCRE, ANTONIO JOSÉ DE (1795-1830), was born on Feb. 3, 1795, at Cumaná, Venez, where his family had for generations held a position of importance. He had only a meagre education and turned early to the profession of arms. In 1811 he was placed in charge of the republican engineers at Marganta, with the rank of heutenant. In 1821 he acted as Simón Bolívar's agent in the campaign against Spain in the presidency of Quito. There in 1822 he defeated the Spanish forces at the battle of Pichincha which definitely ended the power of Spain in that

In March 1823 Peru accepted Bolivar's offer of services in its struggle for independence, and a month later Sucre went to Lima as Colombia's commissioner. Bolivar arrived at Callao on Sept. 1 and was appointed by congress to the command of the patriot forces. During the preliminary stages of organization Sucre served as Bolivar's lieutenant. In Feb. 1824 Spanish troops reoccupied Lima. Congress immediately declared Bolívar "supreme political chief," and he in turn placed Sucre in command of his troops

At the end of July 1824 the aumy which Rolivar had been organizing gathered near Lake Reyes in the Peruvian uplands, and on Aug 6 Sucre defeated the Spanish aimy under Canteria in the battle of Junin. Withdrawing to Cuzco, Canteria waited for additional troops and then marched upon Sucre After two months of maneuviring, Sucre, on Dec 9, faced the combined forces of Spain under Viceroy la Serna on the plain of Ayacucho and utterly routed them

After the battle Sucre and Canterac squeed a treaty of capitulation arranging for the total evacuation of lower Peru by the Spannards Carrying his work of reconquest into the distitct of Charcas or upper Peru—now Bolivia—Sucre convened a deliberative assembly, which on Aug. 6, 1825, declared upper Peru independent of Span and proclaimed it a new state under the name of Rembblica Bolivia.

The liberator was named first president, Sucre to be chief excentre in his absence. In Dec. 1825 Bolivar transferred he authority to Sucre, who resigned May 25, but was immediately elected provisional president. In Feb 1826 the Bolivan congress adopted the famous constitution which Bolivar had drawn up for them, and in October Sucre was elected constitutional president.

p. 1. Mouras an awhward position. The native leaders objected to the presence of a foregare, Sucre fretted at the lumitations to his power, and doubted the practicability of Bolivar's constitution. A natury of soliders at Chaousaca in Apail 1888, followed by an invasion from Peru, crystallused his determination to resign. On Aug. 2 he made his last address to congress and soon afterward moved to Quito, resolved to reture to private life. But in Jan. 1830 he was chosen president of a constituent congress called by Bolivar as a last expedient to preserve the unity of Great Colorn-bits, and was one of the special commissioners appointed to consider ways and means. The plan failed, and on his way back to Quito he was kalled by assissains in the forest to Berustros, near the town of Pasto, on June 4, 1830. Sucre stands today with Bolivar and San Matria as a zeat liberator.

See also W. S. Robertson, The Rise of Spanish-American Nations (1021) (W B P)

SUCRE, legal capital of Bolivia. Pop. (1950 census) 40,128, of whom many are Indans and mestizos. The city is in a delevated valley opening southward on the narrow ravine through which flows the Cachinayo, the principal northen tributary of the Pilcomayo. Its elevation, 8,532 ft, gives it an exceptionally agreable clumate. Petitic valleys provide fruit and vegetables, while the vineyards of Cinti supply wine and spirits. The city has broad streets, a central plasa and a prado.

The cathedral, dating from 1553, was noted for its wealth; the president's palace and halls of congress are no longer used as such; the cabildo, or town hall, a mint dating from 1572, the courts of justice and the university of San Xavier, founded in 1624, are

Sucre is the seat of the archbishop of La Plata and Charcas, the primate of Bolivia. It is connected by rail and highway with Potosi and by a poor road with Cochabamba. A petroleum topping plant was completed in 1949, and the city is connected by pipe line with the Camiri fields.

The Spanish town was founded in 1538 on the site of an Indian village called Chaquisca, or Chuquichaca ("golden bridge"), and was called Charcas and Ctudad de la Plata by the Spaniards. It was the first city of Spanish South America to revolt against Spanish rule—on May 25, 1809. In 1840 the name Sucre was adopted in honour of the first president of Bolyau (q, v).

SUCROSE: see Sugar. (J. W. Mw.)

SUDAN (Arabic BILAD-AS-SUDAN, "country of the blacks," of the Markey of the Markey of the Sahara), the helt of country which extends across the continent of Africa from Cape Verde on the Atlantic to the highlands of Abysshia and to the Red sea. It is bounded on the north by the

Sahaa and on the south by the martime counties of West Africa, by the Congo basın and by the equatoral lakes. Within this by the Congo basın and by the equatoral lakes. Within this betta are three moderately well-defined but irregular zones of climate and vegetation the arid desert steppe stretching from coast to coast just south of the Sahara, an intermediate zone of grassy plains supporting varieties of mimosa and scane, and the tropical zone of denser vegetation and arable land merging into the equatorial zone of dense forests, which terminates on the east-in the mountains and lakes of Uganda. The rainfall varies from 8-roin on the desert fringe to 40-50 in in the southern, equatorial zone. There are large areas in which the ruinfall would appear to be sufficient for cultivation but in which the ligh rate of evaporation makes agriculture without irrigation impossible. High temperatures prevail throughout the year. It is believed that andity is increasing in the Sudan and that desert conditions are spreading southward.

The Sudan is a plateau, averaging somewhat less than 1,500 ft in altitude, in which isolated masses of the primitive tableland rise above the general level. Its length is more than 3,600 mm and its average width slightly less than 1,000 mm. For moie detailed information 560 BAGRAM, BORNU, CHAD, FRENCH EUA/TORIAL APRICA, FRENCH WEAT AFRICA, NICER, NICERIA; SHARI, SUDAN, ANGLO-ECHYTHA; SUDAN, FRENCH, WADAI

Characteristics of the people are black or very dark brown skin, woolly hair, a broad nose with wide nostrils and thick lips they are fairly tall, the men averaging 5 ft. 8 in. The type has been modified by Hamitic invasions from the north. The West African Negro is a cultivator and not a pastoralist except Wester foreign influence has made him so. In the central Sudan Hamitic blood has nermeated more than in the west.

(See also HAUSA; SUDAN, ANGLO-EGYPTIAN Population; and SUDANIC LANGUAGES, with the articles on the peoples therein mentioned)

(K C B)

SUDAN, ANGLO-EGYPTIAN, the easternmost territory of the Sudan (g v), consisting of 95,500 ex mit under the joint sovereignty of Great Britan and Egypt, bounded by Libya on the extreme northwest, by Egypt on the north, by the Red sea and by Abyssians (with Entrea) on the east, by Kenya, Uganda and the Belgian Congo on the south and by the French Equatorial African regions Ubang-Shari and Chad on the west. It extends roughly 1,300 mi. from north to south and more than 1,000 mi from east to west.

to Westwie Peatures.—The Anglo-Seppian Sudan consists of a Jain, with a general altitude of 1,105-1,050 of above sea devel, bounded on the west by the bills of the Nile-Congo were devel, bounded on the west by the bills of the Nile-Congo were devel, bounded on the sea thy the Ethoppian mountains and the Red sea ranges to the north of them. The Nile runs through the centre of the plain from south to north. The three natural zones which extend irregularly across the whole of Sudanic Africa termanate in Anglo-Seppian Sudan

hummocks and hills of basalt, granute and lumestone. The intermediate zone lies between lat. r. r. N. and 16° N. and comprases Darfur, Kordofan and the Nuba mountains, west of the Nile; the Gearm between the White and Blue Nules, south of Khartoum; and the fertile plain between the Blue Nile and the Eritrean and Abyssiana hills. The main feature of this zone is the oas, an area of undulating sand, which merges in the desert of the northwest. The sand absorbs all the rain, which is sufficient for vegetation to fix it. Toward the south, and particularly in the southwest, the surface undulations disappear and a flat, sandy plain is formed with savannah forest (short grasses and trees with gum arabic acacia.) From the Eritrean border near Kassala plains of dark, clayey soil (known as badob or "cotton soil") extend south to about lat 6° N. along the eastern frontier and westward into

the Bahi el-Ghazal and Equatoria provinces, groups of granilic hills rise from the surface of the plain, which is covered with grass or savannah forest and is extensively cultivated, but the southern hint of the dark-soil belt is ill defined and it merges gradually into the tropical zone

The southern tropical zone is one of red soil, where lateritic ironstone appears below the surface Grass and trees grow freely and the soil is readily cultivable

The region of the Red Sea hills is distinctive In the valleys between the hills moisture is sufficient to maintain scrub in north, in the south toward Entrea vegetation is almost luxurant. The sandy plain between the hills and the sea affords grazing, there is some cultivation in the wall beds. Coral teefs fringe the cost, which is mediated by the cost, which is mediated by the cost, which is mediated by the cost which is mediated by the cost, which is mediated by the cost which is the cost which is mediated by the cost which is the cost wh

Climate.—The predomnant restures of the climate are high temperatures, extreme dyness in the north and humd, tropical conditions in the south Rainfall is a dominating fattor in the country's economy. It occurs, with long intervals, in the northern desert, but Abu Hamed is normally the northern limit of the annual rains. The period and the amount of rain increase from north to south in a steep gradient for example, at Gambela, lat 8° N, the average annual rainfall is 5° n, while lattle more than one-eighth of this amount fails at Khartoum, soo m farther north. Except on the Red sea coast, where half the precipitation occurs in the autumn, from 50% to 75% to 75% of the rainfall is deposted in June, July and August

North of lat 12° N the mean temperature is at its lowest in January and usually attains its maximum height in mid-May or early June, a maximum of 126 5° F has been recorded at Wadi Halfa in April South of lat. 12° N the maximum occurs in March or April and the minimum, under the influence of the southerly monsoon and the attendant rainfall, is sometime in July or August Maximum temperatures in the southern Sudan usually do not exceed 110° F, and the range of temperature is much less. From January to May northerly winds prevail throughout the country With the onset of the rainy season an area of southerly winds extends, in May, from the south as far north as Kassala and in June covers the country with the exception of some northern stations and the Red sea coast From May to July dust storms, known as habubs, are frequent where conditions are suitable for example, at Khartoum, where the surface of the land is stirred by much traffic, and at Kassala and at Tokar, where the ground surface 15 fine silt

Flora—The regional botany is best described in three parts (1) the desert zone north of Khardoum, with a predominants y sandy soil, (2) the intermediate zone between lat 11° and 15° N, of clayey or "cotton" soil masted with grantius sand, and (3) the tropical zone south of lat 11°, where the rainfall is heavy and the soil rich

In the desert zone there is an annual rainfall of four inches or leas, and trees can live only on the rwer banks or in the beds of wadies. The trees found are tamarsk, varieties of accas, heeping (Railantes acpyptiaca, a tail, spany tree guring hard timber and edible fruit), down paims (Hyphaene thebazea) and the date paim. In the Bayuda desert, north of Khartoum, much thorny scrub is found Coarse grasses, able to withstand long periods of drought, grow in the desert area and clothe the uncultivated Nile banks from Dongola to Merowe (Merawi). East of the Nile vegetation is spanse, conssting mainly of scrub, but the wadies contain many varieties of tree. Balin of Cilead (Commiphore opobalsonum) grows on the coast near Suakin.

The great acacia forests are found in the intermediate zone. North of the rath parallel of lattice and west of El Obeld these forests are of stunted trees, useful as fodder for camels. The valuable gum-bearing hashab (Acacia zonegal) grows between lat 12° 45° N. and 44° N. The finest plantations are between lat 10° 45° N. and Bollow trunk is regularly used for water storage acts size; its follow trunk is regularly used for water storage. East of the Nile the vegetation consists meinly of grasses and bush on the Gearia and on the cotton-soil plains and forests on the river banks. Plant growth is more luxuriant near the Abyssinian border In the Gearia, where it is unculviated, and in the Gedari region

the ground is covered with grass and herbage all of which is good fodder. There is much mimosa scrub. The lower reaches of the Blue Nile and its affluents are hordered by dense, thorny jungle Wild cotton and castor-oil plants also grow on their banks.

The tropical zone, south of lat II' N, shows three belts of vegetation distinct one from another forests and parkland in southern Kordofan, savannah with fewer trees in the flood valleys and irrigated lands, and swamp vegetation in the sudd area of the Bahr el-Ghazal and the Bahr el-Jebel In southern Kordofan large acacias flourish and there are some timber trees; in the extieme south of the province many of the large trees found also in the Bahr el-Ghazal forests occur South and west of Wau the forest is dense and widespread, the chief trees there are talk (Acacia scyal), heglig, tamarind and the sausage tree or umm shutur (Kigelia aethiopica) On the rocky upper terraces of the ironstone plateau to the west and southwest there is little thorny undergrowth but many large trees, including the Sudan mahogany (Khaya senegalensis) and scrubby oak (Lephira alala) The rubber vine (Landolphia owariensis) and an inferior variety (L peetersiana) is also found. East of the Nile the forests are far less extensive On the Yei river south of lat 4° N forest is found approaching the equatorial type, with enormous evergreen trees, of which the most important is the giant mahogany. Between lat. 7° N and 10° N, in the swamps of the Bahr el-Jebel and the Bahr el-Ghazal, only marsh vegetation occurs. On the Bahr el-Jebel the dominant plant is the papyrus, often growing to a height of 15 ft or more

Fauna,-There are many species of wild animals and many hundreds of species of birds, resident and migratory The lion. leopard and cheetah are the principal felines. Among the ungulates are the elephant, graffe, zebia, wild ass, thinoceros, buffalo, hippopotamus, ibex, wild sheep and numerous kinds of antelope chimpanzee, baboon, grivet and colobus monkeys are found in the forests. Resident birds include bustards, guinea fowl, several kinds of partridge, geese, cranes, the Egyptian vulture, storks, pelicans, plover, weaverbirds, shrikes and stailings. Thousands of sea birds, waterfowl and other birds winter in the Sudan on their way north. Reptiles include the crocodile and various lizards Snakes are not numerous but there are eight poisonous varieties, Scorpions up to eight inches in length (Pandinus imperator) are found. Insect life is abundant, the vicinity of rivers and swamps is infested with mosquitoes and the seroot flies (large blood-sucking horseflies) are a scourge during the wet months. The tsetse fly, in size and general appearance resembling the house fly, is found south of lat 12° N wherever open water and deep shade provide suitable conditions.

# ARCHAEOLOGY

Only in Nubia, with minor exceptions, had there been any scientific excavations by the 1950s, and many of them had not been fully published. In the rest of the Anglo-Egyptian Sudm archaelogy remained in its infancy. No thorough archaelogical surveys had yet been made, though from surface finds and from the observations of officials and others certain general lines were beginning to emerge. Roads by which foreigness obtained the products of the Sudan (particularly slaves, gold and Ivory) were always of paramount importance; and, especially in the northern Sudan, desiccation and soil erosion have increasingly affected the course of history, particularly during the last 2,000 years

The Eastern Region.—In the upper valley of the nver Atbara fossils and Lower Palaeolithic implements have been found, indicating one route by which the early Stone Age cultures of Egypt and Kenya were connected.

In the desert m the northeastern Sudan gold was extensively mined from ancient Egyptian times down to the 11th century a D Stone-built huts, stone mortars, hammers and circular grinding mills occur with pots at the ancient mines.

The most important route in this area from the earliest historic period has been that which gave access from the Red sea (south of Port Sudan) to the central Sudan by a route which passed north of the Abyssiman massif to the Kassala area. The earliest pottery known in the Sudan, associated in the Khartoum area with barthed

bone spears, has been found as far east as Kassala and as far west as Wadı Howar From Goz Regeb has come evidence of occupation from the protodynastic to the Christian period, and at Sarsareib and in the Kassala area are sites dating back to protodynastic and possibly earlier times In the Red Sea hills there are early occupation sites at Agordat in Eritrea (probably predynastic, C Group and Pan-Grave) and at Erkowit At Aqiq on the Red sea coast are remains which suggest that this was the site of Ptolemais Therion, whence the Ptolemies obtained elephants for their army and which probably continued as a trade centre until the Axumite period. In Roman times trade with India diverted attention from the African mainland, but Merce and Axum became affected by influences from India as a result of the development of that trade, and it was probably trade uvalry that led Axum to destroy a degenerate Meroe c AD 350 Early in the Moslem era Ptolemais was overshadowed by Badı on Aırı Island, where there is a rumed town with cisterns and where Moslem tombstones dating from the 10th and 11th centuries have been found Similar tombstones dating from the 8th to the 10th centuries (the earliest is A H 153=cAD, 700) have been found in Khor Nubt, while early Moslem stone-built towerlike tombs occur at Maman east of Kassala and elsewhere. Circular stone graves with flat tops are probably those of Moslem Beja

The Central Region .- In the Blue Nile valley fossils occur passim below the clay of the Gezira plain, notably at Abu Hugar and Singa, where they include a proto-Bushman skull, contempo-

rary with a crude Levallois culture.

Ancient Egyptian expeditions must have penetrated far south of that part of the Nile valley occupied by them during the New Kingdom. One such expedition to localities previously unidentified is recorded by Amenhotep III, one of whose scarabs was found 100 mi E of Khartoum The Blue Nile valley from Khartoum to Roserres was no doubt always the road to Beni Shangul, whence came slaves and gold Occupation sites occur all the way to Roseires, and no doubt the Napatan, Mercitic, Christian and Fung periods at least are represented In the 6th century AD. Axum was trading with this area directly, bartering gold for iron at Fazughli Finds of Napatan date were made at Sennar and Kosti, while at Jebel Moya Sir Henry Wellcome excavated an occupation site and cemetery showing Negroes in trade connection with Napata Finds of Meroitic date were made in and near Sennar. Rock pictures from this period occur at Tebel Geili east of Khartoum, and the artificial water reservoirs which are common as far south as the Tebel Mova area are probably the work of the kingdom of Meroe A Meroitic ram, brought from Soba to Khartoum by Gen. C. G. Gordon, indicates that Soba was probably a Meroitic town before becoming the capital of the Christian kingdom of Aloa (Alwa). Little now remains on the surface at Soba but red-brick fragments and the stone capitals of a Christian church; Old Nubian inscriptions have been found there in the past. Christian sites were reported from the Blue Nile between Khartoum and Sennar and from Geteina on the White Nile. At Sennar the site of the Fung capital (AD 1500-1821) is being destroyed by the river At Abu Geili near Sennar, a site excavated for Wellcome in 1912, Fung pottery was recognized with considerable probability.

The Southern Region .- South of Kosti occupation sites occur along the bank of the White Nile as far as Malakal. Shards of apparently early date have been found near Malakal, Doleib hill and Jebel Zeraf, and a microlithic culture of Wilton type with pottery on Belli Island. Shards from a pre-Shilluk site near Kaka suggest a connection with Sennar and Meroe. Ancient occupation mounds have been reported from the Bahr el-Ghazal in Aweil district, and polished celts of haematite near Yambio.

This southern region must long have been the goal of traders seeking slaves and ivory, and copper mining probably began at Hofrat en-Nahas at an early date. The Azande show evidence of cultural contact with ancient Egypt, and the Masai and the Kikuyu of East Africa seem to appear more than once, in scenes representing the arrival of the tribute of Cush, in the Tombs of the Nobles at Thehes.

The Western Region.-Here the most important road is that which runs west from the White Nile between the desert and the

tropical forest through Dartur and past Lake Chad to West Africa A few roads running north to south across the desert follow lines of water holes and link this great road with the North African coast In early times the steppe country extended farther north, and finds of protodynastic date come from the southern Libyan desert It may be that Tibesti is the source of the amazon stone and some other cultural features common to the Neolithic of the Fayum and Shahemab From Wadı Howar come remains which suggest that the cattle-owning C Group people, first known to archaeologists in lower Nubia, once lived there. The 6th-dynasty inscriptions of Harkuf at Aswan suggest that the ancient Egyptians used donkey caravans on the Denb el-Arba'ın The earliest traditional rulers of Darfur are the Dagu (otherwise Daju, Tajo, Tago). and some of the brands used till recently by the Dagu sultans of Dar Sila may have a hieroglyphic origin. The extent to which the ancient Egyptians and later the kingdoms of Napata and Meroe controlled the great east-west road was still unknown in the 1050s.

Some form of control over northern Kordofan by the kingdom of Napata was suggested by finds at Abu Sofian and Zankor, although the red-brick ruins there may date from the Meroitic period Merotic "archer's looses" were found in Darfur and at Jebel Haraza That after the fall of Meroe itself the Merotic royal family may have carried on in the west is suggested by an Old Nubian graffito at Audun, a tumulus near Kabona in Jebel Meidob. said to be the grave of a queen who brought the Meidob Kagiddi from the Nile, and by the survival of Kash (Cush), the old name of the kingdoms of Napata and Meroe, in the modern tribal names

Kagıddi, Kaja and (Bırgıd) Kajar.

There are many stone-built ruins in the hills of Darfur. A walled stone town containing two royal residences at Jebel Orrei in northern Darfur may possibly owe its origin to Meroe Circular stone forts and other remains in Turra at the northern end of the Marra massif are traditionally associated with the early Fur sultans Contrary to what has been written, there is no evidence of Darfur's having come within the orbit of Christian Nubia, though rock pictures at Jebel Afarit in Kordofan may be crude copies of Christian saints on horseback as represented in the church of Abd el-Qadır at Wadi Halfa Christian pottery has been found associated with stone cairn graves in the Wadi Mugaddam, and rectangular stone graves in the same area are Christian. Darfur must have come under the influence of the mediaeval kingdom of Kanem-Bornu at various times between the 12th and the 16th centuries, and the red-brick mosques at Ein Fara in northern Darfur probably indicate a Bornu occupation in the 16th century. Stone compounds in the area between Kordofan and Dongola may date from this period Certainly in the 12th century the roads through this area were controlled by Kanem. (See also Egypt. Archaeology; Nubia.)

BRILIOMANIN;—A. J. Arkell, D. M. A. Bate, L. H. Wells and A. D. Lecallel, The Pleutotene Fauna of Two Blue Niel Stiet (London, 1931); C. R. Lepaus, Benkmaler aux dezypten und Ackliopten, Ab. (Berlin, 1849); Fréderk Callinal, Poorge à Méred, au Fleuve Blanc, etc. (Crais, 1862—7); E. A. Walke Bungs, The Legybun Sudan, 1 vol. etc. (Crais, 1862—7); E. A. Walke Bungs, The Legybun Sudan, 1 vol. 11; "Some Red See Ports in the Anglo-Egyptun Sudan," Geographical Journal (London, May 1911), A. J. Arkell, "Merce and India," Aspects of Archaeology, pp. 3–36 (Gloucester, 1931); The Well-control Journal of Archaeology, pp. 3–36 (Gloucester, 1931); The Well-control Control of the Sudan, vol. a and n. F. Addison, 1862 Meyor, Control of Cell and Sugada and Dar al Met (Oxford, 1931); G. G. S. Crawford, The Fung Kingdom of Sennar (Gloucester, 1931); G. Mainwright, and articles by various suthers in Sadan Fotes and Records (Chartoon, 1923–5); See also worts etcle unter Numa. (A. J. A.) BIBLIOGRAPHY .-- A. J Arkell, D M. A Bate, L H Wells and A. D.

The southern regions of the Anglo-Egyptian Sudan are without recorded history until the era of the Egyptian conquest in the 19th century. In the northern regions, known as Ethiopia or Nubia, Egyptian influence made itself felt as early as the Old Empire. In process of time powerful states grew up with capitals at Napata and Meroe (see section Archaeology above; EGYPT; ETHIOPIA). The Nubians-that is, the dwellers in the Nile valley between Egypt and Ethiopia-did not embrace Christianity until the 6th century, considerably later than their Ethiopian neighbours. The

Arab invasion of North Africa in the 7th century, which turned Egypt into a Mohammedan country, had not the same effect in Nubia, the Moslems, though they frequently raided the country. being unable to hold it. On the ruins of the ancient Ethiopian states arose the Christian kingdoms of Dongola and Aloa, with capitals at Dongola and Soba (corresponding roughly to Napata and Meroe) These kingdoms continued to exist until the middle of the 14th century or later (see Dongola) Meanwhile Arabs of the Beni Omayya tribe, under pressure from the Beni Abbas. had begun to cross the Red sea as early as the 8th century and to settle in the district around Sennar on the Blue Nile, a region which probably marked the southern limits of the kingdom of Aloa The Omayya, who during the following centuries were reinforced by further immigrants from Arabia, intermarried with the Negroid races, and gradually Arab influence became predominant and Islam the nominal faith of all the inhabitants of Sennar In this way a barrier was erected between the Christians of Nubia and those of Abyssinia By the 15th century the Arabized Negro races of the Blue Nile had grown into a powerful nation known as the Fung. and during that century they extended their conquests north to the borders of Egypt The kingdom of Dongola had already been reduced to a condition of anarchy by Moslem invasions from the north Christianity was still professed by some of the Nubians as late as the 16th century, but the whole Sudan north of the lands of the pagan Negroes (roughly 12° N ) was then under Moslem sway. At that time the sultans of Darfur (q,v) in the west and the sultans or kings of Sennar (the Fung rulers) in the east were the most powerful of the Mohammedan potentates

The first of the Fung monarchs acknowledged king of the whole of the allued these, of which the Hameg were next un mportance to the Fung, was Amara Dunkas, who reigned c 1484—1526 During the reign of Adlan, c. 1596—1605, the fame of Sennar attracted learned men to his court from such distant places as Cano and Baghdad Adlan's great-grandson Badi Abu Daku attacked the Shilluk Negross and raided Kordofan. This monarch built the great mosque at Sennar, almost the only buildings in the town to survive the ravease of the deraybase in the 10th century.

In the early part of the r8th centry there was was between the Sennar and the Abyssinans, in which the last-named were defeated with general saughter, a victory over the "nind6sts" which became celebrated throughout the Mohammedan world Toward the end of the 18th century the Hamag wrested power from the Fung and the kingdom fell into decay, many of the tributary princes reliusing to acknowledge the king of Sennar The disorders resulting from this decline continued up to the time of the conquest of the country by the Egyptians.

From the Egyptian Conquest to the Rise of the Mahdi.— The conquest of Nubia was undertaken in 18:0 by order of Mohammed Ai, the pashs of Egypt, and was accomplished in the two years following. His leading motive was, probably, the desire to obtain possession of the mines of gold and prectous stones which he believed the Sudan to contain. Mohammed Ain also wished to crush the remnant of the Mamelukes, who in 18:2 had established themselves at Dongola, and to keep busy the Albanians and Turks in has army, whose fidelity was doubtful.

Mohammed Ali gave the command of the army sent to Nubia to his son Ismail, who at the head of about 4,000 men left Wadi Halfa in Oct 1820. Following the Nile route he occupied Dongola without opposition, the Mamelukes fleeing before him. (Some of them went to Darfur and Wadai, others made their way to the Red sea. This was the final dispersal of the Mamelukes.) With the nomad Shagia, who dominated the district, Ismail had two sharp encounters, one near Korti, the other higher up the river, and in both fights Ismail was successful Thereafter the Shagia furnished useful auxiliary cavalry to the Egyptians. Ismail remained in the Dongola province till Feb. 1821, when he crossed the Bayuda desert and received the submission of the meks (kings) of Berber, Shendi and Halfaya, nominal vassals of the king of Sennar. Continuing his march south, Ismail reached the confluence of the White and Blue Niles and established a camp at Ras Khartoum. (This camp developed into the city of Khartoum.) At this time Badi, the king of Sennar, from whom all real power

had been wrested by his leading councillors, determined to submit to the Egyptians, and as Ismail advanced up the Blue Nile he was met at Wad Medani by Badi, who declared that he recognized Mohammed Alı as master of his kingdom Ismail and Badı entered the town of Sennar together on June 12, 1821, and in this peaceable manner the Egyptians became rulers of the ancient empire of the Fung In search of the gold mines reported to exist faither south. Ismail penetrated into the mountainous region of Fazughli, where the Negroes offered a stout resistance In Feb 1822 Ismail set out on his return to Dongola, having received reports of risings against Egyptian authority. The Egyptian soldiery had behaved with barbarity. Nair Mimi, the mek of Shendi, had been a sort of hostage to Ismail and entertained hatted of the pasha On Ismail's return to Shendi, Oct 1822, he demanded of the mek 1,000 slaves to be supplied in two days The mek, promising compliance, invited Ismail and his chief officers to a feast in his house, around which he had piled heaps of straw. While the Egyptians were feasting the mek set fire to the straw and Ismail and all his companions were burned to death

Ismail's death was speedily avenged. A second Egyptan army, also about 4,000 strong, had followed that of Ismail's up the Nile, and striking southwest from Debba had wrested, after a zharp campaugn, the provance of Kordofan (1821) from the sultan of Darlur. This army was commanded by Mohammed Bey, the defterdar, son-in-law of Mohammed Ah. Hearing of Ismail's murder the defterdar marched to Shend, defeated the forces of the mek and took terrible revenge upon the inhabitants of Metama and Shendi, most of the inhabitants, including women and children, being burned alive. Nair Mirnt escaped to the Abyssiman frontier, where he maintained his indeendence.

Character of Expytian Rule.—Having conquered Nubia, Senar and Kordofian the Egyptians set up a civil government, placing at the head of the administration a governor general with practically unlimited power. Khurshid Pasha (governor general 1856-30) gained a great reputation both for rectified and vigour. About this period Mohammed Ali leased from the sulfan of Turkey the Red sea ports of Suakin and Massawa and thus got into his hands the trade routes of the eastern Sudan. The pasha of Egypt practically monopolized the trade of the country except that in slaves, for which border lands were raded annually. From the Negro population the army was so largely recruited that in a few years the only non-Sudanese in it were officers. The Egyptian rule proved harmful to the country. The governors general and the leading officials were nearly all Turks, Albanians or Circasians, and, with rare exceptions, the welfare of the various peoples of the Sudan formed no part of their conception of government.

Numerous eftorts were made to extend the authority of Egypt. In 1840 the fettle district of Taka, watered by the Athara and Gash and near the Abysanian frontier, was conquered and the town of Kassala founded In 1837 the pasha himself had visited the Sudan, going as far as Fazughli, where he inspected the gold fadds.

The successors of Mohammed Ali, in an endeavour to make the country more profitable, extended their conquests to the south, and in 1853 and subsequent years trading posts were established on the upper Nile. The government monopoly in trade had ceased in 1849 on the death of Mohammed Ali, The proneer European merchant was John Petherick, British consular agent at Khartoum, Petherick sought, for ivory only, but those who followed him soon found that slave raiding was more profitable than elephant hunting. The viceroy Said, who made a rapid tour through the Sudan in 1857, found it in a deplorable condition. The viceroy ordered many reforms to be executed and proclaimed the abolition of slavery. The reforms were mainly inoperative and slavery continued The European merchants above Khartoum had sold their posts to Arab agents, who oppressed the natives in every conceivable fashion Ismail Pasha, who became viceroy of Egypt in 1863, again gave orders for the suppression of the slave trade, and to check the operations of the Arab traders a military force was stationed at Fashoda (1865), this being the most southerly point then held by the Egyptians.

Ismail, however, was ambitious to extend his dominions and to

develop the Sudan on the lines conceived by him for the development of Egypt He obtained (1865) from the sultan of Turkey a firman assigning to him the administration of Suakin and Massawa, the lease which Mohammed Ali had of these ports having lapsed after the death of that pasha Ismail subsequently (1870-75) extended his sway over the whole coast from Suez to Cape Guardafus, but on the rise of the mahdi (see below) Egyptian authority was withdrawn (1884) from the coast regions south of

Suakin. Baker and Gordon.-At the same time that Ismail annexed the seaboard he was extending his sway along the Nile valley to the equatorial lakes and conceived the idea of annexing all the country between the Nile and the Indian ocean An expedition was sent (1875) to the Juba river with that object, but it was withdrawn at the request of the British government, as it infringed the rights of the sultan of Zanzibar Meanwhile, on the main Nile, control of all territories south of Gondokoro had been given to Sir Samuel Baker, who, reaching Gondokoro on May 26, 1870, formally annexed that station, which he named Ismailia, to the khedivial domains Baker remained as governor of the Equatorial provinces until Aug 1873, and in March 1874 Col C G Gordon took up the same post. Both Baker and Gordon made strenuous efforts toward crushing the slave trade, but their endeavours were largely thwarted by the maction of the authorities at Khartoum. Under Gordon the upper Nile region as far as the borders of Uganda came more or less effectively under Egyptian control On the west the Bahr el-Ghazal had been overrun by Arab or semi-Arab slave dealers who reduced that region to a state of abject misery The most powerful of the slave traders was Zobeir Rahama Pasha (q.v), who, having defeated a force sent from Khartoum to reduce him to obedience, invaded Darfur (1874). The khedive, fearing the power of Zobeir, also sent an expedition to Darfur, and that country, after a stout resistance, was conguered Zobeir claimed to be made governor general of the new province; his request being refused, he went to Cairo to urge his claim At Cairo he was detained by the Egyptian authorities

Though spasmodic efforts were made to promote agriculture and open up communications, the Sudan continued to be a constant drain on the Egyptian exchequer. A project to link Wadi Halfa to Khartoum by railway was abandoned (1877) after 50 mi. of rails had been laid in five or six years at a cost of £450,000. In Oct. 1876 Gordon left the Equatorial provinces and gave up his appointment. In Feb. 1877, under pressure from the British and Egyptian governments, he went to Cairo, where he was given the governorship of the whole of the Egyptian territories outside Egypt namely, the Sudan provinces proper, the Equatorial provinces, Darfur and the Red sea and Somali coasts. Gordon remained in the Sudan until Aug. 1879. During his tenure of office he did much to give the Sudanese the benefit of a just and considerate government. He pacified Darfur and then received the submission of Suliman Zobeir (son of Zobeir Pasha), who was at the head of a gang of slave traders in the Bahr el-Ghazal In 1878 there was further trouble in Darfur and also in Kordofan, and Gordon visited both these provinces, breaking up many companies of slave hunters. Meantime Suliman (acting on the instructions of his father, who was still at Cairo) had broken out. into open revolt against the Egyptians in the Bahr el-Ghazal. The crushing of Suhman was entrusted by Gordon to Romolo Gessi (1831-81), an Italian who had previously served under Gordon on the upper Nile, Gessi, after a most arduous campaign (1878-79), defeated and captured Suliman, whom, with other ringleaders, he executed. The slave raiders were completely broken up and more than 10,000 captives released. A remnant of Zobeir's troops under a chief named Rabah succeeded in escaping (see RABAH ZOBEIR). Having conquered the province. Gessi was made governor of the Bahr el-Ghazal, becoming pasha.

When Gordon left the Sudan he was succeeded at Khartoum by Raouf Pasha, under whom the old abuses of the Egyptian administration were revived. At this time the high European officials in the Sudan, besides Gessi, included Emin Pasha (q.v.), governor of the Equatorial province since 1878, and Slatin Pasha (see SLATIN, SIR RUDOLF CARL VON), governor of Darfur. Gessi found

his position under Raouf intolerable, resigned his post in Sept 1880 and was succeeded by Frank Lupton, an Englishman and formerly captain of a Red sea merchant steamer. At this period (1880-82) schemes for the reorganization and better administration of the Sudan were elaborated on paper, but the revolt in Egypt under Arabi (see Egpyr History) and the appearance of a madhi intervened

The Rise and Power of Mahdism.-Venality and the extortion of the tax gatherer flourished anew after the departure of Gordon, while the feebleness of his successors inspired in the Baggara a contempt for the authority which prohibited their pursuing their most lucrative traffic. When Mohammed Ahmed (q v ), a Dongolese, proclaimed himself the long-looked-for mahdi (guide) of Islam, he found most of his original followers among the grossly superstitious villagers of Kordofan, to whom he preached universal equality and a community of goods, while denouncing the "Turks"-at that time the Sudanese called all foreigners Turks-as unworthy Moslems on whom God would execute judgment The Baggara perceived in this mahdi one who could be used to shake off Egyptian rule The new mahdi married the daughters of their sheikhs and found in Abdullah, a member of the Ta'Aisha section of the tribe, whom he appointed khalifa (lieutenant), his chief supporter

The mahdi's capture of El Obeid on Jan 17, 1883, and the annihilation in the next November of an army of more than 10,-000 men commanded by Hicks Pasha (Col William Hicks [q v]. formerly of the Bombay army) made the mahdi undisputed master of Kordofan and Sennar The next month, Dec 1883, saw the surrender of Slatin in Darfur, while in Feb. 1884 Osman Digna. his amir in the Red sea regions, inflicted a crushing defeat on about 4,000 Egyptians at El Teb near Suakin In April following Lupton Bey, governor of Bahr el-Ghazal, was sent captive to

Omdurman, where he died on May 8, 1888

Gordon at Khartoum.-On learning of the disaster to Hicks Pasha's army, the British government (Great Britain having been since 1882 in military occupation of Egypt) insisted that the Egyptian government should evacuate such parts of the Sudan as they still held, and General Gordon was dispatched, with Lieut Col. Donald H Stewart, to Khartoum to arrange the withdrawal of the Egyptian civil and military population. Gordon's instructions, based largely on his own suggestions, were not wholly consistent; they contemplated vaguely the establishment of some form of stable government on the surrender of Egyptian authority, and among the documents with which he was furnished was a filman creating him governor general of the Sudan. Gordon reached Khartoum on Feb 18, 1884, and at first his mission, which had aroused great enthusiasm in England, promised success To smooth the way for the retreat of the Egyptian garrisons and civilians he issued proclamations announcing that the suppression of the slave trade was abandoned, that the mahdi was sultan of Kordofan and that the Sudan was independent of Egypt He enabled several thousand refugees to make their escape to Aswan and collected at Khartoum troops from some of the outlying sta-

By this time the situation had altered for the worse, and mahdism was gaining strength among tribes in the Nile valley at first hostile to its propaganda. Gordon telegraphed to Cairo asking that Zobeir Pasha might be sent to him, his intention being to hand to Zobeir the government. Zobeir, a Sudanese Arab, was probably the one man who could have withstood successfully the mahdi. Because of Zobeir's notoriety as a slave raider, Gordon's request was refused. All hope of a peaceful retreat of the Egyptians was thus rendered impossible.

The mahdist movement now swept northward, and on May 20 Berber was captured by the dervishes and Khartoum isolated. From this time the energies of Gordon were devoted to the defense of that town After delay, an expedition was sent up the Nile under the command of Lord Wolseley. It started too late to achieve its object, and on Jan 26, 1885, Khartoum was captured by the mahdi and Gordon killed Colonel Stewart, Frank Power (British consul at Khartoum) and Herbin (French consul), who (accompanied by 19 Greeks) had been sent down the Nile by Gordon in the previous September to give news to the relief force, had been decoyed ashore and murdered (Sept. 18, 1884) The fall of Khartoum was followed by the withdrawl of the British expedition, Dongola being evacuated in June 1885 In the same month Kassala capitulated, but just as the mahil had practically completed the destruction of the Egyptian power he

the Khalifa's Rule—The mahdi was at once succeeded by the khalifa Abdullah, wose rule continued until Sept 2, 1898, this period in the history of the Sudan being known as the Mahdio On the date named the khalifa's army was completely overthrown by an Anglo-Egyptian force under Sir Horatio Herbert (afterward Lord) Kitchener. (See EGVPT AND SUDAN CAMPAGINS [1882-1800]

The mahdi had been regarded by his fanatical adherents as the only true commander of the faithful, endued with divine power to conquer the whole world He had at first styled his followers dervishes (i.e., religious mendicants) and given them the iibbah as their characteristic garment or uniform Later on he commanded the faithful to call themselves ansar (helpers), and at the time of his death he was planning an invasion of Egypt. He had liberated the Sudanese from the extortions of the Egyptians, but the people soon found that the mahdi's rule was even more oppressive Gradually all chiefs and amirs not of the Baggara tribe were got rid of except Osman Digna, whose sphere of operations was on the Red sea coast. Abdullah's rule produced complete agricultural and commercial ruin. He was also almost constantly in conflict either with the Shilluks, Nuers and other Negro tribes of the south, with the peoples of Darfur, where at one time an antimahdi gained a great following; with the Abyssinians, with the Kahabish and other Arabic-speaking tribes who had never embraced mahdism, or with the Italians, Egyptians and British Notwithstanding all this opposition, the khalifa found in his own tribesmen and in his black troops devoted adherents, and he successfully defended his position. The attempt to conquer Egypt ended in the total defeat of the dervish army at Toski (Aug. 3, 1889) The attempts to subdue the Equatorial provinces were but partly successful. Emin Pasha, to whose relief H M. Stanley had gone, evacuated Wadelai in April 1889. The greater part of the region and also most of the Bahr el-Ghazal relapsed into a state of chaos.

Pligrimages to the maldi's tomb at Omdurman were substituted for pilgrimages to Mecca The arenal and dockyard and the printing press at Khaitoum were kept busy (the workmen being Egyptians who had escaped massacre). Otherwise Khaitoum was deserted, the khaifa making Omdurman his capital. The population of the country dwindled from warfare and disease, smallpox being endemic.

The European captives were kept prisoners at Omdurman Besides former officials like Slatin and Lupton, they included several Roman Cathohe priests and sisters and numbers of Greek merchants established at Khartoum. Although several were closely imprisoned, loaded with chans and repeatedly fogged, at 1s a notworthy fact that none was put to death. From time to time a prisoner, among them Slatin, made his sesape.

The khalifa, when defeated, fled to Kordofan where he was killed in battle in Nov. 1899 In Jan. 1900 Osman Digna, a fugitive, was captured. As in 1903 and 1908, other mahdis arose, but they were captured and hanged.

The Anglo-Egyptian Condominium—Of the causes which led to the reconquest of the Sudan the most weighty was the necessity of securing control of the upper Nile, Egypt being wholly dependent on the waters of the never for its prospenty. France was endeavouring to establish its authority on the river between Khartoum and Gondokor, as Jean Baptiste Marchand's expedition from the Congo to Fashoda (see AFRICA: History) demonstrated.

The Sudan having been reconquered by "the joint military and financial efforts" of Great Britain and Egypt, the British government claimed "by right of conquest" to share in the settlement of the administration and legislation of the country. To meet these claims an agreement between Great Britain and Egypt was

squed on Jan 19, 1890, establishing the joint sovereignty of the two states throughout the Sudan and defining its northern fronter as lyng along the 2 and parallel of lattude north. The reorganration of the country had already begun, supreme power beaucentred in an official termed the governor general of the Sudan, who by the terms of the agreement was appointed on the recommendation of the British government. Thus in effect Great Buttan controlled the Sudan

Lord Kitchener, the sirdar (commander in chief) of the Egyptian army, under whom the Sudan had been reconquered, was the first governor general On Kitchener's departure to South Africa, at the close of 1800, he was succeeded as sirdar and governor general by Maj Gen Sn Regnald Wingate, who had served with the Egyptian army since 1883 Wingate remained as governor general and sirdar until Dec 1916, when he was appointed high com-missioner for Egypt. With Wingate served Slatin Pasha as inspector general, his knowledge of native affairs being most valuable. But Slatin was an Austrian, and on the outbreak of World War I his services were lost to the Sudan Under a just and firm administration, which from the first was essentially civil, though the principal officials were officers of the British army. the Sudan recovered in a surprising manner from the woes it suffered during the Mahdia At the head of every mudiria (province) was placed a British official, though many of the subordinate posts were filled by Egyptians An exception was made in the case of Darfur, which, before the battle of Omdurman, had thrown off the khalifa's rule and was again under a native sovereign. This potentate, the sultan Ali Dinar, was recognized by the Sudan government, on condition of the payment of an annual tribute During World War I Ali Dinar revolted, an expedition under Lieut Col. P V Kelly inflicted a crushing defeat on the Darfurians outside the capital, El Fasher, on May 22, 1916 The sultan fled and was killed in action in the following November Darfur had meanwhile been incorporated as a province in the

The first duty of the new administration, the restoration of public order, net with comparatively feelbe opposition, though tribes such as the Nuba mountainers, accustomed from time immorial to raid their weaker neighbours, gave some trouble. The delimitation (1903-04) of the frontier between the Sudan and Abyssima helped in the restoration of order in a patificiality less region, but occasional raids by Abyssimans across the border for slaves were to be incorred as late as 1904.

With good administration and public security the population increased steadily. The Sudan government devoted much attention to the revival of agriculture and commerce, to the creation of an educated class of natives and to the establishment of an adequate judicial system It was made easier by the decision to govern, as far as possible, in accordance with native law and custom, no attempt being made to Egyptianize or Anglicize the The Arab-speaking and Mohammedan population Sudanese. found its religion and language respected and showed a marked desire to profit by the new order. To the Negroes of the southern Sudan, who were exceedingly suspicious of all strangerswhom hitherto they had known almost exclusively as slave raiders the very elements of civilization had, in most cases, to be taught. In these pagan regions the Sudan government encouraged the work of missionary societies, both Protestant and Roman Catholic. while discouraging propaganda work among the Moslems

Basis of Prosperity—In its general policy the Sudan government adopted a system of light taxation Prosperity was largely the result. A short route to the sea being essential, a railway from the Nile near Berber to the Red sea was bull (1904–60). It shortened the distance from Khattoum to the coast by nearly 1,000 ml. Sir Eldon Gorst (high commissioner in Egypt) after a tour of inspection declared in his report to 1909, "It do not suppose that there is any part of the world in which the mass of the population have fewer unsatisfied wants."

The next development came out of the search for new cotton fields by the British Cotton Growing association Experiments had been made in 1911 as, to whether long-staple cotton could profitably be grown in the Gezira (the "island" between the

White and Blue Niles immediately above Khartoum) At that time a railway was being built from Khartoum along the edge of the Gezira to Sennar and thence to Kordofan This railway was opened in 1912, it brought the Gezira within easy reach of Khartoum, besides rendering more easily accessible the rich gum and cattle areas of Kordofan In the same year the Cotton Growing association experts who had visited the Sudan reported enthusiastically upon its cotton-growing possibilities, with the result that in 1913 the British parliament guaranteed a loan of £3,000,000 for irrigation and railway schemes Just at this time (1913-14) the value of any project which would give to large areas adequate water supplies by means of artificial irrigation received a striking demonstration. The 1913 rains were very bad and the river flood was the lowest recorded for more than a century, so that all over the northern Sudan, and particularly in the Gezira area, famine conditions prevailed during the following winter. The situation was saved by the government's importing of grain from India. and it is probable that this contributed more than any other factor to the quiet in the Sudan during World War I. (F. R C)

Politics and Development After 1914.-World War I had little effect upon the Sudan But the agitations which were so widespread a feature of its aftermath did not leave the country unaffected Egyptian nationalism was always acutely sensitive about the Sudan Its greatest exponent-Saad Zaghlul-regarded the country as having been legally and permanently acquired by Egypt in the time of Mohammed Alı and spoke of its having been "stolen" by Great Britain, Such a claim made compromise difficult, and when it was met by a British policy based on the concept of trusteeship for ultimate Sudanese self-government, it was, later in the century, to make the Sudanese question the most difficult obstacle to Anglo-Egyptian settlement

After the end of World War I, under the governorship of Sir Lee Stack, the administration followed a policy which was summarized by the Milner commission in 1920 as one of "decentralisation and the employment wherever possible of native agencies for the simple administrative needs of the country," There was an orderly political evolution in the Sudan, although this was interrupted by certain reactions to political disturbances in Egypt When, in Feb. 1922, Egypt was declared independent, provision was made for the maintenance of the status quo in the Sudan, but Egyptian nationalist claims led to the formation of a dissident group under the name of the White Flag league. Cucumstances were complicated by the presence of Egyptian forces in the Sudan. and in Aug 1924 there were a number of local mutinies. The British position was firmly maintained during J Ramsay MacDonald's negotiations with Zaghlul Pasha in the autumn of 1924, and it was perhaps Egyptian nationalist disappointment at this which led to the shooting of Sir Lee Stack on Nov 19, 1924, in the streets of Cairo. This act drew an ultimatum from the British government, which demanded, among other things, the immediate withdrawal of all Egyptian troops and officers from the Sudan When this demand was refused, orders were issued for their expulsion. There were at first difficulties about putting this into effect, and a number of Sudanese detachments in Khartoum mutimed on Nov. 27. Order was restored two days later, and the evacuation was completed. It was followed by the creation of a Sudan defense force. The governor general of the Sudan now ceased to be sirdar of the Egyptian army.

There followed a period of slow but orderly progress in the

affairs of the country. During the term of office as governor general of Sir Geoffrey Archer (appointed Jan. 25, 1925) the process of decentralization was speeded up, and it was continued, after Sir Geoffrey's resignation in 1926, by his successor, Sir John Maffey. One measure (the Powers of the Sheikhs ordinance) in 1927 considerably strengthened the authority of the chiefs over their tribes. In Jan 1926 the Sennar dam was opened and a great part of the Gezira thereby brought under irrigation. Meanwhile, the development of motor transport opened up markets and led to an increase of cultivation and a steady growth of gen-

eral prosperity.

No change in the status of the Sudan was contemplated by the British government in negotiating the draft of a new treaty, which was rejected by the Egyptian cabinet in March 1928. But the mutual need of the two countries was emphasized, in May 1929, by the terms of a comprehensive agreement regarding the development of the Nile for irrigation purposes

During World War II the Sudan took an active part, in recognition of which the United Kingdom government subsequently made a free grant of £2,000,000 to it The entry of Italy into the war in 1940 gave the Sudan a hostile frontier in Eritrea and Abyssinia The defense force was quickly raised by voluntary enlistment from a rifle strength of 4,000 in 1939 to 30,000. Large detachments of this force played an important part in the defense of the territory against the Italians, then in the conquest of Entrea and Abyssinia and subsequently in the campaign in Libya

Once more war brought an increased interest in politics, and this time the administration embarked upon a firm policy with Sudanese self-government as its fairly near objective Steady progress in education had already increased the number of those Sudanese likely to be politically conscious It was estimated in 1934 that these numbered about 12,000; but a considerable increase in educational activities after that time added many more to their numbers Most of them, however, were still town dwellers or in the government service Literacy was, as elsewhere, followed by a growth of the influence of newspapers These contributed much to the acceptance of the concept of the Sudan as a national unit. Broadcasting, too, was influential it tended to awaken political interest even among the illiterate inhabitants of the "black south." Perhaps the most influential organizations in the country were the religious fraternities known as tariqus approach of self-government led the most important of these farther along political paths The mahdists, under the leader-ship of Sir Abd ur-Rahman el-Mahdi, strongly opposed the Egyptian thesis of the unity of the Nile valley, and there were signs that their chief rivals, the Mirghamya, and their leader, Sir Alı el-Mirghani, might be influenced by their rivalry to take a different side in politics

The beginning of negotiations for a new Anglo-Egyptian treaty in 1946 made an acute issue of the future of the Sudan, and this was immediately reflected among the Sudanese Educated opin-10n had for several years been largely moulded in the so-called Sudan Graduates congress, a body composed of most schooleducated Sudanese It was not until after 1945, when Gordon college first received university status, that the country produced graduates in the European sense The congress sent a delegation to join the negotiations in Cairo, but this was refused recognition, and its members lost their unity and gave rise by their divisions to the two main political parties, the Ashigga and the Umma, or

National Front and Independence Front.

The Ashigga, in general, took the Egyptian view, although they chose to interpret this as implying for the Sudan some sort of dominion status under the Egyptian crown. The Umma stood for the speedy achievement of complete self-government and subsequent negotiations with Egypt and with Great Britain They were, however, uncompromisingly opposed to Egyptian sovereignty in any form. The Anglo-Egyptian negotiators found the future of the Sudan their most intractable problem and the talks broke down when, after an apparent misunderstanding, the British prime minister, Clement Attlee, stated on Oct. 28, 1947, that "No change in the existing status and administration of the Sudan is contemplated and no impairment of the right of the Sudanese people ultimately to decide their own future

The new Egyptian government under Nokrashy Pasha maintained its point of view and referred the matter to the Security council of the United Nations in a letter dated July 8, 1947. After discussion, the matter was allowed to remain upon the agenda, an outcome which was regarded by Egyptians as a rebuff In June 1948 the British government announced a comprehensive scheme of constitutional reforms involving the election on Nov. 16 of a legislative assembly, which met eight days before the end of the year. Mohammed Saleh Shengeiti, a former judge of the Sudan high court, was appointed speaker An important group boycotted the elections, but the house was probably a fairly representative one. The Umma was strong in the assembly, which elected as its

president Miralai Abdullah Bey Khalil, the secretary-general of Sudan's right to self-determination. In Feb 1953, after concesthat party A third group, the Black Bloc, claimed to represent the comparatively few literate Sudanese who originated in the southern Sudan On Feb 17, 1949, Sir James Robertson, the senior executive member, announced the government's policy this was to encourage the achievement of full self-government before a decision should be made about relations with the joint sovereigns or about the eventual constitution of the Sudanese state. There was also to be an active policy of social welfare within the limits of sound finance, and a ten-year educational program was announced. In 1950 the treasurer of the English city of Coventry, A H Marshall, who had in 1949 been asked to report on the development of local government, made proposals for drastic changes in policy, involving the creation of single local authorities for all purposes, financially independent and answer-able to the local electors These were accepted in principle by the legislative assembly, which thereby approved what amounted to the replacement of an Egyptian (and originally French) system by an English one National feeling showed itself in debates on the defense force, although it was shown that Sudanization had so far progressed that there were only 40 British officers in 1950 as against 69 in 1939 In Dec 1950 considerable excitement was occasioned by a debate in the legislative assembly on a motion in favour of immediate independence, which was defeated by one vote; but on Dec 15 there was a majority of 391 to 38 in favour of asking Great Britain and Egypt for self-government in 1951.

A potentially serious source of Sudanese disunity was the difference between the Moslem, Arabic-speaking north and the still largely pagan, Negro south Christian European missionaries were active in the south, and this led to assertions that Islam and Arabic were being handicapped. The minister of education announced that 18 northern officials were to be sent to speed up the extension of Arabic to the south, while southern requests for English programs from the Omdurman radio station were refused The Gezira scheme was nationalized in June 1950 and the Sudan Plantations syndicate wound up It was moreover stated that the department of education planned to extend elementary education to cover two-fifths of the children of school age in the northern Sudan within the next decade, a plan that would involve doubling the number of elementary schools in that area There were signs of the spread to the Sudan of the practice of student strikes familiar in Egypt and elsewhere A three-day strike involving 100,000 workers in April 1051 and a transport workers' strike that disrupted life in Khartoum for five days in May were followed by the more serious police strike in June, which led to the declaration of a state of emergency (June 13)

The future of the Sudan was naturally a major point of issue when Anglo-Egyptian relations deteriorated in the autumn of 1951. The unilateral abrogation by Egypt of the treaty of 1936 was matched by legislation denouncing the condominum and pro-claiming the Egyptian monarch to be "king of the Sudan" The British stood by their former attitude; but the Sudanese themselves were clearly no longer the passive objects of the dispute, and there was increasing evidence of a new national awareness and of an independent body of Sudanese opinion. Political development was apparent in the rapid growth of labour organizations, this was attended by strikes, which appeared at times to have little substantial purpose. National feeling, moreover, expressed itself strongly in reaction to certain Egyptian claims that seemed to show an almost proprietary attitude to the Sudan. With the growth of a desire of self-government Egyptian influence lost ground,

The Cairo coup d'état of July 1952, which gave power to Gen Mohammed Naguib, himself partly Sudanese by origin, marked the beginning of a new chapter in the affairs of the Sudan The irresponsible expression of feeling in Egypt was now more effectively restrained. The British government grew increasingly concerned for the fate of the largely non-Moslem peoples of the southern Sudan, but cautious Anglo-Egyptian negotiations made steady progress, especially after General Naguib had, on Nov. 2, 1952, made a momentous and politically courageous declaration abandoning Egypt's claim to sole sovereignty and recognizing the

sions by both sides, came an agreement, the first real Anglo-Egyptian agreement on the Sudan for more than 50 years it provided for Sudanese self-government within three years and for the partial supervision of the process of change by an international commission

territ in partial suppression of sincent and mediaeval history will be found in The Angho-Reyptsus Sudan, ed by Col (later Lord) be found in The Angho-Reyptsus Sudan, ed by Col (later Lord) Edward Gleichen (London, 1905), E A Wallis Budg, The Egyptius Sudan, 2 vol (London, 1907), Sir Harrold MacMichael, A Bistory of the Arabir at the Sudan, vol (Cambindge, 1922) The Egyptius Sudan (1907), Sir Harrold MacMichael, A Bistory of Berghtian Sudan (1907), Sir Harrold MacMichael, A Bistory of Sudan (1907), Soudan (1907), Soudan (1907), The Egyptius Sudan (1907), Soudan (1907),

#### POPULATION

The population, which before the mahdist revolt was estimated at 8,500,000, was reduced by famine, disease, battle and internecine strife to about 1,250,000 between 1882 and 1898. After that date recovery was rapid, and the approximate figure in 1951 was 8,740,000

The northern provinces are predominantly Moslem and Arabicspeaking. Though commonly called Arabs (q v ), the people are of very mixed origin-Arab and Hamite, Hamite and Negro and above all, Arab and Negro-and the name "Arab" covers many stocks in which the actual infusion of Arab blood may be very slight indeed The most convenient classification of these tribes is into (1) camel-breeding nomads, (2) cattle folk (Baggara or Bakkara) and (3) sedentaries. These classes are not mutually exclusive: some tribes include all three, some are both nomad and sedentary. The sedentaries of the Wach Halfa district and in Dongola as far south as Debba are Nubians who have kept their own language (though most of the men speak Arabic also) and are therefore known to the Arabic speakers of Egypt and the Sudan as Barabra (q.v.) or Berberines. Baggara (cattle folk) is a generic, not a tribal, name and is applied to the people who occupy the comparatively well-watered plains of southern Kordofan and Darfur between lat. 13° N. and the Bahr el-Arab. They are nomadic within the limits required by seasonal changes, pasturage and the need for water. Their contact with other Arabs is slight, and they have a closer connection with the Negroes of the south, They speak a distinctive dialect of Arabic.

Ranging across the northeastern quadrant of the country are the Hamitic Beja tribes (see BEJA). These comprise the Bishatin in the Red Sea hills; the Amarar from Musmar to Port Sudan; the Hadendoa, the largest and best-known tribe, whose territory stretches as far south as Tokar; and the Beni Amer, who lie to the east between Tokar and Kassala.

The Nuba (q.v.), who inhabit the plain and the ranges of rugged hills south of El Obeid, have racial characteristics quite distinct from those of the "Nubians" of the north They speak a remarkable multiplicity of languages. They are good cultivators and possess few cattle.

The main interest of the other important pagan tribes of the south lies in their cattle. In tribal organization, in customs and in language each of the main groups is distinct. The Shilluk are found in the plains south of the Nuba mountains; the Dinka, from the Bahr el-Arab across the Bahr el-Ghazal to the Zeraf and east of the White Nile below Malakal; the Nuer, south of Malakal on the Sobat river; the Anuak, on the Pibor river, the Bari, on both sides of the river round Rejaf; and the Azande, on the iron-

stone plateau in the southwest

Social Conditions—It is impossible to generalize in any description of the social conditions of the melley of tribes which occupy this vast country, with its many variations of soil, climate and vegetation and, in the south, its multiplicity of religious beliefs and languages. In the north the Arabic language and the religion of Islam (which, in primitive communities, still rules the everyday life of the people) provide a common basis and give unity of social and political ideas. But superficially a great diversity in the way of life is found, the traditional cleavage between the desert and the sown states. Anthone of Negrods of the north and the nated, black-skinned peoples of the southern provinces, where customs, beliefs and material culture vary from tribe to tribe and there is no political cohesion, no sense of tribal loyalty and, evcept among the Shilluk, no trabal organization.

## GOVERNMENT AND ADMINISTRATION

The head of the government is the governor general, who is appointed by Egypt on the recommendation of the British government under the terms of the agreements of 1899 known as the Condominium agreements. An advisory council for the northern Sudan was established in 1944 as a step toward a closer association of the Sudanese public with government policy. In 1946 an Anglo-Sudanese committee recommended the setting up of a legislative assembly to carry this policy further and to bring in representatives of the more backward southern provinces recommendations were forwarded to the condominium government and modified to meet Egyptian criticism of them, but, even then, the Egyptian government withheld its approval. In 1948, however, the governor general promulgated an ordinance estab lishing an executive council with seven Sudanese and five British members and a legislative assembly with 65 elected, a maximum of 10 nominated and some ex officio members. The legislative assembly met for the first time on Dec 15, 1948. After being passed by the council and the assembly a bill becomes law on its obtaining the assent of the governor general In 1951 the governor general set up a committee to work out a constitution for the Sudan.

Administrative Divisions.—There are nine provinces under provincial governors, comprising 46 districts The provinces (with their capitals) are Bahr el-Ghazal (Wau), Blue Nile (Wad Medam), Darfur (El Fasher), Equatoria (Juba), Kassala (Kassala), Khartoum (Khartoum), Kordofan (El Obeid), Northern (El Damer), Upper Nile (Malakal) The head of the provincial administration is the civil secretary, but the governors of provinces are the chief magistrates and have considerable freedom of action The district commissioners under the provincial governors exercise functions which vary according to the state of advancement of the region. A majority of the most senior posts was still in Butish hands in the early 1950s but the policy of Sudanization had made rapid progress In each province there is a provincial council of 12 to 20 Sudanese members who advise the governor. Local government was gradually extended from 1921 In 1952 there were 17 urban boroughs and 39 rural districts, which had their own budgets.

"Development of the control of the control of the control of the control of appeal, and by subordinate district judges. The high court, who are also members of the court of appeal, and by subordinate district judges. There is a substantial body of legislation covering various branches of civil law. Ceminal justice is administered under the Sudan penal code, which was mustituted on the model of the Indian penal code. Serious crimes are tried by major courts constituted under the code of criminal procedure and composed of a president and two members. There are in addition Sharia (Moslem religious) courts for questions relating to the personal status of Moslems (marriage, divorce, nehertiance and so forth), with a high court (mahkomah) at Khartoum over which the grant cadt presides.

Labour laws are based on British models There were in 1952 about 100 trade unions, the largest being the Sudan Railway Workers' union, with 19,000 members

Defense.-The Sudan defense force, formed in 1925 on the

withdrawal of Egyptian army units, had in 1940 a 1fle stiength of 4,000, officiend by 69 Birthis and 97 Sudanese officers. It was greatly expanded during World War II but was much reduced in numbers after 1945. In 1952 it comprised a camel corps, the eastern Arab corps, the western Arab corps and the equatorial copps, as well as technical and service units based in Khartoum The police force establishment at the end of 1949 was 100 officers and 6,409 men.

Public Health and Education.—Great progress was made during the first half of the 20th century in winning the confidence of the people and in building up an efficient medical service. By 1952 there was a network of 40 hospitals and more than 400 rural dispensaries in the charge of medical assistants trained in the diagnosis of the commoner endemic diseases and competent to satired to the network of the commoner endemic diseases and competent to

attend to the victims of accident or sudden illness The system of education falls into two spheres the northern. which is mainly in direct government hands, and the southern, where Christian missions are the main agents of government in the spread of education The department of education became a ministry at the end of 1948, when the first minister was appointed Higher education is provided by the Gordon Memorial college in Khartoum (founded as a primary school by British public subscription in 1902), which in 1951 was embodied, with the Kitchener School of Medicine, as the University College of Khartoum It has faculties of arts, law, science, engineering, agriculture and veterinary science and had 440 students (including 46 medical students) in 1951 It is in special relationship with London university, whose degrees may be taken from Khartoum In 1800 no more than 300 boys were attending schools in the Sudan, at the beginning of 1950 the number of schools was 1,475 and the number of pupils 137,577 (118,448 boys and 19,129 girls).

#### ECONOMY

Agriculture and Forestry.—Cotton is by far the most important crop from the economic point of view, both long- and short-staple varieties are grown, the former in areas under special irrigation schemes and the latter in areas of rain cultivation Durra (sorghum millets), the main food crop, and dukhn (Penmesteim millets) are widely grown in all districts. When it grown as a cash crop on trigated land to meet the need of the towns Some barley is grown in the Northern province and miscies extensively grown there and on the upper Blue Nile and miscincer of vegetable oil. Peanuts are grown for use as a foodstuff, not for extractive purposes.

The natural grazing is supplemented by grain residuals and ceitain fodder crops, of which lubia (Dolkchos lablab) is the most widely cultivated. Barsim (alfalfa) also finds a place where adequate moisture can be assured throughout the year

The date palm is an important item in the economy of the riverain cultivator between Kharloum and the Egyptian frontier Citrus fruits and mangoes are becoming more popular crops, and bananas, indigenous in the southern provunces, are being grown commercially in Kassala Market gardening is steadily increasing, bamia (lady's-finger), omous and other vegetables, both tropical and European, are grown but demand still exceeds supply Tobacco, coffee and sugar cane are grown in the south but had not become economically important by mid-2oth century

In the 1950s plans for the agricultural development of the rainland of the south were not fully realized, and the prosperity of Sudanese agriculture still depended on irrigation (under various systems of control) and perennial irrigation (under various systems of control) and perennial irrigation (by lift or gravity flow) were employed. Primitive water this and power-driven pumps were used. The only gravity-flow irrigation was in the Gezira scheme fed from the Senara dam. The Gezira is a flat plane attending from the junction of the Blue and White Niles to a line 120 mi. S. and comprising about 5,000,000 ac, with 3,000,000 ac irrigable. The scheme was in the hands of a syndicate from its imagumation in 1911 until the government took it over in 1950. Here, too, cotton is the main crop; durra, lubic and fodder crops also have their place in the system of crop rotation.

The Sudan and Senegal are the two great gum-producing counters of the world, and in the Anglo-Ego plants Sudar gum arabet from the acacus of Kordofan is the most important forcest product. The felling of timber for fuel is controlled, so as to preserve easiting forests and to concentrate fellings in forest reserves when reafforestation can be assured.

Minerals.—The Sudan is poor in minerals. Gold as found in the mountains of the Red sea coast, but the formation of the reds is such that they do not lend themselves to large-scale development. Copper is found (and was formerly worked) at Hoficial en-Nahas on a tributary of the Bah iel-Arab. Iron one deposits en-Nahas on a tributary of the Bah iel-Arab. Iron one deposits en-star in many districts, in the south and west the natives have smelled iron for many years, but, in the absence of coal, the deposits are of no economic value to the country's Statis produced by evaporation at Port Sudan in quantities sufficient to fulfil the country's requirements and provide a surplus for export

Trade—The principal exports of the Anglo-Egyptian Sudan are cotton and cottonseed, guin arabe, cattle and sheep, hides and skins, olicake, melon seed, peanuts and pulses. The principal imports are metals and metal manufactures, machinery and applances, vehicles and transport equipment, piece goods, fuel oil, kerosene and gasoline, coffee, tea, sugar, alcobile beverages, wheat and wheat flour, sacks and hessain. The accompanying table shows the value of external trade in selected years.

Trade of the Anglo-Egyptian Sudan

(11	minious or 15,	gypnan pound	1)		
Itcm	1913	1920	1941	1950	١
Imports Evports and re-exports	2 11 1 19	7 00 5 08	8 o6 8 8r	26 55 31 II	ļ

Authorities Government annual reports (for 1913 and 1920) and UN Statistical Year Book, 1951 (for 1941 and 1950)

Communications.-The railway and steamer services are operated by the government In 1950 the total length of railway in operation was 2,056 mi. Steamer services cover 2,325 mi The main railway line runs from Wadi Halfa via Atbara and Khartoum to Sennar with a main eastern branch from Atbara to Port Sudan on the Red sea, a subsidiary branch runs southward from Port Sudan through Kassala and Gedaref to Sennar, and a second branch runs westward from Sennar to El Obeid. The main steamer services ply from Wadi Halfa northward to the Egyptian river port of Shellal and southward from Kosti on the White Nile to Juba, the capital of the most southerly province. Khartoum is an important stopping place on the main Cairo-Cape air route, with feeder services to the east (Eritrea and Aden) and to the west The vast distances and the lack of sufficient pay load makes the provision of a modern system of roads uneconomic; consequently most rural tracks are rough and many have patches of soft sand Internal and international postal and telegraph services are available, and a number of the principal towns are connected to the international trunk telephone service to Egypt, Great Britain, Europe and the United States

Finance.-From the time of the reoccupation until 1912 there was an annual deficit which was made up by Egypt This debt was agreed at £E5,414,525 in 1938, and repayment of annual instalments began in 1949. Direct taxes, usually providing about 40% of the income, are the business profits tax, the animal tax, the land tax, tithes (ushur, assessed on crop values where no land tax is imposed), the date tax and the tribute (a lump sum assessed on a tube in lieu of animal and ushur taxes) Indirect taxes are derived from customs duties, the government sugar monopoly, liquor and motor vehicle licences Other sources of public reve nue are the post and telegraph services, the railways and the river steamers and the agricultural schemes. Reserve funds stood at £E12,000,000 on Dec. 31, 1949. The public debt was about £E13,000,000 in 1950. Between 1912 and 1945 revenues increased from about £E1,500,000 to £E5,000,000; the estimate for 1951-52 was £E24,782,000. Expenditure in the same period increased from £E1,500,000 to £E17,000,000. The Anglo-Egyptian Sudan has a common currency with Egypt; the Egyptian pound was equal to £1 os. 6d. sterling in 1952.

BINI INCRAPHY —Sudan Government, The Sudan, a Record of Pisters (Khattoum, 1047) and note Facts About the Sudan (Khattoum, 1047) and note Facts About the Sudan (Khattoum, 1047). Sudan, Received in Consequence (Khattoum, 1047). Sudan, Received in Consequence (Khattoum, 1047). As the C. Hamilton (ed.), The Angle-Applian Sudan (London, 1043). J. A dec C. Hamilton (ed.), The Angle-Applian Sudan From Within London, 1047). R. L. Kinivich and B. M. Boyna, Agrendium? Science and the Angle Applican (Antonaba, 1049). J. S. Thirmigham, Islam in the Sudan (London, 1049). See also the various annual reports by the governors general on the administration, insance and conditions of the Sudan (ISS O. London). Pad Pist S. M. Lee Consequence (ISS O. London).

SUDAN, CAMPAIGNS IN: see EGYPT AND SUDAN CAM-PAIGNS (1882-1000)

SUDAN, FRENCH, one of the territones of French West Africa, lying toward the western end of the geographical Sudan, between the Sahara (the Southern Territories of Algeria) and the Ivory Coast. The area is 460,308 eq mi

The western part of the territory includes the valley of the upper Senegal river; the centre and the east companse that of the middle Niger At first the Niger and its tributary the Ban form a sort of mesopotamian region. Then the Niger flows on into an alluvial zone characterized by numeious branch streams and lakes (Lake Debo, Lake Faguabine, etc.) and submerged by flooding in the ramy season. At Timbuktu (Tomboutcou) the river inso into harder rock and change its course from a northeasterly one to an easterly, which shortly becomes southeasterly. Within the loop thus formed stands a sandstone plateau, the Bandagana escarpment; to the north is the Sabara, with the mountainous advar of the Hora.

The climate in the south is typically Sudanic: rainfall amounts to more than 25 in. a year, and the dry season lasts from November to June The vegetation consists of tall grasses with trees here and these. The middle region, or Sahel, has the sparser, prickly vegetation of a steppe. Not to fit the Nigel loop the deserbegins, with great heat (especially from March to May). Lions, hippopotamuses and antelopes are plentfull

History—The empire of Ghana dominated the Sahel between the Senegal and the Niger from the 4th to the 17th century; that of Mail controlled the middle Niger from the 17th to the 17th. The empire of Gao, which began in the 7th century, was overthrown by Moorsh invaders in 1501

For the story of an alleged 15th-century visit to Gao see
DISALGUERS, ANSERIMS MUNG Park explored the Niger in 1796
and in 1805. René Callié reached Timbuktu în 1828. Eugène
Mage în 1864 and J S. Galliem in 1889 swisted the court of
Alimadu (son and successor of the marabout Omar al-Hai) at
Segu (Ségou), when tethey were held captive for some time Gae
tave Borgnis-Desbordes occupied Bamako in 1881, then Lous
tave Borgnis-Desbordes occupied Bamako in 1881, then Lous
time of the Sahart stork place on the sarty years of the sortection of the Sahart stork place in the early years of the sortectury. The colony was first known as Upper Senegal and Niger. In
1970 the Upper Volta was detached from it.

Population.—The population in the middle of the 20th century was estimated at about 3,200,000 persons, with a density, therefore, of less than 7 per square mile. But only the south and the river valleys are consistently ribabilete. Apart from 7,000 Europeans (including 6,000 French people), the mhabitants are divided between White Africans and Negroes. The White Africans are nomads who occupy the Sahara and part of the Sahel, in the west, 50,000 Moors; in the east, 160,000 Turege.

The Negroes are cultivators and also engage in some stock trassing and commerce. The majority are Mandingo-speaking peoples inhabiting the mesopotamian region of the Niger and the adjacent country, of these 200,000 are Mailhaké, 1,100,000 Bambara and 43,000 Dioula (Jula). The Senoufo (1x9,000) and the Bobo (50,000) live in the south; the Dogo (1x9,000) on the Bandingara plateau, the Bozo fishermen and the Songhat (200,000) and the Markolde (250,000) on the Senegal. The stock-massing Peul are disseminated over the whole termtory.

Moslems constitute 55% of the population (Moors, Tuareg, Toucouleur, Sarakolé, Songhai, Dioula and Bozo), pagans 44% and Christians 0.5%. The Roman Catholic missions are French-

(there are three bishops), the Protestant ones American

(unere are inrec bishops), the Protestant ones American Bamako, the capital (about 100,000 mibatinats in 1952), has the administrative centice on the heights of Koulouba and extends for a Kayes (19,000) on the Senegal, Sequ (19,000), Mobil (10,000), Tim-buktu (7,000) and Gao (8,000) in the Nager valley, and Shkasso (15,000) in the south. Houses are built of red earth, with a treac-tive "Scalance style" of architecture). The health service has a large generative for The health service has a large generative hospital and an institute for

the control of leprosy at Bamako, six secondary hospitals, 35 dispensaries and 23 materiaty hospitals. In 1952 the primary schools had 23,000 pupils, secondary schools comprised a lycée and three collèges, and

there were five technical colleges

Government.—The territory, which is divided into 16 circles and 27 subdivisions, is administered by a governor, who is assisted by a territorial assembly elected by direct suffrage. All the inhabitants have French citizenship and all heads of families have a vote. The territory is represented in Paris by four deputies in the national assembly, by four senators and by five councillors of the French union courts of law

Economy.—About 77,000 sq mi can be used for agriculture (in the south and in the river valleys) Food crops are millet (of which there south and in the river valleys) Food crops are millet (of which there was a yield of 650,000 metric tons in 1952), maize (70,000 tons), fomo (Paspalum longistorum), beans, yams, cassava and sweet potatoes (Paspalam longiforum), beans, yams, cassava and sweet potatoes Ruce, the growing of which was promoted by inigation, gave a yield as high as 160,000 tons in 1952. Industrial crops are peanuts (100,000 tons, with shells, in 1952), cotton (6,000 tons) and sisal (400 tons), Natural products of economic importance include kapok (500 tons), shea butter (10,000 tons) from the kaute tree (Butyrospermum parku)

snea Dutter (15,000 cons) from the salary are (15,000 cons).

The "Niggi office," established in 1919 by the engineer Bélime, built dams at Southa and Sansanding to promote the irrigation of the area hable to flood. In this area 20,000 African farmers were settled, and by 1952 it was producing 26,000 tons of rice, 1,400 tons of cotton and

5,000 tons of peanuts

5,000 cons or peanuts
Stock raising accounted in 1952 for 2,300,000 humped cattle, 3,200,000 steep, 3,500,000 goats, 160,000 asses, 80,000 camels and 60,000 horses. These herds supply beasts for export in large numbers to the southern territories of French West Africa.

Mineral resources are meagre there is some alluvial gold and, in the Sahara, some deposits of salt (Taoudeni).

Sahara, some deposts of sall (Taoudeni).

Reside the traditional catifs (leatherwork, weaving and carpet making), industries connected with food and building have grown upmaking), industries connected with food and building have grown upmaking), industries connected with food and building have grown upmaking), industries connected with food and the property of the property Bamako, at Kayes and at Gao.

See J. Richard-Molard, Afrique occidentale française (Paris, 1952);
Agence de la France d'Outremer, Soudan français (Paris, 1952).

(HU. Dr.)

SUDANIC LANGUAGES. This term is applied to a num-

ber of languages spoken by Negro and other peoples from Abysnier of amguages Jones ny Nego and outer peoples from Auyssina to Nigeria. As present i o main divisions are recognized
kanuri. (c) Nilo-Auysanan (15 languages), including Bait,
Turkana, Suk, Nand, Masat. (d) Korician (to languages), including Bait,
Turkana, Suk, Nand, Masat. (d) Korician (to languages), including
Bait, Turkana, Suk, Nand, Masat. (d) Korician (to languages), including
Bait, Gols and Seri. (f) Chari-Wadaun (12 languages), including
Bande, Gols and Seri. (f) Chari-Wadaun (12 languages), including
Bande, Gols and Seri. (f) Chari-Wadaun (12 languages), including
Bande, Alaysa and Saru. (f) Chari-Wadaun (12 languages), including
Batta, Angas and Hausa. (to) Nigero-Canercone (66 languages), including
Guwala, Nike, Exp. Byle, Byle, Dyle, Dyle, Dyle, Syrub, (11) Lower Niger
group, consists of Idyo or Beni. (12) Votale group (52 languages),
Lendung Guwala, Nike, Exp. Byle, Byle, Dyle, Dyle, Syrub, (12) Lower Niger
Group and the Fanti and Abron. (14) Niger-Senegal group (36
languages), Including Mandingo, Via and Mende, (12) The 24 languages),
Including Guwala, Increase are found of the nound classifications conspicus
In Bantu languages. The distinction between noun and verb is weak.
See, A. Mellist and M. Cohen, Les Language at monde (1924); W.
Schnidt, Die Sprachfumilien und Spracher-Kreise der Erde (1921);
SUDATOREUM, in architecture, the vautled sweating room sinia to Nigeria. At present 16 main divisions are recognized

SUDATORIUM, in architecture, the vaulted sweating room (sudor, sweat) of the Roman thermae, referred to in Vitruvius (v, II), and there called the concamerata sudatio. In order to obtain the great heat required, the whole wall was lined with vertical terra-cotta flue pipes of rectangular section, placed side by side, through which the hot air and the smoke from the hypocaust (q.v.), or hollow floor, passed to the roof. (See BATHS;

LACONICUM )

SUDBURY, SIMON OF (sometimes called Simon Theo-BALD or Tybald) (d, 1381), archbishop of Canterbury, was born at Sudbury, in Suffolk, studied at the University of Paris and became one of the chaplains of Pope Innocent VI, who sent him, in 1356, on a mission to Edward III of England, and in 1361 appointed him bishop of London From 1375, when he was made archbishop of Canterbury, he was a partisan of John of Gaunt, In July 1377 he crowned Richard II; in 1378 John Wychiffe appeared before him at Lambeth, Chancellor of England from 1380, Sudbury was regarded by the peasants, who were in revolt, as one of the authors of their distress, and the Kentish insurgents damaged his property at Canterbury and Lambeth and, dragging him from the Tower of London, beheaded the archbishop on Tower hill on June 14, 1381

See W F Hook, Lives of the Archbishops of Canterbury.

SUDBURY, a city in northern Ontario, Can, 264 mi N of Toronto, on the Canadian Pacific and the Canadian National railways It produces more than 90% of the world's nickel and almost all the copper produced in Ontario The smelter of the International Nickel company is at Copper Cliff, a suburb to the west, and the Mond company's smelter and sulphuric acid plant is 8 mi. E. at Coniston A government school of mines and a Jesuit

college are situated there Pop (1951) 42,410

SUDBURY, a municipal borough of West Suffolk, Eng, in the parliamentary division of Sudbury and Woodbridge (1951) 6,614. Area 3 sq mi It lies on the river Stour (navigable up to the town), 22 mi. W. of Ipswich by road One of the mediaeval wool towns, it has many beautiful half-timbered buildings and three Perpendicular churches All Saints, with a fine oaken pulpit dating from 1490, St. Peter's, with a carved nave roof; and St Gregory's, once collegiate, which contains a rich, spire-shaped font cover of wood, gilded and painted. The grammar school was founded by William Wood in 1401 (rebuilt 1857) Wool was replaced by the manufacture of coconut matting; silk manufactures were transferred from London during the 10th century, when horsehair weaving was also established

Thomas Gainsborough (1727-88) was born there, and an earlier native was Simon Tybald, archbishop of Canterbury, who was murdered in Wat Tyler's rebellion and whose head is preserved in St. Gregory's. Before the conquest the borough was owned by the mother of Earl Morcar of the Northumbrians, from whom it was taken by William I It was alienated from the crown to an ancestor of Gilbert de Clare, earl of Gloucester, who in 1271 gave the burgesses their first charter confirming to them all their an-

cient liberties and customs. Sudbury was incorporated in 1554 SUDD, a vegetable obstruction on the upper Nile. It is composed of compacted masses of plants consisting chiefly of a grass, Vossia procera, with Saccharum spontaneum, which cover a large area of the Ghazal swamps. Loosened by storms, these plants reach the main channel near the Sobat river junction, lodge on some obstruction and form a dam, sometimes 25 mt, in length and nearly 20 ft, below the surface. These peaty blocks of decayed vegetation and soil are compressed by the current so that in parts they can support an elephant. At length the pressure of the water forms a side channel or causes the sudd to burst. (See Nile.)

See O. Deuerling, Die Pflanzenbarren der afrikanischen Flusse (Munich, 1900); H. G. Lyons, The Physiography of the Nile and Its Basin (Cairo, 1906).

SUDERMANN, HERMANN (1857-1928), German writer, was born at Matziken, East Prussia, on Sept. 30, 1857, of a Mennonite family long settled near Elbing. His father owned a small brewery, but because of a financial crisis was obliged to apprentice his son, at the age of 14, to a chemist. Young Sudermann was able, however, to study at Tilsit and afterward at Konigsberg university. He then went to Berlin, where he acted as tutor in several houses and worked as a journalist on the Deutsches Reichsblatt (1881-82), afterward turning to novel writing.

His novels Im Zwielicht (1886), Frau Sorge (1887), Geschwister (1888) and Der Katzensteg (1890) revealed neither beauty nor emotional power, but invariably showed keen observation, a vivid touch and dramatic technique. The tale is his chief concern, and he shows a masterly control of tension, as in Closuthes Hochseit (1892), Es Wor (1894) and Das Hohe Lied (1908) showed a falling off, but the old mastery reappeared in Lataussche Novellein (1017)

More mstantly popular, and later more butterly decried, were plays, of which Die Eber (1880) brought him mendants lame, and Hamat (1892), better known as Magda, made him known throughout Europe Part of the great success of Magda was no doubt due to the fact that the title-rôle was interpreted by Modjeska, Berhardt, Duse, and Mrs Patrick Campbell. His dramas, Sodoms Ende (1891), Inhamusfeuer (1900), Es Lebe Das Lebes (1912), Der Stumpsselle Sobretes (1903), Strick Utter Der Stemen (1915) and numerous others ending with Der Hanselfellhandle (1935) were uniformly successful on the stage. During the World War he wrote the cycle of three plays collectively entitled Der Entytoters Will His last novels were Der tolle Projessor (1926) and Puralchen (1928). He belonged to the realistic movement of the last quarter of the roth century, and was not very sympathetic to the new methods and new outlook of post-war literature. He deel at Berlin on Nov 23, 1938

post-wat increasure: Lee Gueta to be benin on 1907 22, 1920
See W Kawerau, Sudermann (1897). H. Landsberg, Sudermann (1902). H. Jung, Sudermann (1902). H. Schoen, Sudermann, Poete dramatique et romaneare (1905), and I. Aveliod, Sudermann (1907). His dramatic works were collected in 1923. See also his autobiography. Das Bilderbuch, memer Jugend (Eng. Irans, NY 1924).

SUE, EUGENE [Joseph Marie] (1804-1857), French novelist, was born in Paris on Jan 20, 1804 He was the son of a distinguished surgeon in Napoleon's army, and is said to have had the empress Tosephine for godmother. Sue himself acted as surgeon both in the Spanish campaign undertaken by France in 1823 and at the battle of Navarino (1828). In 1829 his father left him a fortune, and he settled in Paris. His naval experiences supplied much of the materials of his first novels. In the quasi-historical style he wrote Jean Cavalier, ou Les Fanatiques des Cevennes (4 vols, 1840) and Latréaumont (2 vols, 1837). He was strongly affected by the Socialist ideas of the day, and these prompted his most famous works. Les Mystères de Paris (10 vols., 1842-1843) and Le Juit errant (10 vols., 1844-1845). which were among the most popular specimens of the romanfeuilleton He followed these up with some singular and not very edifying books. Les Sept péchés capitaux (16 vols., 1847-1849) which contained stories to illustrate each sin, Les Mystères du beuble (1849-1856), which was suppressed by the censor in 1857

Some of his books, among them the Intl errant and the Mysics of Parat, were dramatized. After the revolution of 1848 he sat for Paris (the Seine) in the Assembly, and was exited after his protest against the conp d'était of Dec. 2, 1851. His later works were inferior. Sue died at Annecy (Savoy) on Aug. 3, 1857

SUEBI or SUEVI, a callective term applied to a number of peoples in central Germany, the chief of whom were the Marcomann, Quadi, Hernunduri, Semnones, and Langobardi; these trabes inhabited the basin of the Elbe. Tacitus uses the name Suchi in a worder sense to include not only the tribes of the basin of the Elbe, but all the tribes north and east of that river, including even the Swedes (Sulones).

From the 2nd to the 4th century AD, the name Suebi is seldom used except with reference to events in the neighbourhood of the Pannonian frontier, and here probably means the Quadi. From the middle of the 4th century it appears in the regions south of the Main, and the names Alamanni and Suebi are used synonymously The Alamanni (q.v.) seem to have been joined by one or more other Suebic peoples, some of whom accompanied the Vandals in their invasion of Gaul and founded a kingdom in northwest Spain Besides the Alamannic Suebi we hear of a people called Suebi, who shortly after the middle of the 6th century settled north of the Unstrut There is evidence also for a people called Suebi in the district above the mouth of the Scheldt. It is likely that both these settlements were colonies from the Suebi of whom we hear in the Anglo-Saxon poem Widsith as neighbours of the Angli. The question has been raised whether these Suebi should be identified with the people whom the Romans called Heruli. After the 7th century the name Suebi is practically only applied to the Alamannic Suebi (Schwaben), with whom it remains a territorial designation in Wurttemberg and Bavaria

mans a territorial designation in with the sear, B.G. 1 37, 51 et seq, iv 1 et seq, vi 0 et seq, Strabo, p 390 et seq; Tactus, et seq, vi 1 et seq, vi 0 et seq, Strabo, p 390 et seq; Tactus, Germana, 36 et seq, K Zeuss, De Deutschen and die Nachbardammen, pp 55 et seq, 315 et seq; C Bremer in Paul's Grundriss (and et), in 197-590, H M Chadwick, Origin of the English Nation, 216 et seq (Cambridge, 1907).

SUECA, a town of E Spain, in Valencia Pop (1940), 16,864

SUEČÁ, a town of É Špan, in Valencia Pop (1940), 16,864 (mun, 19,890) Sueca is separated from the Medietreranen (7m east) by the Sierra de Cullera It is a modern town, although many of the houses have the flat roofs, view-turrets (muadors) and horseshoe arches characteristic of Mousish architecture Sueca has a thriving trade in grain and fruit from the Júcar valley, which is irringed by materiass, created by the Moors

SUEDE FINISH, a nap produced by separating the surface fibres of leather on a cathorudum or enercy wheel Although this piecessing may be directed either at the grain of leather or the flesh surface, it is mere often applied to the latter. Suede finish usually indicates chrome or alimit tanning as opposed to vegetable tanning, and the resulting leather is soft, pillable, and

Stong It is used for shoes, hats, coats, gloves, belts and handbags SUESSULA, an ancient town of Campania, Italy It commanded the entrance to the Caudine pass (See Caudine Forks)
Traces of the theatre may still be seen Oscan tombs were exavated, and vases, bronzes, etc., have been found Suessula lay on the Via Populia On the hills above Cancello to the east of Suessula was stutated the fortified camp of M. Claudins Malcellus, used as an outpost against Hanmbal in Capua (See Punic Wasch).

SUETONIUS TRANQUILLUS, GAIUS, Roman historna, lived during the end of the stat and the first half of the and century at a He was the contemporary of Tactus and the younger Pliny, and his theraty work seems to have been cheely done in the reigns of Tasjan and Hadrana (a.n. 98–186). His father was multary tributes in the XIIIth legon, and he humself began life as a teacher of rhetoric and an advocate. To us he is known as the lographer of the twelve Cascars (including Julius) down to Domitian. As Hadran's private secretary (magistar epistolarum), he must have had access to the Impenia farthwes, e.g., the transactions of the senate. He was a correspondent of the younger Pliny, who as governor of Bithynia took Suctionus with Im Hadran's biographer, Aclius Spartianus, tells us that Suetonius was deprived of his private secretaryship because he had to been sufficiently observant of court etiquette towards the emperor's wife during Hadrans's absence in Britain

The Lives of the Cosson is tather a chronicle than a history It gives no general picture of the period. It is the empeore who is always before us, yet the portinit is drawn without real insight for the personal anecolotes are very amusing; but the author panders too much to a taste for gossip. None the less he is next to Tactius and Dio Cassius the chief (sometimes the only) authority. The language is clear and simple Of his De viris illustribus, the lives of Terence and Hotace, fragments of those of Lucan and the delder Phiny and the greater part of the chapter on grammariams and rhetoricansa, are extant. Other works by him (now lost) were Prata (= hatpluors=patch-work), in ten books, a kind of encyclopsedia; the Roman Year, Roman Institutions and Customs, Children's Games among the Greeks, Roman Public Spectacles, On the Kings, On Cicew's Republic.

SUEZ, a port of Egypt on the Red sea and southern terminus restored the waterway till finally trade between Europe and the of the Suez canal Pop (1937) 49,686 Suez is supplied with water by the fresh-water canal, which starts from the Nile at Cairo and was opened in 1863 Before this, water had to be brought from "the Wells of Moses," a small oasis 3 mi distant About 2 mi S of the town are the quays constructed on the canal and connected with the town by an embankment. On one of the quays is a statue to Thomas Waghorn, the organizer of the "overland route" to India The ground on which the port is built has all been reclaimed from the sea. The accommodation provided includes a dry dock 410 ft long, 100 ft broad and nearly 36 ft deep There are separate basins for warships and merchant ships, and in the roadstead at the mouth of the canal is ample room for shipping. Suez is a quarantine station for pilgrims from Mecca

In the 7th century a town called Kolzum stood, on a site adjacent to that of Suez, at the southern end of the canal which then joined the Red sea to the Nile On the Ottoman conquest of Egypt in the 16th century Suez became a naval as well as a trading station, and there fleets were equipped which for a time disputed the mastery of the Indian ocean with the Portuguese According to Niebuhr, in the 18th century a fleet of nearly 20 vessels sailed yearly from Suez to Jidda, the port of Mecca and the place of correspondence with India The overland mail route from England to India by way of Suez was opened in 1837 The regular Peninsular and Oriental steamer service began a few years later, and in 1857 a railway was opened from Cairo through the desert The present railway follows the canal from Suez to Ismailia and Zagazig, whence branches diverge to Cairo and Alexandria

SUEZ CANAL, an artificial waterway about 100 mi long, connecting Port Said on the Mediterranean sea with Suez on the Red sea, thus enabling shipping between Europe and the east to avoid the long sea passage by the Cape of Good Hope.

The Isthmus of Suez is one of the world's crossways. It joins the African to the Asian continent. It separates the Mediterranean from the sea routes that lead most directly to the far east At its narrowest point it is barely 75 mi across At the end of the Tertiary period a channel joined the two seas. As a result of marine deposits, of silting from the Nile and probably also of seismic action, the isthmus gradually assumed the aspect which it presented to travellers before the construction of the Suez canal, a waste of sand dunes with occasional salt depressions At one time the over Nile entered the Mediterranean by seven separate channels instead of two only as at present. The Pelusiac, the most easterly of these branches, passed north of the site of modern Kantara, while the Tanitic branch entered the Mediterranean about 10 mi. E of the present town of Port Said. Farther south the Bitter lakes remained for long connected with the Red sea.

The Earliest Canal in History,-Plans to traverse Egypt with a navigable waterway, or at any rate to connect lower Egypt with the Red sea, go back to very ancient times. The need in those distant days was to link the important commercial centres of the Nile valley with the Red sea trade routes. The Nile itself assured exit at need to the Mediterranean. And so it is that the earliest canals of which history has mention were constructed to link the Nile valley to the Red sea and not to pierce the narrow neck of land which separated the latter from the Mediterranean, There has been much argument among scholars about the dates and exact alignments of these earliest works

The available evidence is meagre enough but it seems to be established that, perhaps as early as 2000 B.C., a canal linked the Pelusiac branch of the Nile, via the Wadi Tumilat, with the Bitter lakes, whence another channel was dug to the Red sea Following the vicissitudes of Egyptian political history this canal was sometimes allowed to fall into disuse, and again, depending on the vigour of individual rulers, it was re-excavated to serve the southward-looking commerce of the day. After the Persian conquest Darius the Great is credited with the restoration and enlargement of the canal of the Pharaohs. The Ptolemies, followed by the Romans and later still by the Arabs, are known to have

east passed to other routes and into the hands of other people

Maratime Canal Projects.—The Cape route to India and the east was discovered in 1498 This gave to the countries on Europe's western seaboard an immense advantage in the competition for Indian trade France, however, looks out not only onto the Atlantic but onto the Mediterranean and this, combined with its growing political and economic rivalry with England, explains why the thoughts of Frenchmen turned early to the possibility of piercing the Isthmus of Suez with a navigable waterway. This possibility was often debated in French writings during the 17th and 18th centuries, the discussions all being coloured by the then prevalent misconception that an important difference in levels existed between the two seas that the contemplated channel was intended to unite. It was against this background that, in the struggle against England, Napoleon was sent by the Directory (1708) to occupy Egypt With him went a distinguished French engineer, Charles Lepère, with orders to study and report on the possibility of constructing a sea-to-sea canal across the Isthmus of Suez Lepère, labouring under the still prevalent misconception that the level of the Red sea was about 30 ft higher than the level of the Mediterranean, reported against a canal to join the two seas and advocated instead the reopening of the old canal of the Pharaohs It was left to M A Linant de Bellefonds, another notable French engineer, to prove (1853) that the difference in levels between the two seas was unimportant and so to remove what was until then regarded as an almost insuperable difficulty in the way of excavating a navigable channel to cut the Suez isthmus. In the meantime the Saint-Simonians had interested themselves in the project. It was they who, after some abortive explorations in the isthmus, founded (1846) an international organization called the Société d'Études pour le Canal de Suez This body had for its object a full study of the whole subject, including the possibility of attracting the support of European investors in the enterprise.

De Lesseps .- The stage was now set for the arrival on the scene of a French personality of the first order Born in 1805. Ferdinand de Lesseps (q v), following in his father's footsteps, entered the French diplomatic service. At the age of 27 he was appointed vice-consul at Alexandria, where later (1835) he was promoted consul general From the five years he spent in Egypt at this time may be dated the first stirrings of the great ambition which was presently to dominate his life He read Lepère's reports with fascinated interest while he also enjoyed the friendship of Linant de Bellefonds.

His social gifts and the charm of his personality were such that he gained the particular favour of the viceroy, Mohammed Ali. With the latter's younger son, Mohammed Said, he was on terms of affectionate intimacy After service in Rotterdam, Barcelona, Madrid and Rome he returned to private life In his new-found lessure his thoughts turned again to Egypt and to the possibility of piercing the Suez isthmus with a navigable canal

An unexpected chance favoured him. Abbas, who had succeeded Mohammed Ali as viceroy, was violently suspicious of western, and particularly of French, influence. He was murdered in 1854 and was succeeded by Said, De Lesseps' close friend. On hearing of Said's succession De Lesseps started immediately for Egypt. His hopes of enlisting the sympathy of the new viceroy for the project he had at heart were well founded. On Nov 30, 1854, Said signed what is known as the first act of concession. It authorized De Lesseps to form the Compagnie Universelle du Canal Maritime de Suez, the purpose of the company being to pierce the Isthmus of Suez by a navigable canal, to exploit the waterway when constructed and to build one or two ports at its extremities The concession was to last for 99 years.

The Company Formed,-This was followed by a second and more precise act signed by Said on Jan 5, 1856. The statutes of the new company formed an annex to this act which also recited that, subject to the approval of the viceroy's suzerain, the sultan of Turkey, the canal and its dependent ports should be open at all times comme passage neutre to all merchant ships without distinction of individuals or of nations, provided that the transit dues were duly paid. The company itself in a succeeding article was expressly prohibited from according to any individual or to any company or organization any particular or preferential treatment whatsoever The period for which the concession was to last was confirmed at on years, to count from the date on which the canal was opened for navigation. At the end of that period. and in default of other airangements, the canal was to pass into the hands of the Egyptian government. In addition to the mantime canal the company was made responsible for excavating a fresh-water canal from the Nile near Cairo to Lake Timsah, from where branches were to run parallel to the new waterway, one north to Pelusium and the other south to Suez. The company was to have the right to fix and levy transit dues on ships and passengers subject to the restriction that such dues might not exceed 10 fr per ton or per passenger The company's central offices were to be located at Alexandria with administrative headquarters in Paris. The Egyptian government was to receive as a first charge 15% of the net profits, while a further 10% was to he distributed to those persons who had helped most in the fulfilment of the enterprise The company's sanctioned capital was to consist of 200,000,000 fr divided into 400,000 shares of 500 fr. each

Before the signing of the second act of concesson De Lesseps had assembled (Oct 1853) an International Scientific commission composed of eminent engineers and naval experts from various countries, including Great Britain A subcommittee of this commission visited Egypt to advise about the actual alignment of the proposed canal In accordance with the subcommittee's advise it was deeded, with the viceroy's approval, that the channel should run in a direct line from Suse to the Gulf of relusion, passed and the subcommittee's advise to the Gulf of relusions, passed to the countries of the subcommittee and the subcom

British Opposition—The concession had hardly been signed when political complications arose. The British government, from fear of French pretensions in Egypt and annous about the safety of communications with the British Indian emprise, est itself to oppose the construction of the canal by every means in its power. Not content with making its displeasure felt in Carvo, the British government used all its influence, consideable at this time, in Constantinople to prevent the sultan's government from giving its approval to the acts of concession signed by the viceoy. In the result it was not until March 10, 1866, that the sultan's sanction was forthcoming, by which time the work of constructions the control of the sultant in the result is already under way.

For De Lesseps, undeterred by Palmerston's threats and abuse or by the wcullations of the Sublime Porte, the moment the second act of concession was signed set the work in train. The shares of the new company were placed on the market in Nov. 183 With the vision that inspired all his actions, De Lesseps had decided that all the western powers should participate in financing the enterprise. Blocks of shares were therefore set aside for each of these countries, including a block of 30,000 shares, one-fifth the whole issue, for Great Britain.

His hopes were, however, disappointed. Neither Great Britain nor the United States (the latter had been offered a block of 20,-000 shares) subscribed at all More than half the shares (207,111) were taken up in France, while the Egyptian government, which had been allotted a block of 64,000, actually subscribed for 177,not to wait for the sultan's approval and on April 25, 1859, he himself turned the first spadeful of sand at the site where later was to rise the town of Port Said. Soon, however, he ran into difficulties. Under British pressure a formal order emanated from the sultan requiring all operations on the spot to cease forthwith. Expenses were heavy as well, and the actual progress made was disappointing by comparison. Nevertheless, by 1862 the freshwater canal had reached Lake Timsah and toward the end of the same year a narrow channel had been excavated between Lake Timsah and the Mediterranean. In 1863 the fresh-water canal was continued to Suez. In the meantime Port Said itself was rising on the former flats and marshes of Lake Menzala.

So far the work had been done by Egyptian labour The second act of concession provided that at least four-fifths of the labourers employed by the company should be Egyptians, and later the vice-10y undertook to supply labouters as required by De Lesseps' engineers, who were to house and feed them and also to pay them at certain specified rates Although wages and conditions were both better than the men could obtain elsewhere in the Egypt of that day, the khedive Ismail, who had succeeded Said on the latter's death in 1863, allowed himself to be persuaded that for the good of the country the men would be better employed elsewhere The British government in its tireless resistance to the whole project made representations to the same effect in Constantinople As a result the Sublime Porte ordered (April 1863) not only that "forced labour" should cease but that the company should retrocede to the Egyptian government the bulk of the lands granted to them by Said in 1856 On Jan 16, 1864, the company appealed to the emperor Napoleon III asking him to arbitrate, ostensibly in order to protect the considerable French capital already sunk in the enterprise By his award, made in July 1864, the company was allowed 38,000,000 fr as compensation for the abolition of "forced labour," 16,000,000 fr. for the retrocession of the Wadi-Lake Timsah-Suez section of the fresh-water canal (the upstream portion between the Nile and Wadi had already been handed back by an agreement dated March 18, 1863) and 30,000,000 fr. in respect of certain lands granted to the company by Said The compensation, 84,000,000 fr. in all, was to be paid to the company over a period of 15 years

The emperor's award was accepted by both parties, and from this date onward the work made rapid progress. More machinery was imported to compensate for reduction in labour force. Political opposition to the project had also by this time died away. Finally in the summer of 1869 (the waters of the Mediterranean and the Red sea were united in the Bitter lakes.

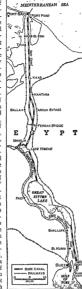
Altogether up to the end of 1869, when it was possible to open the canal for traffic, the accounts of the company showed a total expenditure of 432,807,882 fr

The Opening of the Canal.—The canal was formally opened on Nov. 17, 1869, amid scenes of great splendour, the procession of shaps being headed by the French impernal yacht. "Angie" with the empress Eugéme hersell on board De Lesseps dieaem, so long chenshed, thus ended in trumph Great Britani, tardily generous, rendered him toward the end of this same year all the honour and all the credit that were his due He was received in London by Queen Victoria, who confaired upon him the insigna of knight grand commander of the Star of India. He was made a freeman of the city of London and a magnificent fete was held in his honour at the Crystal palace.

As originally constructed the canal had a depth of 8 m with a bottom width of 22 m Over the years after 1860 the Suez Canal company was diligent in improving, widening and deepening the waterway. In the early days, except in the Bitter lakes, vessels could pass each other only at certain crossing places or gares As a result of successive widenings passing became possible at any point over the greater part of the canal, one vessel stopping while the other proceeds on her way. The width of the canal had by 1053 been increased to 120 m. The depth of the central channel (nowhere less than 60 m. wide) was 13 50 m., permitting the passage of ships with a draught up to 34 ft. In 1948 the board of directors undertook two further important improvements was decided to deepen the navigable channel by 50 cm., permitting the passage of vessels with a draught of 36 ft. In addition, a bypass channel II km, long was excavated in the northern section of the canal. Ships making the passage of the canal were marshalled in convoys, and the existence of this channel, which was opened to traffic in 1951, made it possible for north- and southbound convoys to pass each other without meeting in the main canal. For all these improvements and for annual maintenance, the latter in itself no mean task, the company maintained a staff of highly qualified engineers In addition, all proposed major works were scrutinized each year by an International Consultative commission composed of distinguished engineers, with specialized marine experience and recruited from various countries, including part of De Lesseps' International Scientific commission, was assume the responsibilities placed upon Turkey by that instrument

brought into being as long ago as 1884

International Status .-- As already mentioned article to of the second act of concession prescribed that the canal should always be open comme passage neutre to merchant ships of all nations Neither this nor the sultan's firman of 1866 approving the grant of the concession sufficed however to "neutralize" the canal For a status of neutrality can be conferred only by international agreement De Lessens himself had always been in fayour of the canal's being proclaimed neutral, and the issue assumed acute form at the time of the Arabi revolt (1881-82) As a result a convention was signed at Constantinople on Oct 20. 1888, by representatives of France, Great Britain Germany, Austria-Hungary, Italy, Russia, Spain, Turkey and the Netherlands Article 10 of this convention recites that the canal shall always "be free and open, in time of war as in time of peace, to every vessel of commerce or of war, without distinction of flag." Great Britain, however, in signing formulated a reservation that the provisions of the convention should apply only in so far as they were compatible with the actual situation in Egypt and in so far as they would not fetter the liberty of action of the British government during its occupation of that country But by the Anglo-French agreement of April 8. 1904, Great Britain declared its adherence to the stipulations of the convention and agreed to their being put into force except as regarded a provision by which the agents in Egypt of the signa-



MAD OF THE SHET CANAL

tory powers were to meet once a year to take note of the due execution of the convention. But though the principle of free user is confirmed by article 10 of the

TABLE I.-Ships in Transit Through the Suez Canal

Item	1913	1917	1929	1932
Number of transits Net tonnage (in thousands) .	5,085 20,034	2,353 8,369	6,274 33,466	5,032 28,340
	1938	1942	1950	1951
Number of transits Net tonnage (in thousands)	6,171	7,646	11,751 81,796	11,694 80,356

convention of 1888 it does not seem possible to maintain that the canal enjoys a status of neutrality No warlike acts can, it is true, be committed within its limits without a violation of the convention. It is not on the other hand like a neutralized territory over which passage of armed forces is denied to belligerents. Equally the territorial waters of a neutral state provide no exact parallel, for in their case there are no limitations as to time of arrival and departure. After World War I the Central Powers who were signa-

three from Great Britain This commission, the modern counter- tories of the convention of 1888 agreed that Great Britain should

During World War I the entire resources of the Suez Canal company were placed at the disposal of the British military authorities who were responsible for the defense of Egypt's eastern frontier against the Turks The Turkish attack (Jan.-Feb 1915) was repulsed and thereafter till the end of the war traffic through the canal continued without interruption. In World War II the company once again placed its staffs, equipment, workshops, all its resources in fact, at the disposal of the British armed forces then defending Egypt's western frontier against Italy and Germany No serious land threat developed during that war, though the canal was heavily bombed in 1940 and again in 1941

The Activities of the Company.-Management of the Suez Canal company is entrusted to a board of 32 directors Of these, by 1053, nine were British When Great Britain, thanks to the prompt and audacious action of Disraeli (see Beaconspield,

TABLE II -Goods in Transit Through the Suez Canal

Direction	1913	1917	1929	1932
Southward	11,320	1,339	12,896	6,314
Northward	14,455	5,436	21,620	17,318
Total	25,775	6,775	34,516	23,632
Direction	1938	1942	1950	1951
Southward	7,768	5,995	12,141	17,420
Northward	21,011	15,931	60,468	59,333
Total	28,779	21,926	72,609	76,753

BENJAMIN DISRAELI, EARL OF), acquired the khedive's shares (176,602) in 1875, it secured three seats on the hoard, while hy an agreement dated Nov 30, 1883, between the company and representatives of the British shipping industry, seven (by 1953, six) seats were allotted to British shipping interests. The composition of the board by 1953 was as follows French 16, British 9, Egyptian 5, Dutch 1, US 1. The board meets once a month in Paris A committee of eight directors chosen by the board meets once a week under the chairmanship of the president to conduct the current affairs of the company, subject, where the statutes so prescribe, to the final approval of the board or, as the case may be, of the general assembly of the shareholders. This last meets once a year, also in Paris Two of the British government directors have seats on the committee of management

In Egypt the relations of the company with the Egyptian government are conducted through an agent supérieur with his headquarters in Cairo. The headquarters of the canal management are at Ismailia There the company's staffs are organized in three principal departments works, traffic and administration. The traffic department has sole charge of the passage of ships through the canal, marshals convoys, controls their timings and speed (the maximum speed permitted is 14 km per hour), allots berths to ships and manages the pilot service. Engineering work of all kinds, including dredging, is in charge of the works department All questions of staff and of establishments generally are the responsibility of the administration department,

In 1924 the company's shares were doubled in number, to 800,-000. Of these the British government hold 353,204. The shares are subject to redemption by annual drawings ending in 1968 when the company's concession is due to expire. All holders of 25 or more shares are entitled to vote at the annual general assembly of the shareholders. Each shareholder so qualified may cast ten but not more than ten votes.

The company through the years followed a wise policy over transit dues. This policy, frequently reasserted, was to revise the dues in a downward direction whenever a prudent consideration of its own financial position made it possible. The 1953 rates of transit dues were 36 50 Egyptian plastres per Suez net ton for laden ships and 17 piastres per Suez net ton for ships in ballast. Dues on passengers were abolished by a decision of the board taken in 1951

In the early days of the company there was some difference of

opinion about the method of measuring ships for the assessment of transit dues An international commission met at Constantinople in 1873 to discuss the question, the Bittish (Moorsom) system was recommended and after 1874 "Suez net tonnage" was raiculated aftet this system

TABLE III -Passengers in Transit Through the Sucz Canal

Year		Passengers		Yea	Passengers			
1901-10*			242,000	1941				14,124
1918	•		105,914	1942			•	590
1919-20*	•		513,825	1943			٠	173,269
1921-34*	•		283,855	1944	•	•	•	418,832
1935 .	•		625,465	1945	•		•	983,937
1936 .			781,929	1946	•	•	•	932,007
1937 -			697,800	1947		•		587,135
1938 .			479,802	1948	٠			454,864
1939 .			410,523	1949				610,951
1940 .			167,805	1950				664,284

\*Yearly average

The relations between the company and the Egyptian government have always been intunate and cordul. These relations were regulated as the need arose by a series of conventions freely negotiated between the company and the government. The last of these, dated March 7, 1949, provided mer alla for increased Egyptian representation on the board of directors, for a progressive increase in the employment of Egyptians in all ranks of the company's service and for an increased subvention (7% of the gross profils) to the Egyptian government

In 1952 the ships which used the Suez canal flew the flags of no fewer than 43 nations. The Suez canal is a permanent feature of world geography. It would be difficult to imagine a world deprived of the use of this waterway. That statement alone is perhaps the best tribute to Ferdinand de Lesseps. (F V W.)

perhaps the best tribute to Ferdinand de Lesseps (V. V.).

BERMOORAFT——Chatles-Row, L'Halme et le conal de Suez, voi de BERMOORAFT—Chatles-Row, L'Halme et le conal de Suez, voi conal consideration (London, 1931). A. Sugfidel, Suez and Faunne (London, 1932). Moustapha el-Hidasou, Les problèmes contemporarus perits par le canal de Suez (Paris), 2013). H. J. Schamber and Suez (Paris). Sugfidel Suez (Paris). Conal de Suez (Paris). Delle Suez (Paris).

SUFFOLK, EARLS AND DUKES OF. These English titles were borne in turn by the families of Ufford, Pole, Brandon, Grey and Howard. Robert, son of a Suffolk landowner, John de Peyton, acquared he lordship of Ufford in that county and was known as Robert de Ufford. He held an important place in the government of Freihau diwide Edward I and ded in 1785; his son Robert, clieds arrivings on, another Robert (2, 1299–1350), was created Baron Ufford in 1309. Robert's clieds arrivings on, another Robert (2, 1299–1369), was Created Baron Ufford in 1309. Check and Politicas. On the death, without heirs, of his son William, the 2nd earl, who took part in the suppression of the pessants' revolt in 1381, the earldom became extinct, his extensive estates reverting to the crown

In 1385 the earldom of Suffolk and the lands of the Uffords were granted by Richard II to his friend Michael Pole (c. 1330—89), a son of Sir William atte Pole. (See Pole Family.)

In 1514 the title of duke of Suffolk was granted by Henry VIII to Charles Brandon (see Suproux, Charles Branbox, 187 BURS 07), and it became extinct on the death of his second son, Charles, in July 1527. In the same year it was revived in favour of Henry Grey, marquess of Dorset, who had married Frances, a daughter of the first Brandon duke. Grey, who became marquess of Dorset in 1530, was a prominent member of the reforming party during the reign of Edward VI. He took part in the attempt to make his daughter, Jane, queen of England in 1535, possible of the strength o

earldom was held by his descendants. (See Suffolk, Thomas Howard, IST Earl of.)

SUFFOLK, CHARLES BRANDON, 1ST DUKE OF (c. 1484-1545), was the son of William Biandon, standard bearer of Henry VII, who was slain by Richard III in person on Bosworth field He was high in Henry VIII's favour and held a succession of offices in the royal household. On May 15, 1513, he was created Viscount Lisle, having entered into a marriage contract with his ward, Elizabeth Grey, Viscountess Lisle in her own right, who, however, refused to marry him when she came of age. He distinguished himself at the sieges of Terouenne and Tournai in the French campaign of 1513 At that time Henry VIII was secretly urging Maigaret of Savoy, regent of the Netherlands, to marry Brandon, whom he created duke of Suffolk Brandon took part in the jousts which celebrated the marriage of Mary Tudor, Henry's sister, with Louis XII of France, on whose death he was sent to congratulate the new king Francis I An affection between Suffolk and the dowager queen Mary had subsisted before her marriage, and Francis charged him with an intention to marry her. Francis, perhaps in the hope of Queen Claude's death, had himself been one of her suitors in the first week of her widowhood, and Mary asserted that she had given him her confidence to avoid his importunities Francis and Henry both professed a friendly attitude toward the marriage of the lovers, but Suffolk had many political enemies, and Mary feared that she might again be sacrificed to political considerations. The truth was that Henry was anxious to obtain from Francis the gold plate and jewels which had been given or promised to the queen by Louis, and he practically made his acquiescence in Suffolk's suit dependent on his obtaining them. The pair cut short the difficulties by a private marriage.

Suffolk was only saved from Henry's anger by Wolsey, and the pair eventually agreed to pay to Henry £44,000 in yearly installments of £1,000, and the whole of Mary's dowry from Louis of £200,000, together with her plate and jewels They were openly married at Greenwich on May 13. The duke had been twice married already, to Margaret Mortuner and to Anne Browne. Anne Browne ded in 1511, but Margaret Mortuner, from whom he had obtained a divorce on the ground of consanguinity, was still living. He secured in 1528 a build from Pope Clement II assuring the legitunery of his marriage with Mary Tudor, and of the daughters of Anne Browne.

Suffolk was present at the Field of the Cloth of Gold m 150, and m 1523 he was sent to command the English troops at Calais He laid waste the north of France. Suffolk was in favour of Henry's divorce from Catherine of Aragon and, in spite of his obligations to Wolsey, attacked him when his fall was imminent. The cardinal, who was acquainted with Suffolk's private history, reminded him of his ingratitude. "If I, simple cardinal, had not been, you should have had at this present no head upon your shoulders wherein you should have had a tongue to make any such report in despite of us."

After Wolsey's diagrace Suffolk's influence increased daily. He was sent with the duke of Norfolk to demand the great seal from Wolsey; the same noblemen conveyed the news to Queen Catherne of Anne Boleyn's marriage, and Suffolk acted as high steward at the new queen's coronation. He was commissioned by Henry to dismiss Catherine's household. He received a large share of the plunder after the suppression of the monasteries. In 1544 he was for the second time in command of an English army for the invasion of France. He died at Guildford on Aug 44, 1545.

invasion of France. He need at Collision of Aug. 24, 1545.

There is abundant material for the history of Suffolk's career in the Letters and Papers of Henry VIII, ed by Brewer in the Rolls Senes See also Dugdale, Baronage of England, vol ii (1675); G. E. C., Complete Peeroge. An account of his mati uncount adventures is in the appendix to a novel by E. S. Holl, The Barvest of Festerdus.

SUIFOLK, CHARLES HOWARD, OTH EARL OF (1675-733), who succeeded to the tile in June 1734, married Henrietta, a daughter of Sir Henry Hobart, bart., of Bickling, Norfolk. Both husband and wife were in the household of the prince of Wales, who, as George II, acknowledged Mrs. Howard as hus mistress. She was formally separated from her husband before

1731 when she became countess of Suffolk The earl died on Sept 28, 1733, but the countess, having retired from court and married the Hon George Beakley (d. 1746), lived until July 26, 1767. Among Lady Suffolk's Iriends were the poets Pope and Gav and Charles Mordaunt (earl of Peterboroush)

A collection of Letters to and from Henrietta Countess of Suffolk, and her Second Husband, the Hon George Berkeley, was edited by J. W. Croker (1824) See also L. Melville, Lady Suffolk and her Circle (1924).

SUFFOLK, THOMAS HOWARD, 1ST EARL OF (1561-1626), second son of Thomas Howard, 4th duke of Norfolk, was born on Aug 24, 1561 He behaved very gallantly during the attack on the Spanish armada and afterwards took part in other naval expeditions, becoming an admiral in 1599 Created Baion Howard de Walden in 1597 and earl of Suffolk in July 1603, he was lord chamberlain of the royal household from 1603 to 1614 and lord high treasurer from 1614 to 1618, when he was deprived of his office on a charge of misappropriating money. He was tried in the Star Chamber and was sentenced to pay a heavy fine Suffolk's second wife was Catherine (d 1633), widow of the Hon Richard Rich, a woman whose avarice was partly responsible for her husband's downfall She shared his trial and was certainly guilty of taking bribes from Spain One of his three daughters was the notorious Frances Howard, who, after obtaining a divorce from her first husband, Robert Devereux, earl of Essex, married Robert Carr, earl of Somerset, and instigated the poisoning of Sir Thomas Overbury (q.v) The earl died on May 28, 1626

SUFFOLK, WILLIAM DE LA POLE, DUKE OF (1396-1450), second son of Michael de la Pole, second earl of Suffolk, was born on Oct 16, 1396 Suffolk served in all the later French campaigns of the reign of Henry V, and in spite of his youth held high command on the marches of Normandy in 1421-22 In 1423 he joined the earl of Salisbury in Champagne, and shared his victory at Cievant. He fought under John, duke of Bedford, at Verneul on Aug 17, 1424, and throughout the next four years was Salisbury's principal lieutenant in the direction of the war. When Salisbury was killed before Orleans on Nov. 3, 1428, Suffolk succeeded to the command After the siege was raised, Suffolk was defeated and taken prisoner by Jeanne d'Arc at Jargeau on June 12, 1429. He was soon ransomed, and during the next two years was again in command on the Norman frontier. He returned to England in November 1431, after over fourteen years' continuous service in the field

Suffolk had already been employed on diplomatic missions by John of Bedford; anxious for peace, he attached himself to Cardinal Beaufort The question of Henry VI.'s marriage brought him to the front Humphrey of Gloucester favoured an Armagnac alliance. Suffolk brought about the match with Margaret of Anjou. When he returned to England in June 1444, after negotiating the marriage and a two years' truce, he received a triumphant reception He was made a marquess, and in the autumn sent again to France to bring Margaret home. The French extorted from him a promise to surrender all the English possessions in Anjou and Maine, a fatal concession Humphrey of Gloucester died in February 1447, within a few days of his arrest, and six weeks later Cardinal Beaufort died also Rumour, though without sufficient reason, made him responsible for Humphrey's death, while the peace and its consequent concessions rendered him unpopular. So also did the supersession of Richard of York by Edmund Beaufort, duke of Somerset, in the French command Suffolk's promotion to a dukedom in July 1448, marked the height of his power. The difficulties of his position may have led him to give some countenance to a treacherous attack on Fougères during the time of truce (March 1449). The renewal of the war and the loss of all Normandy were its direct consequences. When parliament met in Nov. 1449, the opposition showed its strength by forcing the treasurer, Adam Molyneux, to resign Molyneux was murdered by the sailors at Portsmouth on Jan. 9, 1450. Suffolk boldly challenged his enemies in parliament, appealing to the long and honourable record of his public services. The Commons now presented articles of accusation dealing chiefly with

alleged maladministration and the III success of the French policy, there was a charge of anumg at the throne by the betrohal of his son to the little Margaret Beaufort Suffolk demed the accusations as false, untrue and too borrible to speak more of Ultimately the king sentenced him to banishment for five years Suffolk left England on May I. He was intercepted in the Channel by the ship "Nicholas of the Tower," and next morning was beheaded in a little boat clanesade

Popular opinion at the time judged Suffolk as a trator. This view was accepted by Vorkist chroniclers and Tudor historians, who had no reason to speak well of a Pole Later legend made him the paramour of Margaret of Anjou, which story appears in the Mirrour for Magistrates, and Shakespeare's a Henry II (Act III se i) Suffolk's best defence is contained in the touching letter of farewell to his son (Paston Letters, 1 142), and in his noble speeches before parlament (Roll of Parliament, v 176, 183). The policy of peace which he pursued was just and wise, he foresaw its risk to himself.

Suffolk's wife, Alice, was widow of Thomas, earl of Salisbury, and granddaughter of Geoffrey Chaucer By her he had an only son John, second duke of Suffolk

son John, second duke of Suffolk
Bibliotanatvi —Suffolk is necessarily prominent in all contemporary
authorities. The most important are J Sieversson's Wars of the Bigauthorities. The most important are J Sieversson's Wars of the BigPolitical Peems and Songe, in 222-234 (for the popular very-) hethree are in the Rolls Series, and the Pasion Letters Of French
writers E de Monstrelet and Jehan de Wauma ate most useful for his
military career, T has man and Mattheu d'Ecouchy for his full (all
modern accounts see especially W Stubbs, Constitutional History
(favourable), The Political History of England (1906), vol vs, by
C. Oman (uniforwarable) and G du Fresne de Beaucourth History
de Charles VII See also H A Napser's Historical Notices of Sumcombic and Evotine (1858)

SUFFOLK, an eastern county of England. Area 1,482 sq. miles Much of the county is formed by low hills, raing occasionally over 400 ft. They are a continuation of the Childers and they form the main watershed of the county. They consut of chalk, covered to the east by boulder clay, with glacial sand interspersed with patches of London clay, Pilocene deposits and alluvium. Alluvium also appears in the fens in the north-west. Subsidence has let the sea far mit to the land along the rivers.

Palaeolithic implements have been found in fair abundance in some of the gravels in the north-west of the county, less abundantly from there southward to the Stour and only sporadically in other parts of the county In Neolithic times the middle of the county with its boulder clays was probably for the most part forested, and this accounts for the fact that most of the artefacts of this age have been found on the higher chalk lands of the west and on the lighter soils near the coast especially in the north and south extremities of the county In other parts they are found generally along the river-valleys that are floored with gravel. A marked feature of pre-historic Suffolk is the number of beakerpots of the late Neolithic or early Metal age which have been found there. These have been found particularly around the estuaries of the Stour, Orwell and Deben, where presumably, the immigrants landed first It is thought that they then pushed up the rivers into the north-western part of the county and here a number of other beakers have been discovered. Bronze implements have been found in much the same places as the Neolithic, except that they are scarce in the north-east. In the centuries immediately preceding the Christian era Suffolk was invaded by Brythonic tribes, and traces of their handswork have been found here Along with Norfolk it formed part of the kingdom of the Iceni, and it was ravaged by the Romans after the unsuccessful revolt of Boudicca (Boadicea). The Roman road from Colchester to Venta Icenorum crossed the county from near Stratford St. Mary to Scole Just north of the Gipping this road threw out a branch in the direction of Dunwich, whence it led northwest again to cross the Waveney near Bungay. To the west there ran from north to south from Norfolk the continuation of the Peddar's way. The ancient track of the Icknield way ran along the chalk hills of the north-west. On the Suffolk coast the Romans built two forts to guard the Saxon shore-the first has left traces

SUFFOLK 521

at Burgh castle, the other, which was at Walton near Felixstowe, has been washed away by the sea,

The county of Suffolk (Sudfole, Suthfole) was formed from the south part of the kingdom of East Anglia which had been settled by the Angles in the latter half of the 5th century. The most important Anglo-Saxon settlements appear to have been made at Sudbury and Ipswich It suffered severely from the Danish incursions and after the treaty of Wedmore formed part of Danelaw The whole shire lay within the diocese of Dunwich, which was founded c 631. In 673 a new bishopric was estab lished at Elmham to comprise the whole of Norfolk which had formerly been included in the see of Dunwich. The latter came to an end with the incursion of the Danes, and on the revival of Christianity in this district Suffolk was included in the diocese of Ely. The county has now become part of the new diocese of St Edmundsbury and Ipswich. There were a number of religious houses in the county, and the most important remains are those of the great Benedictine abbey of Bury St. Edmunds, the college of Clare, originally a cell to the abbey of Bec in Normandy and afterwards to St. Peter's Westminster, converted into a college of secular canons in the reign of Henry VI. still retaining much of its ancient architecture, and now used as a boarding-school; the Decorated gateway of the Augustinian priory of Butley, and the remains of the Grey Friars monastery at Dunwich A peculiarity of the church architecture is the use of flint for purposes of ornamentation Another characteristic is the round towers, the principal examples being those of Little Saxham and Herringfleet, both Norman By far the greater proportion of the churches are Perpendicular, while the church of Long Melford should be mentioned on account of its remarkable Lady chapel Special features are the open roofs and woodwork and the fine fonts

The Normans built castles in the county at Eye and Walton, and there are remains of the entrenchments and part of the walls of Bungay, the ancient stronghold of the Bigods, the ruins of Mettingham, built in the reign of Edward III; Wingfield, surrounded by a deep moat, with the turret walls and the drawbridge still existing; the ruin of Framlingham, with high and massive walls, originally founded in the 6th century, but restored in the 12th, the outlines of the fortress of Clare castle, anciently the baronial residence of the earls of Clare, and the Norman keep of Orford castle Probably the establishment of Suffolk as a separate shire was scarcely completed before the Conquest, and although it was reckoned as distinct from Norfolk in the Domesday survey of 1086, the fiscal administration of Norfolk and Suffolk remained under one sheriff until 1575. The shire court was held at Ipswich, In 1086 Babergh was rated as two hundreds, Cosford, Ipswich and Parham as half hundreds, and Samford as a hundred and a half, Hoxne hundred was formerly known as Bishop's hundred and the vills which were included later in Thredling hundred were within Claydon hundred More than half the county was included in the ecclesiastical liberties of St Edmund and St. Aethelreda of Ely, and in these the king's writs did not run.

In 1173 the earl of Leicester landed at Walton with an army of Flemings and was joined by Hugh Bigod against Henry II Since 1290 the county was constantly represented in Parliament by two knights. In 1317 and the succeeding years a great part of the county was in arms for Thomas of Lancaster Queen Isabella and Mortimer having landed at Walton found all the district in their favour. In 1330 the county was raised to suppress the supporters of the earl of Kent; and again in 1381 there was a serious rising of the peasantry chiefly in the neighbourhood of Bury St. Edmunds. Although the county was for the most part Yorkist it took little part in the Wars of the Roses. In 1525 the artisans of the south strongly resisted Henry VIII's forced loan. It was from Suffolk that Mary drew the army which supported her claim to the throne. In the Civil Wars the county was for the most part parliamentarian, and joined the Association of the Eastern Counties. Within the county there are several interesting examples of domestic architecture of the reigns of Henry VIII and Elizabeth-Hengrave hall (c. 1530), near Bury

St Edmunds, Helmingham hall, surrounded by a moat crossed by a drawbridge and West Stow manor, with a fine gatehouse

The Reform bull of 1832 gave four members to Suffolk, at the time distranchising the boroughs of Dunwich, Ofrord and Aldeburgh. For parliamentary purposes the county constitutes five divisions, each returning one member, viz, Lowestoft division, Eye, Bury St. Edmunds, Sudbury and Woodbridge. Ipswich returns one member, and part of the borough of Great Yarmouth falls within the county.

Suffolk was enriy among the most populous of English counties. Fishing feets had left its ports to bromp back cod and ling from the carried on a trade with Planders From the yatum the carried on a trade with Planders From the yatum the product of the carried on a trade with Planders From the yatum the yatum the yatum that yatum that yatum the yatum that y

china factory flourished at Lowestoft.

In the 18th century Suffolk was famed for its dairy products, but the high price of grain during the wars of the French Revolution led to the breaking up of the pastures and it is now one of the principal grain-growing counties in England. In 1939 the acreage of land under crops and grass was 712,346 ac, of Which 499,373 ac were arable Barley is the chief grain cop with 119,987 ac, wheat next, 107,914 ac, and then oats with more than one-third the acreage of wheat. Mangolds, turnips and swedes occupied 19,724 ac and sugar beet 47,466 ac, Stiffelb being the greatest grower of this crop after Nortoik Beans and peas covered 38,003 ac. The acreage of clover and votation grasses for hay was 51,540 ac. Suffolk punch lorses are famous and the native bread other towns, while a large number of cattle are also fattened in the country. Sheep, usually a cross between the old Norfolk horned and the Southdown are neared on the dner soils, while large number of piezs are also bred.

The most important manufactures relate to agriculture They include that of agricultural implements, especially at 1 peach, Bury St Edmunds and Stownarket, and that of artificial mures at 1 pswich and Stownarket, for which coprolites are du, Malting is extensive, with small manufactures, including silk, cotton, linen, woollen and horschair and cocon out matting

The LN.E. railway serves the county Suffolk comprises 11 lundreds, and after 1888, for administrative purposes, was divided into East Suffolk (857 6 sq mn., excluding Ipswich), population (1938) 300,770, and West Suffolk (610 8 sq mi), population (1938) 102,390 Between Sept 1939 and Feb. 1941, however, the total population decreased 6% as a result of warinne evacuation. The following are the municipal broughs;

(1) EAST SUFFOLK. Aldeburgh, Beccles, Eye, Ipswich, a county borough and the county town, Lowestoft, Southwold.

(2) West Suffolk. Bury St. Edmunds, Sudbury.

There is one court of quarter sessions for the two administrative counties, which is usually held at Ipswitch for East Sutolk, and then by adjournment at Bury St. Edmunds for West Sutolk, and then by adjournment at Bury St. Edmunds in Sudbury have separate courts of quarter sessions. The county is in the docase of St. Edmundsbury and Ipswitch, except for the Rural Deanery of Lothingland, which is in the diocese of Norwich. The National Trust owned only 7 acres in this county in 1942.

National Tible Owner only factor and assignation of Suffals (1845-88); Week A Suchime, The History and Assignation of Suffals (1845-88); If the Suffals Traveller (1875), A. Page, Supplement to less Suffals Traveller (1875), M. Page, Supplement to the Suffals Traveller (1847); Vettorn County, History: Suffals, Christopher Marlowe, People and Places in Markhand (1977). Land of Bradat (Land Ullisation Survey) Parts 72 and 73 (London, 1941).

SUFFOLK, a city of southeastern Virginia Pop. 12,287 in 1950. It is the largest peanut market in the world; is served by five railroads, five trunk line highways and deep water to the sea The region is agricultural. Besides the peanut plants, industries include meat packing, lumber, pipe organs, chemical, candy and vehement than able. The disasters which had befallen the navy dairy products, screen doors and windows, vegetable and frunt packages, cement and cinder blocks, woodworking, agricultural implements, fish and oysters, marl pits, caskets, mattresses and peanut oil St Luke's Episcopal church, a few miles from Suffolk (built in 1632) is the oldest brick church in the U.S. Suffolk was

founded in 1742 and chartered in 1910 SUFFRAGAN, (1) a diocesan bishop in his relation to the metropolitan, (2) an assistant bishop (See BISHOP)

SUFFRAGE, the right or the exercise of the right of voting in political affairs, in ecclesiastical use, the short intercessory prayers in litanies spoken or sung by the people as distinguished from those of the priest or minister

(See Electoral Systems, Electors, Representation, Vot-ING, and, for the women's suffrage movement, Women's Suf-

SUFFREN SAINT TROPEZ, PIERRE ANDRÉ DE (1729-1788), French admiral, third son of the marquis de Saint Tropez, was born in the Château de Saint Canat (Aix) on July 17, The French navy and the Order of Malta offered the usual careers for the younger sons of noble families of the south of France who did not elect to go into the church Suffren entered the close and anstocratic corps of French naval officers as a "garde de la marine," the equivalent of a cadet or midshipman, in Oct 1743, in the "Solide," one of the line of battleships which took part in the confused engagement off Toulon in 1744 He was then in the "Pauline" in the squadron of M Macnémara on a cruise in the West Indies In 1746 he went through the duc D'Anville's disastrous expedition to retake Cape Breton, which was ruined by shipwreck and plague

Next year (1747) he was taken prisoner by Hawke in the action with the French convoy in the Bay of Biscay. When peace was made in 1748 he went to Malta to perform the cruses with the galleys of the Order of Malta technically called "caravans," a reminiscence of the days when the knights protected the pilgrims going from Saint Jean d'Acre to Jerusalem. In Suffren's time this service rarely went beyond a peaceful tour among the Greek islands During the Seven Years' War he was present as lieutenant in the "Orphée" in the action with Admiral Byng, which, if not properly speaking a victory, was at least not a defeat for the French, and was followed by the surrender of the English garrison of Minorca. In 1757 he was again taken prisoner, when his ship the "Océan" was captured by Boscawen oft Lagos On the return of peace in 1763 he intended again to do the service in the caravans which was required to qualify him to hold the high and lucrative posts of the Order He was, however, named to the command of the "Caméléon," a zebec-a vessel of mixed square and lateen rig peculiar to the Mediterranean-in which he cruised against the pirates of the Barbary coast Between 1767 and 1771 he performed his caravans, and was promoted from knight to commander of the Order. From that time till the beginning of the War of American Independence he commanded vessels in the squadron of evolution which the French government had established for the purpose of giving practice to its officers. His nerve and skill in handling his ship were highly commended by his chiefs.

In the years 1778 and 1779 he served with the squadron of D'Estaing (q.v.) on the coast of North America and in the West Indies. He led the line in the action with Admiral John Byron off Grenada, and his ship, the "Fantasque" (64), lost 62 men His letters to his admiral show that he strongly disapproved of D'Estaing's half-hearted methods. In 1780 he was captain of the "Zèle" (74), in the combined French and Spanish fleets which captured a great English convoy in the Atlantic. His candour towards his chief had done him no harm in the opinion of D'Estaing. It is said to have been largely by the advice of this admiral that Suffren was chosen to command a squadron of five ships of the line sent out to help the Dutch who had joined France and Spain to defend the Cape against an expected English attack, and then to go on to the East Indies.

He sailed from Brest on March 22 on the cruise which has made him unique among French admirals, and puts him in the

of his country during the last two wars, and which, as he knew. were due to had administration and timid leadership, had filled him with a burning desire to retrieve its honour. He was by experience as well as by temperament impatient with the formal manoeuvring of his colleagues, which aimed at preserving their own ships rather than at taking the English, and though he did not dream of restoring the French power in India, he did hope to gain some such success as would enable his country to make an honourable peace On April 16, 1781, he found the English expedition on its way to the Cape under the command of George Johnstone (1730-1787), at anchor in Porto Piaya, Cape Verde islands. Remembering how little respect Boscawen had shown for the neutrality of Portugal at Lagos, he attacked at once Though he was indifferently supported, he inflicted as much injury as he suffered, and proved to the English that in him they had to deal with an admiral of oute a different type from the Frenchmen they had been accustomed to He pushed on to the Cape, which he saved from capture by Johnstone, and then made his way to the fle de France (Mauritius), then held by the French D'Orves, his superior officer, died as the umted squadrons, now II sail of the line, were on their way to the Bay of Bengal,

The campaign, which Suffren now conducted against the English admiral Sir Edward Hughes (1720?-1794), is famous for the number and severity of the encounters between them Four actions took place in 1782 south of Madras (Feb 17), near Trincomalee (April 12), off Cuddalore (July 6), after which Suffren seized upon the anchorage of Trancomalee, compelling the small British garrison to surrender; and again off Trincomalee (Sept. 3). No ship was lost by the British in any of these actions, but none was taken by them Suffren attacked with unprecedented vigour on every occasion, and if he had not been ill-supported by some of his captains he would undoubtedly have gained a distinct victory As it was, he maintained his squadron without the help of a port to refit, and provided himself with an anchorage at Trincomalee.

His activity encouraged Hyder Ali, who was then at war with the company. He refused to return to the islands to escort the troops coming out under command of Bussy, maintaining that his proper purpose was to cripple the squadron of Sir Edward Hughes

During the northeast monsoon he would not go to the islands but refitted in the Malay ports in Sumatra, and returned with the southwest monsoon in 1783. Hyder Ali was dead, but Tippoo Sultan, his son, was still at war with the company Bussy arrived and landed. The operations on shore were slackly conducted by him, and Suffren was much hampered, but when he fought his last battle against Hughes (April 20, 1783), with fourteen ships to eighteen he forced the English admiral to retire to Madras, leaving the army then besieging Cuddalore in a very dangerous position

The arrival of the news that peace had been made in Europe put a stop to hostilities, and Suffren returned to France. While refitting at the Cape on his way home, several of the vessels also returning put in, and the captains waited on him Suffren said in one of his letters that their praise gave him more pleasure than any other compliment paid him,

In France he was received with enthusiasm, and an additional office of vice-admiral of France was created for him, He had been promoted baills in the Order of Malta during his absence He died on Dec. 8, 1788, when he was about to take command of a fleet collected in Brest. The official version of the cause of death was apoplexy, and as Suffren was a very corpulent man it appeared plausible Many years afterward, however, his body servant told Augustin Jal, the historiographer of the French navy, that he had been killed in a duel by the prince de Mirepoix The cause of the encounter, according to the servant, was that Suffren had refused in very strong language to use his influence to secure the restoration to the navy of two of the prince's relatives who had been dismissed for misconduct.

Suffren was crippled to a large extent by the want of loval and capable co-operation on the part of his captains, and the vehemence of his own temperament sometimes led him to disregard front rank of sea commanders. He was by nature even more prudence, yet he had an indefatigable energy, a wealth of resource, and a thorough understanding of the fact-so habitually disregarded by French naval officers-that success at sea is won by defeating an enemy and not by merely outmanoeuvring him, and this made him a most formidable enemy

The standard authority for the hie of Suffren is the Histoire du Bailt de Suffren by Ch Cuna (1854) The Journal de Bord du Bailt de Suffren Suffren Suffren Guerral (1854) The Journal de Bord du Bailt de Suffren dans l'Inde, edited by M Mores, was published in 1888 Thier is an appreciative study in Gaptain Mahan's The Influence of Sea Tower support History, 1600-173 (1690).

SÜFÜSM (tasawwuf) is formed from the Arabic word Sūfī, which was applied, in the 2nd century of Islam, to men or women who adopted an ascetic or quietistic way of life The word Sufi from suf (wool) refers to garments worn by such persons.

Mysticism in Islam goes back to Mohammed who, on one side of his nature, was an ascetic and in some degree a mystic Notwithstanding his condemnation of the solitary life and celibacy of Christian monkery, the example of the Hanifs, with some of whom he was acquainted, and of the Christian hermits made a deep impression on his mind and led him to preach the efficacy of ascetic exercises, such as prayer, vigils and fasting Again, while Allah is described in the Koran as the one God working his arbitrary will in unapproachable supremacy, other passages lay stress on his all-pervading presence and intimate relation to his creatures, eg, "Wherever ye turn, there is the face of Allah" (ii, 109), "We (God) are nearer to him (man) than his neck-vein" (l, 15). The germs of mysticism latent in Islam from the first were rapidly developed by the political, social and intellectual conditions which prevailed in the two centuries following the prophet's death Devastating civil wars, a ruthless military despotism caring only for the things of this would, Messianic hopes and presages, the luxury of the upper classes, the hard mechanical picty of the orthodox creed, the spread of rationalism and free thought, all induced a revolt toward asceticism, quietism, spiritual feeling and emotional faith Thousands, wearied and disgusted with worldly vanities, devoted themselves to God The terrors of hell, so vividly depicted in the Koran, awakened in them an intense consciousness of sin, which drove them to seek salvation in ascetic practices

Sūfiism was originally a practical religion, not a speculative system It arose, as Junayd of Baghdad says "from hunger and taking leave of the world and breaking familiar ties and renouncing what men deem good, not from disputation." The early Sufis were closely attached to the Muslim church. It is said that Abū Hāshim of Kūfa (d. before AD 800) founded a monastery for Sufis at Ramleh in Palestine, but such fraternities seem to have been exceptional. Many ascetics of this period used to wander from place to place, either alone or in small parties, sometimes living by alms and sometimes by their own labour. They took up and emphasized certain Koranic terms, such as dhikr (praise of God), consisting of recitation of the Koran, repetition of the Divine names and the like, and tawakkul (trust in God), now defined as renunciation of all personal initiative and volition,

leaving one's self entirely in God's hands. Quietism soon passed into mysticism. The attainment of salvation ceased to be the first object, and every aspiration was centred in the inward life of dying to self and living in God. Toward the end of the 2nd century the doctrine of mystical love was set forth in the savings of a female ascetic, Rābi'a of Basra, the first of a long line of saintly women who played an important role in the history of Suffism. Henceforward the use of symbolical expressions, borrowed from the vocabulary of love and wine, becomes increasingly frequent as a means of indicating holy mysteries which must not be divulged. This was not an unnecessary precaution, for in the course of the 3rd century, Sufiism assumed a new character. Side by side with the quietistic devotional mysticism of the early period there now sprang up a speculative and pantheistic movement which was essentially anti-Islamic and rapidly came into conflict with the orthodox ulemā. It is significant that the oldest representative of this tendency, Ma'rūf of Baghdad, was the son of Christian parents and a Persian by race. He defined Şūfīism as a theosophy and his aim was "to apprehend the Divine realities." A little later Abū Sulaiman al-Darani in Syria and Dhu'l-Nun in Egypt developed relation between God and the soul by glowing and fantastic alle-

the doctrine of gnosis (ma'rifat) through illumination and ecstasy The step to pantheism was first decisively taken by the Persian Abū Yazīd (Bāyezīd) of Bistām (d AD 874), who introduced the doctrine of annihilation (fand), ie, the passing away of individual consciousness in the will of God.

#### ITS EVOLUTION

In the evolution of Sūfīism, influences outside of Islam made themselves powerfully felt. Christian influence had its source, not in the church, but in the hermits and unorthodox sects, to whose ideal of unworldliness Suffism owed much. More than one Sūfī doctrine-that of tawakkul in particular-show traces of Christian teaching. The monastic strain which insinuated itself into Şüfüsm ın spite of Mohammed's prohibition was derived, partially at any rate, from Christianity But Buddhistic influence may also have been at work Buddhism flourished in Balkh, Transoxiana and Turkestan before the Mohammedan conquest, and in later times Buddhist monks carried their religious practices and philosophy among the Muslims who had settled in these countries. The use of rosaries, the doctrine of fanā, which is probably a form of Nirvana, and the system of "stations" (maqāmāt) on the road thereto, would seem to be Buddhistic in their origin. The third great foreign influence on Suffism is the Neoplatonic philosophy Between Ap 800 and 860 the tide of Greek learning, then at its height, streamed into Islam The so-called "Theology of Austotle," which was translated into Arabic about AD 840, is full of Neoplatonic theories, and the mystical writings of the pseudo-Dionysius were widely known throughout western Asia. It is not mere coincidence that the doctrine of gnosis was first worked out in detail by the Egyptian Şūfī, Dhu'l-Nun (d. AD 859), for Suffism on its theosophical side was largely a product of Alexandrian speculation

By the end of the 3rd century Sufi mysticism was fast becoming an organized system, with rules of discipline and devotion which the novice was bound to learn from his spiritual director, to whose guidance he submitted himself absolutely, as to one regarded as being in intimate communion with God At the head of these directors stood a mysterious personage called the Outb (Axis); on the hierarchy of saints over which he presided the whole order of the universe was believed to depend. During the next two hundred years (A.D. 900-1100), various manuals of theory and practice were compiled the Kuāb al Luma' by Abū Naṣr al-Sarrāj, the Qüt al-Qulüb by Abū Tālib al-Makkī, the Risāla of Qushairī, the Persian Kashi al-Mahjūb by 'Alī ibn 'Uthmān al-Hujwīrī, and the famous Ihyā by Ghazālī. They all expatiate on the discipline of the soul and describe the process of purgation which it must undergo before entering on the contemplative life. The traveller journeying towards God passes through a series of ascending "stations", in the oldest extant treatise these are (1) repentance, (2) abstinence, (3) renunciation, (4) poverty, (5) patience, (6) trust in God, (7) acquiescence in the will of God After the "stations" comes a parallel scale of "states" of spiritual feeling (ahwāl), such as fear, hope, love, etc., leading up to contemplation (mushāhadat) and intuition (yaqīn). It only remained to provide Sūfīism with a metaphysical basis, and to reconcile it with orthodox Islam. The double task was finally accomplished by Ghazālī (q.v). He made Islamic theology mystical, and since his time the revelation (kashf) of the mystic has taken its place beside tradition (nagl) and reason ('agl) as a source and fundamental principle of the faith,

## MANY SHADES OF OPINION

The Sūfis comprise many shades of opinion-from asceticism and quietism to pantheism. The pantheistic type which prevails in Persia throws the transcendental and visionary aspects of Suffism into undue relief, as in the sayings attributed to Bayezid (d. A D 874), e.g., "I am the winedrinker and the wine and the cup-bearer"; "I went from God to God, until they cried from me in me, 'O Thou I.'" The peculiar imagery which distinguishes the poetry of the Persian Sūfis was developed by Abū Sa'id ibn Abi'l-Khair (d AD, 1049) in his quatrains which express the

SUGAR 524

gones of earthly love, beauty and intoxication Henceforward, the great poets of Persia, with few exceptions, adopted this symbolic language The whole doctrine of Peisian Suffism is expounded in the celebrated Mathnawi of Jalal-uddin Rumi (q v) but in a discursive and unscientific manner, its leading principles

may be stated briefly as follows God is the sole reality (al-Hagg) and is above all names and definitions. He is not only absolute being, but also absolute good, and therefore absolute beauty. It is the nature of beauty to desire manifestation, the phenomenal universe is the result of this desire, according to the famous tradition in which God says, "I was a hidden treasure, and I desired to be known, so I created the creatures in order that I might be known" As things can be known only through their opposites, being can only be known through not-being, wherein as in a mirror being is reflected; and this reflection is the phenomenal universe, which accordingly has no more reality than a shadow cast by the sun

The Sufi theosophy as it appears in Persian and Turkish poetry tends to abolish the distinction between good and evilthe latter is nothing but an aspect of not-being and has no real existence-and it leads to the deification of the hierophant who can say, like Husain b Mansur al-Haliāj, "I am the Truth" Sūfī fraternities, hving in a convent under the direction of a shaykh, became widely spread before AD 1100 and gave rise to dervish orders, most of which indulge in the practice of exciting ecstasy by music, dancing, drugs and various kinds of hypnotic suggestion (see DERVISH).

Suggestion (see Derivish).

Bilintomarium—The foremost authority is R. A. Nicholson, whose writing: (Selected Poems from the Divini Shamis Tabriz, translated with an introduction, etc. (Cambridge, 1894); Barguny Concerning the lation of the Kaihf al-Mahjab, the Oldest Person Treatse on Shim Incomo, 1911, Sinders in Islame, Mysteam (Cambridge, 1911), The Idea of Personality in Shimis (Cambridge, 1921), coperate with its more popular testies The Mysteas of Islam (London) capter with its more popular testies The Mysteas of Islam (London). 1914]) have caused most previous works to have merely an anti-quarian interest. He also published the text and translation of The Mathnawi of Jaldiu dain Rámi (Books 1 and 11, London, 1925, 1926) An excellent introduction to the study of Islamic mysticism is given An excellent introduction to the study of Islamic mysticism is given in TE | W (bib) History of Demon Peetry, 1 as 3 arg (London, mr. E) is the History of Demon Peetry, 1 as 4 arg (London, W Histor, followed by Eira sur les origins du lesque technique de la mystique mustalmane (Paris, 1922), is a mine of cuultion Some account of Stitum is also given by D B Macdonald, The Religious Alleidade and Life is Islam (Cheago, 1950) and It Goddinke, Vorlewale. uber den Islam (Heidelberg, 1925)

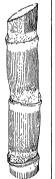
SUGAR. Though sugar did not become a major carbohydrate food until the 19th century, even neolithic man found its sweet taste palatable. In prehistoric and classical periods some fruits and honey apparently were the major sweet foods. The present major source, sugar cane, is beheved to have originated in the South Pacific or Monsoon Asia It has been widely distributed for at least two or three millenniums, but seems to have arrived in the Mediterranean part of Europe relatively late, perhaps with the Arabs after 4 D. 636. As late as the 14th century its product was a scarce luxury in the western world. The beet, now a second major source, was known as a sweetish vegetable during the middle ages, but was not known as a source of crystalline sugar until late in the 18th century. In some areas, the coco palm, the aloe, the maples and the sorghums, as well as some other plants have served as minor but locally important sources of sweetish foods or sugars. Technologists have learned to convert starch, particularly those of grains, to glucose by treatment with dilute acid.

While the name "sugar" was originally applied to the sweet, crystalline substance, sucrose, derived from the sugar-cane plant, its meaning was broadened to cover many organic compounds of somewhat similar construction. Gathering energy from sunlight by means of their chlorophyll, green plants make sugars out of carbon dioxide and water, such as sucrose or its components, glucose and fructose. By condensing several molecules of glucose into one large molecule, many plants make starch; and by combining one molecule of glucose with one molecule of fructose, many plants make the compound sugar, sucrose, which is the true sugar of commerce. Glucose, fructose, starch and sucrose are all important constituents of the human diet. Starch, sucrose and fructose re-

vert to glucose in the course of digestion and assimilation. The relative sweetness of fructose, sucrose and glucose is as 17 to 7 Crystalline sucrose, the familiar table sugar, is derived on a commercial scale from the juices of the sugar cane and the sugar beet.

#### SUGAR CANE

The sugar cane is a giant perennial grass producing clumps of solid prominently jointed stalks, each bearing two ranks of swordshaped but gracefully arching leaves Diverse varieties of sugar cane are grown in the widely separated sugar-cane regions of the world Some of these produce stalks only ½ in in diameter, while others make stalks up to 3 in in diameter. Leaves vary in width as the stalks do in diameter Stalks of all possible colours may be found, but those in red, vellow, purple and green predominate Varieties with striped stalks are not uncommon Well-developed stalks reach 10 to 20 ft in length, but stalks 42 ft, long have been measured While some sugar cane plants produce real seeds, these are never used for renewing commercial cultures, the cane growers planting and replanting their fields with pieces of stalks These pieces or cuttings are usually placed lengthwise in furrows and lightly covered with soil A proper cutting includes several joints,



COURTESY, MAMAIIAN PLANTERS ASSOCIATION FIG 1 -- PORTION OF CANE STALK (CUTTING) SUCH AS IS USED FOR DIANTING

each of which bears a dormant eve or bud Under favourable conditions, the eyes on a cutting sprout within a few days after planting, each sprout developing roots at its base and growing into a new plant New shoots spring up from the stubble after a crop of sugar cane has been cut, so it is customary in most sugar-cane growing regions to harvest several crops from a field before it is replanted

Sugar cane grows to best advantage on a rich, moist soil under sunny skies in a fronical climate A uniform high temperature. strong sunlight and frequent showers during the growing season are desirable. Winter frosts may do much damage in marginal areas The cane likes plenty of water and is a voracious feeder, responding quickly when plant foods are applied to

the soil about its roots

Cultural practices are designed to meet local conditions Rainfall is a major factor and makes for nonirrigated or irrigated types of agriculture which have different costs and result in different yields of sugar per acre Heavy, rugged equipment is required to prepare the soil Plowing is usually deep, but a fine-surfaced seedhed is not essential Cuttings or seed pieces 12 to 24 in long, cut from the upper ends of stalks, are placed end-to-end in rows spaced 4 to 6 ft apart and covered with soil 2 to 4 in deep. Plantings can be made at any time when suitable soil temperature and moisture are obtained.

Subsequent cultivation is primarily for weed control. Maximum cane yields depend on the maintenance of an adequate soil moisture supply from either rainfall or artificial irrigation. The crop transpires an enormous amount of water while growing, and irrigation records show crops requiring as many as 3,000,000 gal. (more than 100 in per acre) annually for maximum growth Also, since the crops remove large amounts of plant nutrients from the soils, a permanent soil fertility is maintained through heavy applications of fertilizers. A carefully controlled technique determines what, how much and when fertilizer is needed

A field of sugar cane ready for harvesting will consist of many primary stalks and subsequent tillers. If the crop is a heavy one, some of these will be erect, but many will be recumbent. Harvesting takes place at from 8 to 30 months after the crop is started The length of time in which a crop can be grown depends upon the SUGAR 525

suspension of normal growth and makes early harvesting neces-

In Australia, Florida, Louisiana and Hawau considerable progress has been made in developing cane harvesting machinery, but in most countries sugar cane is still harvested by hand, the stalks being chopped off at or near the surface of the ground and cut up into suitable lengths for convenient handling by men who wield sharp knives especially designed for the purpose. Harvested cane is conveyed from the field to the factory by the methods most conveniently and economically employed on each plantation some plantations all of the cane is transported on animal-drawn carts and wagons, on others these have been replaced by motor trucks, while on many of the larger and more modern plantations the cane stalks are loaded onto cars and hauled over railroad tracks by locomotives On some plantations situated on mountain slopes. the cane is transported in streams of water diverted at a high elevation from a river and conducted through the fields in a series of flumes into which the cane stalks are thrown These flumes converge at the factory and deliver the cane directly to the crushing

Yields as high as six and seven tons of cane stalks per acre per month of growing time have been harvested, and in the better sugar producing regions somewhat more than a half ton of sugar per acre per month of age at harvest has frequently been recovered

Sugar Cane Breeding.—The genus Saccharum to which sugar cane belongs includes wild as well as cultivated forms. Saccharum robustum, one of the wild species, grows in profusion in the New Guinea region. In appearance, it resembles closely certain of the cultivated sugar canes, but lacks the juiciness and the high successe content of the latter. A more slender wild relative, Saccharum spontaneum, is widely distributed throughout India, Malaya, the Philippines and the East Indian archipelago Like S robustum, it is pithy and contains little sucrose

The sweet, juicy, domesticated types are apparently unable to perpetuate themselves in the wild It seems probable that they owe their origin and development to chance mutation and perhaps also to hybridization among the wild species, followed by long continued selection and propagation at the hand of man

Both cultivated and wild forms of sugar cane come into flower under the influence of shortening days—in the northern hemisphere from September to December, in the southern hemisphere from March to June The "tassel" or "arrow" is a handsome plumelike panicle which bears many hundreds of small spikelets The seed when seen under magnification, resembles a grain of wheat in miniature, it is so small that nearly 100 sugar-cane seeds would be required to equal the weight of a single wheat grain

In 1858, J W Parris, a planter in Barbados, succeeded in growing to maturity sugar-cane seedlings which had germinated along the borders of a field of sugar cane which had flowered profusely. However, this achievement was not widely publicized and was soon forgotten When, in 1888, J B. Harrison and J. R Bovell in Barbados and, independently, F. Soltwedel in Java reported success in their attempts to grow seedlings of sugar cane, their findings were hailed as a new discovery, affording opportunities to create new cane varieties of exceptional ment.

In Java, interest in sugar-cane breeding was stimulated from the beginning by the occurrence of disease epidemics among the existing varieties which emphasized the need for new diseaseresistant types Resistant varieties were imported from India and elsewhere, and were hybridized with the local varieties. A wild Javanese cane was also found to be disease resistant and was subsequently used extensively as a parent in crosses with the sweet but susceptible cultivated varieties.

Sugar-cane breeding became an important function of experiment stations in many cane-growing countries. New varieties were developed which far surpassed the old varieties in vigour, disease resistance and yield of sucrose. These superior varieties are, for the most part, complex hybrids in which have been combined the desirable qualities of many parent strains.

Insect Pests of Sugar Cane.-There are many insect pests of sugar cane. Several species of moth borers badly damage cane in-

duration of favourable growing conditions, cold weather causes Louisiana, the West Indies, South America, Mexico, India, Java and the Philippines The giant moth borer (Castnia licoides) is particularly destructive in Trinidad and the Guianas The frog hopper (Tomaspis saccharina) is an important pest in Trinidad In Australia, heavy losses are caused by the white grubs of several species of Scarabaeid beetles. Other species of the same family are sugar-cane pests in the Philippines, Java, Mauritius and the West Indies Another conspicuous pest of sugar cane in the Malay archipelago and in Formosa is the woolly aphis (Oregma Sap-sucking leat hoppers of the genus Pyrilla are lanigera) especially inturious in India

Very little can be done to control these pests, except by biological or natural methods In Hawan, this method has been applied with great success, where about a dozen different insect pests at-tack sugar cane. These include a leaf hopper (Perkinsiella saccharicida), a beetle borer (Rhabdocnemis obscura), a root grub (Anomala orientalis), a leaf roller (Omiodes accepta), an aphis (Aphis sacchari), two army worms (Laphygma exempta and Cirblus unibuncta), two species of mealy bugs, an oriental grasshopper, a mole cricket and a bud worm Most are of oriental, Malayan or South Pacific origin Satisfactory control of them was permanently effected following a thorough study and importation of the beneficial insects found naturally operating on them in their home countries.

Sugar Cane Diseases .- The sugar-cane plant is attacked by many diseases, a number of which may cause serious losses Crop damage by disease depends principally on the susceptibility of the variety grown and existing environmental conditions A disease of major importance in one country may be of minor importance in another.

Sereh disease (cause unknown) in Java once caused great reductions in sugar yield, yet with new varieties it became of little significance Gumming disease (Bacterium vasculorum) has exacted heavy tolls on sugar yields in Brazil, Australia, Fiji, Mauritius and the West Indies Leaf scald (Phytomonas rubrilineans) occurs in Fiji, Australia, Philippines, Java and Hawaii and has, at times, caused severe losses Fui disease (a virus) has greatly reduced sugar yields in Fiji, Australia and the Philippines. Mosaic, a serious virus disease, has at one time or another become epidemic in almost every sugar-cane country of the world; in some instances the absolute failure of the industry was averted only by resorting to resistant varieties. Other major cane diseases are eyespot (Helminthosporium sacchari), Pythium root rot (Pythium arrhenomanes), smut (Ustilago sacchari), chlorotic streak (cause unknown), and red rot (Colletotrichum falcatum)

The physiological diseases (nonparasitic) caused by unfavourable environmental factors such as climatic conditions, physical nature and chemical composition of the soil, are often responsible for unsatisfactory sugar yields.

Sugar-cane diseases have been most effectively controlled through the development of resistant varieties by breeding and selection. The application of fungicides as dusts and sprays has



FIG. 2.-ANCIENT STONE-ROLLER CANE MILL

been of little or no value in the control of cane diseases Rigid Larger factories have two complete tandems and a few have three quarantines governing the interchange of cane cuttings and seed has aided greatly in preventing the spread of cane diseases

Cane Juice Extraction.-The earliest cane mills consisted of two vertical tollers (fig 2) of wood or stone, geared to a long lever or sweep and turned by hand or animal power The cane stalks were fed into the narrow opening between the rollers, but only a small amount of the total juice in the cane was extracted This type of mill was followed by two rollers set horizontally one above the other and later by the three-roller mill (fig. 3) with two bottom rollers and a top roller. By means of pinion gears fitted to extensions of the shafts of each roller, the power that turns the top roller is transmitted by the pinions to the two lower rollers, so that the three rollers rotate slowly at the same speed The cane feed enters the mill between the top and front, or feed, roller and emerges between the top and back, or discharge, roller, thus receiving two separate crushings in each three-roller unit, the juice from each of these units flowing into separate receivers

Modern mill roller sizes range from 34 in. to 37 in in diameter and 78 in to 84 in in length and have suitable surface and juice grooves cut into their surfaces to improve their grip on the feed and allow easy drainage of the juice They have from 21 to 31 r.p.m. with surface speeds of 25 to 30 ft. per minute.

Hydraulic pressure from an accumulator is applied to jacks acting downwardly on each end of the top roller, which is free to move vertically, thus exerting a heavy pressure on the feed of crushed cane passing between the rollers. The top roller thus floats on the cane blanket, changing its vertical position slightly with changes in thickness of the blanket, under a pressure of 70 to 80 tons per foot of its length or a total pressure of 500 to 550 tons. A modern tworoller unit with coarse grooves is known as a crusher, and a coarse grooved three-roller unit set at the head of a train of mills is also called a crusher.

Cane milling plants in modern factories consist of the slat carrier upon which the cane is unloaded from the cars or trucks, one or two sets of knives along the carrier to act as levellers to compact the feed, a crusher or a double crusher (two two-roller units), and then four to six units of three-roller mills in tandem, with suitable bagasse conveyors between each unit of the train. In some factories a shredder of the high-speed revolving-hammer type is placed between the crusher and the three-roller mills to disintegrate the cane further A conveyor then carries the fibrous residue or final bagasse to the boiler furnaces or to storage This bagasse usually supplies an excess of fuel for normal steam requirements

tandems, crushing up to 6,000 or more tons of cane in 24 hours,

To facilitate extraction of the sugar-containing juice of the cane, the bagasse on the conveyor before entering the last mill unit receives and absorbs a spraying of very hot water equal to one-fourth or one-third the original weight of the cane (see fig. 3). This system of dilution is known as compound imbibition, in which the last mill juice, which includes the water, is returned and absorbed in the bagasse entering the next to last mill This resulting dilute juice is again returned to the bagasse blanket before the next earlier unit and is repeated until all mills except the first three-roller unit receive bagasse containing diluted juice. The combined juice of the crusher, first and second mills flows into a single receiving tank, and this mixed fuice is pumped to the boiling house If compound clarification is practised (see below), the mill juices are divided; the crusher with first mill juice (undiluted) is primary juice and the second mill juice containing all the dilute juices is secondary juice. The percentage of sucrose extracted in modern milling plants ranges from 96 to as high as 99 and varies with the amount of field trash and soil accompanying the cane, and with the tonnage rate, number of mill units, hydraulic pressures, dilution used and the skill of the engineering staff The final bagasse contains from 38% to 45% water, from 1% to 4% sucrose, about 50% fibre and around 2% ash. Fresh bagasse, as burned, has a fuel value of 2,700 to 3,000 British thermal units (B.T U.) per pound and on a dry, ash-free basis about 8,300 B T.U per pound.

The strained mixed juice from the milling plant contains from .2% to nearly 1% suspended matter, is of dark brown colour, full of air bubbles and acid in reaction with a pH of 4 5 to 5.4. The density range is 12% to 14% dissolved solids, sucrose 10% to 12% and purity (sucrose per cent solids) 80 to 86; these figures vary greatly in different localities. There are small percentages of glucose, fructose, organic acids, ash, nitrogen compounds, pectin, gum and colouring matters The suspended matter consists of held soil, bits of cane fibre and a small amount of cane wax. The crushed cane residue, bagasse or megasse is used as fuel under the boilers, as wall board and, more potentially than actually, as cellulose for paper.

# THE SUGAR BEET

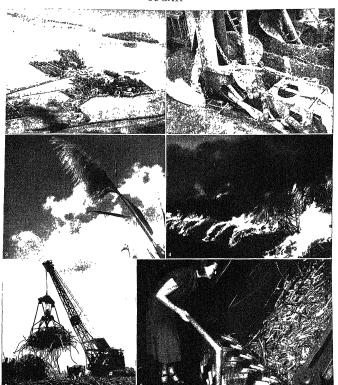
The beet, Beta vulgaris, long used as a garden vegetable and for cattle fodder, was not prized for its sugar content until a full half century after the discovery in 1747 by A S. Marggraf that the sugar in beet juice was the

same as that in cane Experimental and promotional work by Franz Carl Achard about 1799 in which the king of Prussia became interested and work by J. P. B. Delessert was followed by a decree by Napoleon that 70,000 ac be planted to beets as soon as possible Meanwhile the development of the White Silesian beetroot, from which all modern strains have come, was carried on by Moritz von Koppy. By 1840 the sugar beet provided about tion and by 1880 exceeded cane as a producer, in which leading position it remained in most years until World War I.

The sugar beet has a wide range in the temperate mid-latitudes but sugar content develops best in areas with moderate summer temperatures averaging 63° F. to 73° F. for the three summer months and with welldistributed growing-season rain-

Continent	Acreage (in coo ac )*					Production (in ooc short tons)				
and	Average				Average					
,	±935~39	1945-49	1950	1951	1952†	1935-39	X945~49	1950	1951	1952†
North America	-									
Canada	_50	66	102	.93	93 678	504	600	1,128	966	1,00
United States	827	755 821	925	601 784	678	9,595	10,262	13,535	10,485	10,33
Total	877	821	1,027	784	771	10,009	20,952	14,663	11,451	11,34
	102	1				1				
	124	49	69	95	101	1,202	322	938	1,136	1,21
	174	117	155 1801	1775	163	1,603	1,026	2,048	2,048	2,17
Finland	10	13	24	2779	178	1,057	1,790	s,890) 308	2,706¶ 168	2,72
France	791	715	976	1,005	1,030	9,976	7,942	14,965		11,37
Germany, Western	335	355	477	551	550	4,900	4,010	8,354	13,041 8,444	8,37
Ireland	55	19	477	60	50	300	672	050	0,444	55
Italy	17.2	237	429		554	3,422	2 640	4,925	6,567	6.20
Netherlands	106	111	165	400 166	154	1,760	2,640 1,888	5,417	2,700	2,86
Spain	161	100	230	264	207	1,245	1,515	1,525	2,046	3,39
Sweden	128	126	120	134	134	2,080	1,000	2,124	1,000	2,06
Switzerland	6	74	15	16	15	IO.	206	295	231	22
United Kingdom	3446	415	425	421	4119	3,395	4,401	5,842	5,080	4.81
Yugoslavia	77	2,684	243	251	200	658	1,041	938	2,135	1,28
otal above	2,640	2,684	3,577	3,815	3,863	32,684	39,078	50,128	48,855	47,36
otal other European countries	1,510	1,750	2,248	2,303	2,308	18,402	13,331	20,843	20,633	10.16
Potal Burope	4,160	4,434	5,825	6,118	6,171	\$1,080	43,400	70,971	69,488	10,16
T.S.S.R.	3,096	2,492	3,200	3,300	3,300	19,982	12,830	19,000	17,000	40,50
	35	63	85	104	IXI	144	265	416	546	58 26
	63	34	35	33	38	310	105	193	236	
Urumusy	3	115		125	123	434 TO	724	943	1,500	1,10
		218	7		282		10	,60	99	10
Grand total	8.985	7.065	253	272	TO 594	80 077	68 107	1,612	2,381	2,05

s for furtigated areas unless otherwise stated. Pheliumany, I Includes about 5,000 area own in Denmark to 1875. Sincluded subout 5,000 area own in Denmark to 1875. Sincluded subout 5,000 area own in Denmark to 1875. Sincluded subout 5,000 areas own in Denmark to 1875. Sincluded subout 65,000 about 1000 processed in Sweden. Topoged bests. Altervested for user 5,000 about 1000 processed in Sweden. Topoged bests. Altervested for user 5,000 about 1000 processed in Sweden. Topoged bests. Altervested for user 5,000 processed in Sweden. Topoged bests. Altervested for user 5,000 processed in Sweden. Topoged bests. Altervested for user 5,000 processed in Sweden. Topoged bests. Altervested for user 5,000 processed in Sweden.

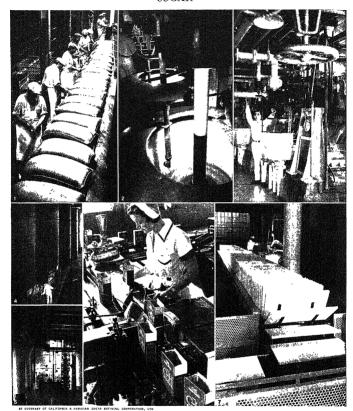


#### SUGAR-GROWING IN HAWAII

- 1. A typical U.S. super community in the level. In a vectate tisted of super such as the super such in the center sound which community in the redition read it are the red-free homes of worker. Pleanting the croc One salats are cut into their pieces and dropped into furrows, usually from a big machine which feeds the "seed-lings" suchematically.

- 5. The "grab" harvester, which breaks off the sugar oene stalks at ground level and lifts them onto trucks. Not all farms, however, transport cane stalks to the mill in trucks. Some use a system of flumes in which running water carries the canes others have their own rail-roads, and still others employ a system of overhead trollegs.
- 6 Stalts, washed and out into small precess entering the mill. This state roller grinds the jutes exit the states. Another cleaning perantion treats the julos, which is then bolled until crystals form. When the crystals are separated from the molesses, they form "raw" supar, which is put in bags and sent to the mainland United States for refining.

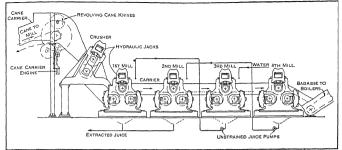
PLAIE 11 SUGAR



# REFINING SUGAR

- Opening bags of "raw" sugar as they enter the refinery. The brown crystals are about 97% pure in "raw" form.
- The sugar is washed again at the refinery, in centrifugal machines which throw off more impurities. This operation brings the sugar to a purity of about 99 4 %
- The sugar, still in signed form, is next filtered through klessiguhr, a special form of earth that removes more of the small amount of impurities attil remaining
- 4, Large char filters, where still another cleaning operation takes place.
- Here, liquid sugar is filtered through charcoal to make it water-white 5 The liquid sugar is boiled once more in tall vacuum pans until it is again crystallized Small, dry "seed" is mixed into the liquid to start the crystals forming
- 6 When the crystals have formed, the sugar is screened into various sizes Most common of these is table sugar, shown being packaged into convenient cartons for household use
- 7 Specialty sugars such as crystal tablets are cut from blocks of sugar. Cube sugar is moulded and dried into shape

SUGAR 52'



COUNTEST, HONOLULU INON WORKS

FIG 3 -CANE MILLING PLANT

fall, unless irrigation is practised In the United States it is most favoured by conditions on the northern margin of the Corn Belt Soils should be fertile, deep, well drained and without hardpan, for the plant is a deep-roated one.

Production, shown in Table I, is predominantly European, a result more perhaps of national policies than of favourable natural conditions. Three areas are outstanding, the Kiev and Podolia section of southwestern U S S.R., the Magdeburg area of Germany

and the chairy plains of northern France

Growing and Harvesting the Beet,-Sugar-beet seed must be sown each year to produce the annual beet crop. Since 1942 not whole seed but treated seed has been largely used the treatment consisting of removal of corky outer layers, reduction to uniform size and in the number of seed germs per unit and treatment with fungicides and insect repellents. The time of planting depends on the weather and area but is mostly done in the spring. The seedbed is care-Planting is in rows spaced 12 to 28 in apart fully prepared and in some areas will have been prepared for irrigation as well. The stand in the row is later thinned, or blocked by hand hoe or mechanically so that the young beet plants are spaced about 10 in apart in the row, giving a density of as many as 30,000 to 40,000 plants per acre Weeds must be severely controlled with hoe, cultivator or chemical spray. Fertilizer is applied to the seedbed or as a side dressing. In all except humid areas irrigation is generally practised, amounting to as much as 30 in of water in dry areas; each plant may require as much as 20 gal of water during its growth. Harvesting, formerly done by hand but now considerably mechanized in some areas, consists of a process whereby each beet is lifted and topped Topping consists of cutting away a top layer of the beet and the attached leaves which are used for livestock feed, being almost as nutritious as alfalfa hay The decapitated roots are then picked up, perhaps mechanically after windrowing, and hauled by truck or wagon, depending on the area, to the receiving station of a beet sugar factory if one is near, or to a concentration station for shipment to a more distant factory. There the beets are stored in piles 15 to 20 ft high and more than 100 ft. wide, with perhaps controlled ventilation and protection against freezing The accumulation of such a stockpile is necessary to prolong the processing season much

beyond the short harvest season.

Beet Seed Production.—The breeding of the sugar beet and the production of high-grade seed is a scientific story in liself. Much of the research, hybridization and multiplication of desirable strains had been carried on in Europe, though the U.S. moved forward in that respect particularly after the 1930s. The seed beets are taken in from the field over whiter and tested for surar bearing the production of the second production of the

qualities, the desirable ones are replanted in the spring, so that seed may be harvested in the late summer or autumn of the second year. Trade in sugar beet seed has been an important part of world seed trade.

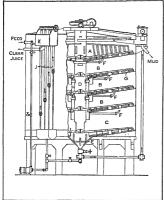
Insect Pests and Diseases.—About 40 insects cause economic damage to the sugar beet. The best webworm causes damage ove wide areas unless controlled with DDT, arsenucals or some other new compounds. The best army worm and others are destructive but may be controlled by ditching and the use of crude oil. Wire worms may be controlled by ditching and the use of crude oil. Wire worms may be controlled by fungaturity the soil with ethylene dibrounde and by DDT. The crown borer causes damage in the west. Things, munng files, several kinds of bestelles and grashop pers damage the leaves; nematodes, centupedes and cutworms are sometimes destructive.

Seedings may be damaged or destroyed by damping off or bled too fungs and several other organisms. Foliage may be sevel other organisms. Foliage may be sevel damaged by curly top, a wirus disease carried by a small leafhopper Leafspot is a most serious disease in the middle west, mossic and mildew take a toll in some areas at times. Root rots, if conditions frayour them, may cause surmicant loss

Juice Extraction.—As the beets are flumed into the factory they may carry some dirt, small stones and other field trait them. These beets are fed, through a series of trash- and stone cathers, into a tumbling washer for removal of adhering dirt. It cleaned beets are then weighed and delivered to the sheing ma chines.

Unlike sugar cane, which is crushed to extract the juice, sugar beets are slaced with a minimum rupture of plant cells. This procedure permits later extraction of the juice (by diffusion through the walls of the plant cells) in a higher degree of purity tha would be obtainable from crushed beets. The first operation is the extraction of the juice is slicing the beets. The modern sice is a revolving drum with a series of inwardly slanting groove knives forming part of its perpihery. The beets are fed into the drum and the V-shaped chips or cossettes (which somewhat ru the semble sheestring potatoes) cut from them are discharged from toutside of the drum, and conveyed to the diffusion battery for indice extraction.

This diffusion battery consists of an endless connected seruof 10 to 14 vertical cylindrical tanks (commonly called celleach fitted with top and bottom doors and having a capacity of two to five toos each. Inside of each cell is a network of loochains to hold the cossettes from packang too ughtly in the ce-Between each cell and the next in the sense is a heater for mai taining the temperature of the extracted juice, together with nece sary pipes, valves and fittings. This endless chain of cells is som 528 SUGAR



COURTESY, PETREE & DORR ENGINEERS, INC

Fig 4 --- CANE Juice CLARIFIER

A. Floculating cell for entering julce B Shallow settling cells. C. Mud-thickening cells. D. Rotary central feed-tube. E. Thickened mud discharge cone. F. Clear julce draw-off. G. Rotary squeeges sediment surspars. H Annular mud discharge ceeing I Foam canal and mud-pump discharge. J. Clear julce to discharge box K. K. Discharge to

times arranged as a circular, sometimes as a straight, battery. The operation of the battery is relatively simple. To start operation any cell in the battery is filled with the sheed beets, or cossettes. That cell is closed and hot water is introduced until all voids are filled.

While the first cell is being filled with water, the next cell is being filled with cosesters, and when this latter cell is closed it is connected to the first cell, and so on around the series. In this fashion hot water enters any chosen unit, leaches or diffuses sugar from the contained best cossettes, and this solution proceeds, through a heater, into the next filled unit. The water always enters the oldest or earliest filled unit of the water always enters the oldest or earliest filled unit of the most recently filled one. This solution of sugar, called away lunce, which leaves the that within the plant cells of the newly sheet best, and is periodically withdrawn, through a measuring device, for purification and sugar recovery.

At the end of a specified extraction period, the exhausted cossettes are discharged from the oldest, or exhausted, unit, and the hot water supply transferred to the next unit in the series. This empty unit is then refilled and becomes the newest unit.

The diffusion battery is thus an endless chain of units or cells, within which hot water is passed over sliced beets, starting with nearly exhausted cossettes and moving progressively over cossettes of increasing sugar content, and from which the resulting raw juice is periodically withdrawn.

By-Products.—Beet pulp, either moist or dried, perhaps mixed with molasses, is used as a livestock food. Pulp drymg is highly developed, and pellelizing is done with some of the material to meet specialized requirements of sheep feeders. The wet pulp is stored in also until used. Several kinds of waste may be processed particularly to recover glutamic acid and other amino acids when it proves to be commercially feesible to do so.

### THE MANUFACTURE OF SUGAR

The early stages of the manufacture of sugar are carried on in the general area of the production of sugar cane or beets. The later stages, particularly the refining, is much more likely to be carried on in port areas near great consuming populations.

Chemical Treatment of the Juice.—This discussion will be pointed particularly to the treatment of cane junce but beet junce treatment differs only in details. As part of the dissolved non-sugars are colloidal (see Collotos), the junce must undergo some form of chemical treatment before it can be filtered satisfactorily. The natural acidity of the junce must also be neutralized, because sucrose decomposes on heating with the acid junces, the sucrose combining with water and breaking up into two simpler sugars, ellucose and furctose, as shown in the equation.

Sucrose Glucose Fructose  $C_{12}H_{22}O_{11}+H_2O=C_6H_{12}O_6+C_6H_{12}O_6$ 

This is termed inversion of sucrose, and the resulting mixture of glucose and fructose is termed invert sugar.

The object of chemical treatment is fourfold (1) to neutralize the natural acidity (as just explained), (2) to remove suspended impurities, thus rendering the juice transparent; (3) to precipitate dissolved nonsugars, thus increasing the purity of the juice and (4) to decolourize the juice in the manufacture of white

The chemical agents used are quicklime (CaO), usually added in the form of hime cream or mik (CaO(H)), sulphut donde gas (SO<sub>2</sub>); carbon dioxide gas (CO<sub>2</sub>), and, occasionally, hisphoride gas (SO<sub>2</sub>); carbon dioxide gas (CO<sub>2</sub>), and, occasionally, phosphorie acid (HgPO<sub>2</sub>). The effect of these chiemical agents is completed by heating the juice to the boiling point in an appraatus called a junce beater, the juice being pumped at high speed through several series of long brass tubes, heated externally by low-pressure steam or evaporator "vapour" Certain impurities, pieveously dissolved in the juice, are thus rendered insoluble and form a dark coloured precipitate which occludes most of the colloidal material and which can be separated from the juice in various ways. (1) bley, forming a scum which can be removed by skimming ladles, (2) by allowing it to subside (after separation of the air) and removing it as a sediment, (3) by filtration through cloth or other filtering media; (4) by centrifugal action.

In the manufacture of raw sugar, a dilute milk of lime solution of ro's to  $x \ge 8 \operatorname{rns}$  (o's Baumel) to facilitate control of the reaction, is mixed with the juice to approximately  $p \pi 8$  o whits sequivalent to about  $z \parallel b$  of available CaO per ton of came The mixture is heated to the boiling point and discharged into continuous clariners or into settling tanks (subsiders or clautiers), each holding  $z_{\rm coo}$  and  $z_{\rm$ 

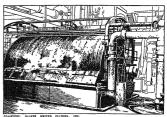


FIG. 5.-ROTARY DRUM FILTER

SUGAR 529

juces and more compact settlings. If compound clarification is practised, the high density and high purity primary juce and the lower density, lower purity secondary juce are clarified separately through continuous clarifiers. The latter juce is then reclarified by mixing with the juce fed to the primary lentifier and the primary settlings mixed and resettled with the secondary juce in the secondary in the seco

The settlings, in modern practice, are filtered by rotary drum vacuum filters (see fig. 3) of large capacity and high efficiency. The older practice was through filter presses (see Fittraviros) Clear, settled junce and the clear portion of the filtered junce mixed and passed to the multiple-effect evaporatoi (described below)

In the manufacture of white sugar, a more thorough punification of the junce is essential Two methods are used acid sulphitation and carbonation. In the former, from 4 to 5 gal of lime cream about 27 Brix (15° Baumé) are added per 1,000 gal of junce, and sufficient sulphur dioxide gas to precipitate this lime, with the formation of a granulal precipitate of calcium sulphite (CaSOs), as shown in the equation

### $CaO + SO_0 = CaSO_0$

The gas may be added either before or after himing, the final result being the same The juice is then heated and subsided

The diffusion juice of the sugar beet is purified by a process known as carbonation. This consists essentially in defecation of the hot raw juice with either milk of lime or a saccharate-of-lime milk followed by precipitation of this lime by a gas rich in carbon dioxide obtained from the factory limekiln. The amount of lime used is around 3 % of the weight of the beets sliced. By this treatment much of the colloidal and other impurities are removed with the precipitated carbonate of lime. This carbonation procedure is customarily conducted in two stages, with an intermediate removal of the first precipitate. Such divided procedure prevents possible resolution of some of the first-precipitated impurities, which would occur if the process were conducted in only one stage Removal of the precipitated impurities from both the first and second carbonation processes is accomplished by filtration or analogous means, commonly by a combination of settling and filtration The clarified juice from these carbonation procedures is then customarily treated with sulphur dioxide gas in order to bleach some of the residual colouring matters and to remove small remaining amounts of lime This treatment is again tollowed by filtration, vielding a pale yellow solution of sugar known as thin

Formerly the juice was carbonated in batches. An important mprovement was the adoption of continuous carbonation whereby the juice, lime and gas are all introduced continuously into the carbonator, and the treated juice is removed continuously. This procedure results in a more uniform preceptate than did the older methods and permits use of settling devices instead of filters for separating much on the precipitation.

Evaporation of Water.—A large quantity of water must be evaporated from the purified juice before the dissolved success can begin to crystallize. To avoid destruction of sucrose at high temperatures the juice is biolical inclosed vessels under vacuum, thus lowering the boiling point. Further, in order to economize fuel, multiple-effect evaporators are used.

Fig. 6 is a sectional view of a double-effect evaporator with an enlarged first offect, for vapour beating of mixed junce and boiling vacuum pans at certain stages. The general principles are the same with three or more effects, and vapour can be removed from any effect except the last for junce heating. The lower part of each vessel contains numerous vertical brass tubes, their open ends passing through perforations in two horizontal plates. The space between these plates forms a steam drum having a centre well open at each end, a steam inlet and condensate drain. The centre well encrease evaporator capacity by causing rapid crutation of the juice up through the tubes and down the well. The large space above the drum in silled with steam or vapous generated by the boiling juice. Steam entering the drum of No 1 condenses on the exterior of the tubes, transmitting its latent heat to

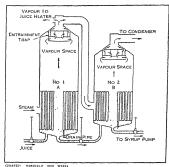


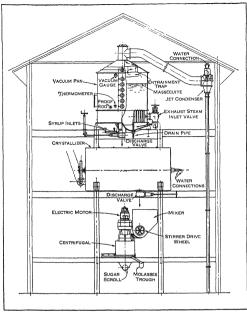
FIG 6 -- DOUBLE EFFECT EVAPORATOR

the june inside the tubes and causing it to boil. A portion of the vapour this generated is extracted for "extra" use, and the remainder passes to the steam drum of No 2 and there acts in the same manner as in No 1. The vapour generated here by the boiling junce passes to a "jet" condenser which does not require an air pump, and maintains a vacuum of 25 to 26 in in the list effect which in this instance is No 2. This vacuum fixes the boiling point of the junce then, the temperature at which vapour (leaving No. 2) can condense on the tubes in No. 2, and the presence of that vapour and the beling point of the junce in No. 7 Consequently, the high vacuum and tow boiling point in No. 2 promises of the value of the vacuum and tow boiling point in No. 2 promises of the value of the vacuum and tow boiling point in No. 3 promises of the value of the vacuum and tow boiling point of the junce in No. 2 promises of the value of the vacuum and the value of the value

In fig. 6 the level of the boiling juuce in No 2 is maintained constant at B by drawing in junce from No. 1, similarly, the level in No 1 is maintained constant at A by drawing in juuce from so, acternal supply tank. At the same time, concentrated juuce or syrup, is drawn off continuously from No. 2 by a pump, and at such a rate that the density of the syrup in No. 2 and of that drawn off remains constant at between 60° and 65° Brix (3.2° and 35° Baumé). This syrup contains about 60%, of dissolved solid (including sucrose). It is, therefore, an unsaturated solution, free from crystals.

Crystallization of the Syrup.—The final stage of evaporation, accompanied by the crystallization of the syrup, is carried out in vacuum pans. This apparatus is shown in fig. 7 Part of the interior, the steam or vapour-heated tubes forming the "clandrap," centre well and cone bottom are shown on the right. Above and to the ight, is the jet condenser (shown in section) wherein the vapour generated by the boiling syrup is condensed by a sense of water jets. A vacuum of about 26 in is maintained inside the pain by the suction of the condenser, thereby lowering the boiling point of the syrup to about 130° F. Cane and best sugar factories are equipped with three or more pans, each discharging from 1 to to 3 tons, or more, of crystals after each boiling operation is com-

Sufficient syrup is first drawn into the pan to occupy only a part of its total capacity, and steam is admitted to the calandran which is covered by the syrup After a period of rapid boiling, the syrup becomes superstaurated and microscopic crystals form to form. This is called the graining point. It is important to produce a sufficient quantity of gains as rapidly as possible in order



COUNTESY, HONOLULU IRON WORKS
FIG. 7 —CROSS SECTION THROUGH RAW SUGAR BOILING-HOUSE

that the crystals may be of nearly uniform size during all stages of growth. To obtain a more rapid formation of grain in a minimum of time, shocking is commonly employed by introducing into the supersaturated syrup, just prior to the natural graming point, a few ounces of powdered white sugar. The number of grain introduced is immaterial: they induce formation of new crystals. Hardischer grain by either method, the operator stops to formation of new crystals by quickly reducing the supersaturation with a little water or a quantity of insaturated syrup from the supply tank. The boiling then proceeds on syrup with either intermittent or set feed, holding the amount of supersaturation within narrow limits, causing the previously formed grain to grow until the nan is filled.

The boiling time for high purity syrup is from 3 to 4 hours, and 8 to 12 hours for the lowest purity products. To make a largegramed final product, the operator starts crystal growth with a relatively small quantity of grain, thereby increasing the rate of growth of each grain. Conversely, to make a small-granod final product, he, starts with a larger quantity of grain, thereby reducing the rate of growth of seck prain.

The time available for growth can be extended by transferring half the contents of a full pan to a second, empty pan, the two

halves then being boiled simultane. ously with further additions of syrup to each, causing continuous growth of the original grain until both pans are filled During the process of boiling, the operator is guided by the appearance of small samples of the crystallized syrup which he removes from the pan at short intervals by means of a proof The samples are spread stack upon a sheet of glass and examined by transmitted light from a When the pan is full, the mixture of crystals and mother liquor (called massecuite) is finally concentrated until it contains from 0% to 11% of water It is then semifluid and contains about 65% by weight of crystals and 35% of mother liquor Air is now admitted to the pan, the bottom gate opened and the massecuite discharged There are several boiling-control devices in use They operate by control of vacuum, elevation of boiling point (massecuite temperature above water temperature) and electrical conductivity, and are either automatic or of vis-

ual aid to the pan operator The mother liquor separated in the centrifugals, described below, contains a high percentage of sucrose It is reboiled in the vacuum pan where it crystallizes, forming second-grade massecuite This 19 treated in the centrifugals, where it separates into second-grade crystals and second-grade mother liquor. The last is reboiled in the vacuum pan to form third-grade or final massecuite which is discharged into large cylindrical crystallizers, each fitted with a slowly rotating central shaft carrying water coils or pipes of ample surface ratio, which control the massecuite temperature and act as

surrers. Fig. 8 shows one of several types for rapid cooling of high-density masscure to a pre-determined minimum temperature, such as zeo F, holding it at this temperature for a time interval with warm water, then releating with warmer water to a predetermined optimum saturation temperature. This reduces the sucrose content and purity of the final mother liquer or final molasses to a much lower minimum and in far less time than by the older type of air-cooled crystaller. The final massecute is purged at its original high density in modern high-speed centrifugals running 1,800 to 2,200 r.pm (see fig. 7 and 9). Molasses true purities (sucrose per cent true solids) of 30 to 33 are obtainable. Besides sucrose and reducing sugar it contains various organic and inorganic impurities derived from the original cane highs.

To save time and fuel, it is a common custom to grain, usually by shocking, only the final massecutus. The purged final crystalls are mixed with syrup to a heavy magma and used for seeding the two higher grade massecuties. The first two grades produce as usuar, and any third-grade sugar not required for seed is melted and returned to process in one of the high-grade pans.

Separation of Crystals from Mother Liquor.—This operation, called curing or purging the sugar, is effected by centrifugal action in a number of machines operating simultaneously. Each SUGAR 529B

(fig 9) consists of a vertical metal basket or drum which is suspended on a central vertical spindle and for high grades is rotated at speeds of 1,200 to 1,400 rpm, low grades, 1,800 to 2,200 The cylindrical wall of the basket is made of perforated steel plate and litted with an inner lining of brass wire, a-in mesh screen, over which is fitted a very finely perforated round-hole or slotted screen After the basket is set in motion, a charge of massecuite enters through a central opening at the top, and centrifugal action forces the massecuite against the perforated lining which acts as a strainer, allowing the fluid mother liquor to pass through but retaining the crystals The second grade is washed with a few pints of warm water to improve purging Separation in first and second grades is complete in about two minutes, but the lowest grade requires a much longer time. Fig. 7 shows positions of vacuum pan, crystallizer used for final massecuite, massecuite mixer, centrifugals and scroll conveyor for the sugar

In the manufacture of raw sugar, the above treatment yelds crystals containing from 96% to 98% of sucross and, inversely with the sucrose, should not contain over 1 o% to 0.5% of water, to avoid detenoitation in storage. The colour, mosture and adour of this sugar are largely due to residual mother liquor adhering to the crystals, which cannot be completely separated by centrifugial action alone. The conveyer carries the sugar from the centrifugials to a storage bin from which the sugar gravitates through chutes and weighing machines into bags or into bulk sugar storage awaiting shipment in bags or bulk form to the refinery.

In the manufacture of direct process white sugar, the separation of the mother luquor is carried much further by spaying a large quantity of water over the layer of sugar in the centrifugal basket while rotating at full speed. Former practices of repurging the sugar in a second set of centrifugals and of spraying sugar with bluing water, to concate yellowish timt, were largely abandoned with improvements in the technique of manufacture. After passing through a rotary direct the dry white sugar contains from 99.5% to 99.9% of sucrose

Desugarization of Molasses .- After all possible sugar has been crystallized from the purified beet juices, there remains an end product, molasses, containing about 50% sugar Since the molasses produced in a factory may retain 15% to 20% of the sugar of the ouginal beets, many factories recover this sugar by a special desugarization process which consists essentially of the following steps finely powdered quicklime is added to chilled diluted molasses and combines with most of its sugar to form an insoluble saccharate of lime This precipitate is filtered off; most of the molasses impurities remain in the filtrate from which small additional amounts of saccharate may be recovered by heating it, The saccharate is mixed with factory sweet waters to form a saccharate milk which is then introduced into the carbonators in place of the milk of lime usually added at that point. The carbon dioxide gas, added here, breaks up the lime-sugar combination releasing the sugar which is recovered in the usual operations of the factory. This method of desugarization is known as the Steffen lime process, after its inventor Carl Steffen, and is much used in the United States Plants for the desugarization of beet molasses by means of baryta, or of strontia, are in operation in a few localifres.

cahties. (H L LN; A.A. BI; M. H SL, J K. R.)

Refining of Raw Sugar.—The objects of refining raw cane
sugar are to remove impurities and to prepare the pure sugar in

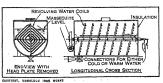
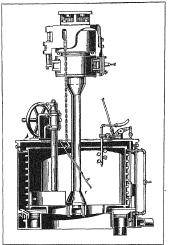


FIG. B .- TEMPERATURE CONTROLLED CRYSTALLIZER



COURTESY WESTERN STATES MACHINE CO
FIG 9 -SUGAR CENTRIFUGAL BASKET SECTION

the various forms required by consumers.

The cane sugar refining process consists essentially of three principal operations: (1) removing adhering molasses from the aw sugar crystals and melting the crystals in it water to form a solution, (2) filtering and decolourizing the solution; and (3) re-crystallizing the sugar from the decolourized solution.

Disabung or Melling the Rese Suger—In modern practice, dissolving is usually accomplished in three steps, the first two of which are for the purpose of eliminating at least 19% of the impurities which accompany the raw sugar. First, the raw sugar is mingled with a hot syrup, previously removed from mw sugar, to form a magma which is fed into centrifugal machines Second, the magma is spun in the centrifugals to remove the syrup, and the crystals are sprayed with water to wash off adhering molasses. Third, the washed raw sugar is discharged from the centrifugals and is dissolved in hot water to produce what is termed washed raw sugar liquor.

The minging, washing and separation of washed sugar crystals from the syrup constitute what is called the affination process, and he resulting syrup is known as affination syrup or wash syrup. This process results in the production, from 100 tons of raw sugar (90% sucrose), of about 85 tons of washed raw sugar crystals (90% sucrose) and about 15 tons of dissolved solids (85% sucrose and 15% impurities) in the affination syrup.

The washed raw sugar is melted in large cylindrical melting anks with hot water or, preferably, with high-purity, low-density sweet water, a by-product resulting from other refinery operations. The melting tanks are usually capable of holding from 5 to 10 tons of sugar together with the necessary quantity of solvent to give a washed raw sugar liquor containing 60% to 65% sugar in solution. Tanks are equipped with mechanical stirrers, per-

forated steam coils for heating and the necessary facilities for regulating the density and temperature of the liquor, which properties have an important bearing upon the effectiveness of the subsequent filtration process

The affination syrup is handled separately, its impurities eventually being eliminated by recrystallization of its sucrose

Filtering and Decolourizing the Liquor -The washed raw sugar liquor ranges from light brown to dark brown in colour and contains variable amounts of insoluble impurities in suspension These impurities are removed by forcing the liquor under pressure through cotton or metal cloth in leaf filters or filter presses (see FILTRATION), this apparatus having almost entirely supplanted the old style bag filters A small quantity of filter aid is regularly added to the liquor to maintain satisfactory flow rate and clarity of filtrate The filter and most commonly employed is diatomaceous earth, or kieselguhr, although a small amount of paper pulp is also used This filter aid forms a porous layer upon the cloth of the filter leaves or plates, and the suspended impurities entering with the liquor are retained in this layer as the house passes through under pressure. The filtered liquor is transparent but has a colour that may range from straw to brown, depending upon the character of the raw sugar being processed Kieselguhr filter aid is generally discarded after use, but in some

Table II —Production of Centrifugal\* Sugar by Areas and Major
Producing Countries† (Raw value, thousands of short tons)

	-		*****						,
					1935-30 Average	1945-49 Average	1951	1952‡	
North America					8,737	11,025	15,055	12,805	
Cuba					3,183	5,897	7,954	5,6800	
United States (beet)					1.518	1,513	1.552	1,532	
United States (cane)					474	455	418	557	
Puerto Rico					974	455 1,134 861	1,360	1,100	1
Hawan					980	861	7.045	1,075	
Meuco					353	6.16	807	86<	
Dominican Republic					AOX	506	650	700	1
Iamaica					110	235	208	320	ł
Barbados .					714	131	176	180	ł
Barbados Trimdad Canada (beet)					70	144	154	160	
Canada (beet)					1 76	99	133	160	
Europe (beet)		:			7,274 2,020 1,078	5,949 2,056	9,680	9,583	
Eastern Europe					2,020	2,056	3,175	3,170	
France					1,078	823	3,306	1,350	
Germany, Western					010	524	1,396	1,100	
Italy United Kingdom					410	329	83.4	800	
United Kingdom					514	613	753	740	i
Spain¶ Netherlands					202	200		535	
Netherlands					261	270	383	400	
Belgium .					250	247 266	300	365	
Denmark .					200	266	397	335 3259	
Sweden					340	311 2,508	3239	3280	
Asia (cane)					5,237	2,508	4,646	4,858	
India					1,300	1,304	1,000	1,700	
Philippines, Republic of					1,058	382	1,073	1,245	1
Formosa					1,240	372	610	800	ı
Formosa Indonesia Turkey (beet) Palistan					76	102	466	500	1
Turkey (beet)					76	131 36 80 2,998 1,418	228	185	ı
Pakistan					30	36	96	125	
China including Manchuria			•		100	80	95	109	
South America (cane) .					2,115	2,998	3,817	3,987	
Brazil					810	1,418	1,865	2,044	
Argentina					510	654 483 198		700	1
Peru					444	483	509	520	ı
British Guiana	٠				210	198	260		ł
Peru British Guiana Colombia USSR (beet)					SY		240	250	1
USSR (beet)	٠				2,761	1,643	2,300	2,500	1
					1,293	1.452	1,710	1,791	ı
Union of South Africa .					498	542	53.2	600	ı
					320	351	535	560	ı
Egypt			•		166	211	215 138	215	i
Réunion	٠	•			91	81	138	150	l
Oceania (cane) . Australia		•			1,113	961	96x 834	1,175	ı
Australia Figi	•				894	830	834	1,030	ŀ
Treate to a comp	•			•	150	131	24,158	145	1
World total (cane) .				•	16,754	131 18,054 9,382	24,158	22,644	1
World total (cane) World total (beet) World total (beet & cane)					11,770	9,382	14,011	14,055	1
World total (beet or cane)	•				28,530	27,436	38,169	36,699	1

<sup>\*</sup>Centrifugal sugar, as distinguished from no roduced by the centrifugal process, which is

refineries is regenerated by the application of heat in a kiln, where the organic impurities removed from the liquor are burned out Removal of similar impurities from used paper pulp is accomplished by thorough washing with hot water in pulp washers

Decolourization of the filtered liquor is accomplished in most refineries by its percolation at a relatively slow rate through a deep bed of bone char in char filters-large cylindrical vessels. usually of cast iron, measuring from 15 to 50 ft in height and from 4 to 10 ft in diameter. Each filter is fitted at the top with a door for the admission of the bone char and with one or more similar doors near the bottom for the removal of the used chair A perforated metal false bottom, which is carefully covered with a specially woven cloth blanket before each filling, supports the column of char. An inlet pine is provided at the top for admission of the liquor to be decolourized, while an outlet pipe is connected to the filter bottom for the efflux of the decolourized liquor

In operation, a filter is filled to the top either with dry char or a mixture of char and houor, then filtered washed raw sugar liquor is admitted through the inlet pipe The rate of liquor flow is regulated by a valve in the outlet pipe. Upon completing its flow through the char, the decolourized liquor passes, by way of an extension of the outlet pine, to a hour classification and distribution gallery, commonly termed the liquor gallery. There the liquors from the various char filters are segregated according to quality and are directed to the proper places for further processing

Following a specified period of washed raw sugar liquor filtration, lower purity syrups resulting from other phases of the refining process are applied to the char for decolourization, in order to utilize the maximum decolourizing ability of the char. This causes the appearance of colour in the effluent, which is then directed to the second-liquor tank and, subsequently, upon the appearance of still more colour, may be directed to a third-liquor tank

After several hours, the decolourizing power of the char begins to deteriorate, because of the cumulative effect of the colouring matter and soluble impurities adsorbed from the liquor. At a predetermined point, the syrup supply is shut off and hot water is applied in its place This water displaces the syrup remaining in the char and gradually dilutes it, producing what is termed sweet water The operation is known as sweetening off the char. When the sugar content of the sweet water has fallen to a fraction of 1%, the effluent is run to waste and the flow of hot water through the char is continued for several hours in order to wash from it the maximum possible quantity of impurities Following this, the char is removed from the filter, sent to a drier and thence to a char kiln where it is heated to a high temperature, this burns off some of the organic matter and restores the decolourizing ability of the char, thus rendering it fit for reuse As this cycle of operations is repeated over and over, the char suffers gradual deterioration because of the cumulative effects of imperfect regeneration and of attrition due to handling. Consequently, it is common practice to maintain a policy of periodical discard of spent char and addition of new char.

Some refining has been carried on by the use of activated vegetable carbons which decolourize liquors by adsorption, and also by the use of certain chemical compounds which liberate nascent chlorine and have a bleaching action

Crystallization - The colourless and slightly coloured liquors are then recrystallized by boiling in vacuum pans which are heated by steam and within which a rather high vacuum is maintained by means of suitable condensers and vacuum pumps. The vacuum pans are equipped with the necessary facilities for control of sugar crystal formation and growth, so that at the completion of a boiling period the crystals discharged from a pan are of the proper size to meet the trade requirements for the particular type of sugar under production

The massecute discharged from a vacuum pan upon completion of boiling is a mixture of crystals and mother liquor or syrup. This massecuite is then directed to centrifugal machines in which the syrup is separated from the crystals and the crystals are sprayed with water to remove all possible traces of syrup from their surfaces. In this operation the purity of the crystals is

tde. Years shown are for crop years; generally the harvesting so baths of the year shown or in the eatly months of the following tie augat producing countries in the southers bemisphere, such auritus, Union of South Africa, etc., where the season begins

hary ion probably would slightly exceed that of x951-52 except for restrictions de-ied Cubra government, on the control of th

ticks.

"An office of the state 
TABLE III -Production of Noncentrifugals Sugar, by Areas

und Dje	esjica Commirtes [			
	1935-39 Average	1945-49 Average	1951	1952
Ana	4,340	4,606	5,148	5,211
Burma	86	74	75	75
China	350	305	485	520
Formosa	32		- 8	10
India	3,008	3,366	3,675	3,700
Japan	. 4	14 I	15	15
Pakistan	600	772	800	800
Philippines, Republic of Ryukyu Island	63	44	50	50
Ryukyu Island	90	4	10	20
Thailand	17	22	21	21
South America	874	1,302	1,177	2,173
Brazil	370	395	300	300
Colombia	420	755	720	720
Ecuador	15	17	23	23
Peru	9	25	24	22
Venezuela	66	110	IIO	110
North America	163	393	272	272
Costa Rica	15	36	33	33
El Salvador	17	27	10	IC
Guatemala	318	35	30	30
Honduras	8		8	
Mexico	83	174	165	165
Nicaragus	7	14	15	1.5
Panama	2	9	11	111
World total	5,377	6,211	6,597	6,658

"Succept fugal sugar no-folds all types of sugar produced by other than the entiring of the sugar produced by other than the enteringed. The estimates molides such thrush known as piloncills, passels, perpices, chancers, the sugar produced by 
raised to about 99 9% sucrose. The syrup is reboiled two or three times in order to secure maximum sucrose extraction before returning it to char for further decolourization Magnetic filtration by an 10n exchange process gives promise of displacing this technique The moist white sugar leaving the centrifugals is carried by conveyers to sugar driers in which the moisture content of the sugar is reduced, by means of a current of hot air, to a very small fraction of 1% The granulated sugar drier, or granulator, consists of a large revolving cylindrical drum, the axis of which is slightly inclined from the horizontal. The interior is fitted with a number of narrow longitudinal shelves which alternately lift. the sugar and shower it down through the current of heated air as the drum revolves

From the driers the dried sugar passes to sets of vibrating or gyrating screens which remove undestrable coarse particles and dust and classify the sugar into the sizes demanded by the trade. The sifted sugar is then spouted to bins, from which it is drawn into automatic weighing and filling machines. The modern refinery is equipped with many such machines, designed to pack a wide variety of types and sizes of containers, generally ranging from 1-lb, paperboard cartons to 100-lb cloth or paper bags and, to a limited extent, 300- to 350-lb barrels.

The several varieties of cube, loaf and tablet sugars are prepared

of heavy white sugar syrup The resulting moist magma is then pressed or moulded in various types of machines in which either pressure or centrifugal force 18 utilized to produce moist cubes, tablets or slabs These moist forms are dried in hot-air ovens. where the sugar in the binding syrup crystallizes, thus bonding together rigidly all the crystals in the cube, tablet or slab. Cubes and moulded tablets are packed directly after drying. Loaf sugar and chipped tablets are produced either by direct cutting of the slabs with special chipping knives or by first sawing the slabs into bars and then chipping the bars as desired

made from granulated sugar by grinding in various types of attrition mills or impact pulverizers. In some cases the pulverized material is also passed through bolting cloth before packing

Soft, or brown, sugars are boiled from specially selected, darkcoloured, char-filtered liquors which result from the char filtration of affination syrup. Soft sugars are not washed in the centrifugals, but are allowed to retain a certain amount of syrup on the crystals, the quantity of syrup retained is regulated by the centrifuging process to give the desired sugar colour Soft sugars are characterized by very small crystal size which gives them a soft, spongy texture, and by their colour and pleasing flavour

Various grades of edible syrups are prepared by blending lightand dark-coloured char-filtered liquors and syrups to meet desired specifications

By-products,-By-products of a sugar refinery are restricted to: (1) a relatively small amount of molasses which is usually fermented for the production of alcohol or used in the manufacture of cattle food and (2) the discarded spent bone char; which is used as poultry feed or as fertilizer and soil conditioner (A H Hn, X.)

## PRODUCTION, TRADE AND PRICES

Cane sugar can be and is produced in nearly all tropical areas and beet sugar in many temperate countries Beet sugar makes up roughly one-third of the total (see Table II) and is primarily a product of Europe, the U S.S R and the United States Caribbean America is outstanding in centrifugal cane-sugar production, whereas India and Pakistan contribute nearly three-fourths of the less highly refined type of cane sugar Because of intimate relationship with war areas, the beet sugar production, which was slightly in excess of cane sugar production as late as 1912 was hard hit twice during the next 40 years, whereas cane-sugar pro-duction suffered no such hazards. Both generally had an upward trend but cane sugar greatly increased its margin over beet-sugar production

Comprehensive information on heet-sugar production in the United States is shown in Table IV and cane sugar production for continental United States and territories supplying the United States in Table V Information on production of miscellaneous sugars is harder to obtain However, such harvests are not insignificant locally. The palm-sugar season as a village or forest industry in some areas lasts about four months during which time a yield of as much as 40 to 80 lbs. of raw sugar is obtained per tree, or more than one ton per acre The yield of the long-used maple yard of northeastern United States, though highly variable from season to season, averages about 3 lb per tree but may go as high as 20 lbs.

Following World War I, sugar was uncommonly scarce and prices very high This encouraged restoration and expansion of beet-sugar production, and national self-sufficiency became the by mixing specially boiled white sugar with a controlled amount order of the day. Cane sugar areas, too, increased production

Table IV.—Sugar Boels, Beel Sugar and Pulp; Acreage, Yield per Acre, Production, Season Average Price per Ton Received by Farmers, and Value: Production of Beet Swar and Other Products. Unsted States

			Suga	beets		Best sugar and pulp (in oco tons)				
Year of harvest	Acreage (	creage (in ooo ac )		Production (in coo	Price*	Farm value (in \$000)	Sugar produced (refined)	Molasses pulp	Moist pulp	Dried pulp
1935 1936 1937 1938 1939 1940 1941 1942 1943 1944 1945 1946 1947 1949 1949 1959	809 853 813 983 993 796 1,048 619 633 775 968 800 768 1,014 757	763 7776 753 925 918 912 755 954 550 555 713 802 802 604 607	10 4 11 6 11 6 12 4 11 7 13 4 13 7 12 2 11 2 12 1 13 2 14 2 13 6 14 8 14 8 15 3	7,008 8,018 8,759 11,407 10,781 12,194 10,342 1,685 6,5147 6,718 8,616 10,560 11,503 9,424 10,190 11,533 10,485 10,485	\$5 76 6 05 5 4 75 4 70 5 4 77 6 47 10 60 11 20 11 20 11 20 10 50 11 70 11 70	45,565 54,636 46,101 53,418 51,342 66,028 80,279 58,089 71,154 87,036 117,835 148,177 99,035 110,380 115,199 122,507	1,185 1,304 1,283 1,676 1,644 1,756 1,491 1,019 935 979 1,183 1,715 1,280 1,480 1,480 1,450	125 137 166 210 175 180 181 181 181 195 165 217 207 171 293	1,454 1,543 1,600 1,858 1,711 1,088 1,088 1,063 1,008 1,173 1,434 1,647 1,282 1,761	74 73 51 105 98 114 101 138 77 101 101 139 76 118

\*Includes price support payments, but excludes Sugar act payments the training the training training to the training training to the training training training to the training trainin Powdered or icing sugar is

TABLE V.—Sugar. Production in Continental United States and Principal Areas Supplying United States with Sugar\*

			Beet]	Cane a	Cane and beet '						
Crop year †	Continen- tal  US‡	Hawanş	Philippine Islands	Puerto Rico	Virgin Islands	Total of preceding columns	Cuba	Total including Cuba	Continen- tal U S	Excluding Cuba	Including Cuba
1935 1936 1937 1938 1939 1940 1941 1943 1943 1945 1945 1946 1947 1948 1948 1949	383 437 402 583 594 419 400 498 437 475 425 376 477 564 488 557	1,042 1,044 941 994 977 947 836 870 836 872 831 630 872 8,35 901 906 1,045 1,075	979 1,118 1,052 1,041 1,035 550 5 5 5 78 398 730 685 935 1,245	026 996 1,077 852 1,019 932 1,148 1,038 723 964 908 1,088 1,277 1,286 1,228 1,360 1,228 1,360 1,190	48 46 78 1 4 3 4 5 3 4 5 1 7 1 2 2	3,334 3,503 3,503 3,507 3,551 3,254 2,058 2,303 2,104 2,211 2,081 2,081 2,466 3,464 3,730 3,908 4,070	2,904 3,379 3,180 3,994 3,157 2,734 3,799 3,229 4,741 3,924 4,476 6,075 5,761 6,149 7,064 5,580	6,238 6,882 6,010 6,621 6,708 5,088 6,787 5,622 6,845 6,155 6,155 8,014 9,306 9,206 9,501 10,070 11,872 9,759	1,268 1,305 1,373 1,793 1,750 1,870 1,505 1,732 1,000 1,048 1,266 1,523 1,835 1,370 2,012 1,550 2,012 1,550	4,602 4,808 4,912 5,320 5,310 5,133 4,125 3,104 3,279 3,347 3,980 4,556 4,815 5,034 5,742 5,600	/,506 8,277 8,292 8,414 8,467 7,867 7,354 7,853 7,823 7,823 10,437 11,231 10,576 11,161 12,091 13,424 11,289

Machae centrical only. Compare with harvesture season beginning in the full months or in the early month of the following will industed beginning and Fernis Myrmal against season beginn 02: 11 rogs; profestions were from mendings of Oct 103; to Dec 31; 1634. For crop year 1932 and subsequent years professions in trong principal of the next calendar year. [Refined between the compared of the profession of

partly because of favourable prices but also because of new cane varaetes and the availability of new venture capital So, after 1927, until the outbreak of World War II, there was world overproduction of sugar in relation to effective demand. Stocks cumulated, the carry-over in 1929, for example, was 9,000,000 tons Attempts at finding a solution, some of which will be discussed presently, were generally unsuccessful. In the years just before World War II, consumption was approximately equal to production, yet the world price for unprotected raw sugar was about one cent ner pound.

The war changed all that; production was interrupted in some areas, trade was badly disrupted, and rationing became general in many major consuming countries. The Sugar Committee of the Combuned Food Board, membership consusting of the Unted States, Great Britain and Canada, reviewed the supply and distribution in the free world Production at the war's end was the smallest in relation to requirements in 25 years. The International Emergency Food committee indicated that available supplies would provide that all claimant countries could receive only about 70% of prewar consumption

One of the outstanding developments in the world food picture after World War II was the raph recovery of sugar production. As the sugar supply situation began to relax somewhat in 1947 and prospects for the new rora papeared favourable, the International Emergency Food council first notified importing countries that they might exceed previously recommended allocations; then late in 1947 allocation recommendations were discontinued on sugar. Though demand continued strong, production expanded to new record levels and outbreak of the Korean war in 1950 did not result in a shortage of supplies or any major price changes.

Approximately one-thard of the world's sugar enters international trade. Cuba is the major exporter whereas the United States, western Europe and Japan are major importers. In very large part, this is cane sugar; even before World War II the trade in beet sugar was small, mostly from Poland and Czechoslowkia. The economic and political problems of the sugar industry, such as high overhead costs, regional specialization and one-trop economies, technological obsolescence and multiple competition—on only between countries but between cane and beet production, and perfectned arrangements have noticeably affected trade even perfectned arrangement perfect of the sugar intering world trade is "freet" sugar, not regulated by bulletral or preferent

Intergovernmental attempts to solve some of the problems of sugar have been in evidence for nearly 100 years, beginning with a convention signed by four western Buropean countries in 1864. Acter major events were the Brussels Sugar convention of 1902, tile International Sugar agreement of 1931 (including the Chadbourne agreement) and the International Sugar agreement of 1937,

later extended Some students concluded that these agreements were sought as an instrument for maintaining the market position of the lowest cost producers, an exceptional situation

The 1931 International Sugar agreement, something between an intergovernmental commercial treaty and a private cartel, was an undertaking by exporter countries to set export quotas and to allocate the American market It finally lapsed in 1935 The International Sugar agreement of 1937 was signed by 21 countries, only to remain largely moperative because of World War II It provided for delineation of the free market, set export quotas and introduced some flexibility whereby export quotas might be gradually reduced if necessary

Cuba as the major exporter, first in the 1920s and again in 1952, attempted to bring the surplus situation under control by requiring reduction in its own production and setting part of the surplus up as a reserve to be deliberately marketed over several years instead of forced on the depressed market

In 1953, the British Commonwealth Sugar agreement was extended through 1960, increasing the negotiated price to an equivalent of 5 29 cents per pound

Governmental programs and policies have been much concerned with sugar, somewhat as regards production (particularly beet usugar), but more often with control of trade, processing and sale of the refined product. Beginning in the 17th century differential tanffs as between raw and refined sugar tended to add the growth of a sugar refining industry in western Europe Revenue traffs, drawbacks, export subsidies, quotas, licences, rationing and price fixing were all explored and used. Some details may be noted for one country

In the United States the precedent of raising federal revenues by taxing sugar was set in 7.5% with a sugar tantf. The industry from 1865 to 1920 was protected by direct subady and by tarify and during war periods was rather 1920ly controlled. Tariff duties on sugar were modified 14 times between 1897 and the 1930s, reaching a high during the 1930-34 period of 2 cents per pound on Cuba 96° sugar and 2 5 cents per pound on sugar from other countries. In 1048 the duty on Cuban sugar was set at 0 5 cent per pound and in June 1951 the duty was made 625 cents per pound on sugar from other countries.

The Jones-Costigan, act of 1935 provided for a processing tax on sugar and gave the secretary of agriculture power to estimate consumption needs and allocate quotas to four groups of producing areas. Benefit payments and the tax were declared unconstitutional in 1936, but the quota provisions were extended and included in the Sugar act of 1937. That law established a per-

Table VI.—United States Sugar Deliveries by Type of Product or Business of Buyer (In 000 cwt refined)

Product or business of buyer	1950	1951	1952
Bakery and allied products, cereals and cereal			
products	12,724	12,444	13,617
Confectionery and related products	13,919	12,450	12,933
Ice Cresm and dairy products	5,074	5,140	5,541
Beverages	15,017	14,104	15,365
Canned, bottled, frozen foods, jams, jellies,			
preserves, etc.	11,010	21,165	10,056
Multiple and all other food uses .	4,993	4,026	5,230
Nonfood products	780	794	915
Hotels, restaurants, institutions	554	576	321
Wholesale grocers, jobbers, sugar dealers .	60,775	54,218	57,006
Retail grocers, chain stores, supermarkets .	23,44X	20,515	21,461
All other deliveries, including deliveries to gov-	-		
ernment agencies	1,750	2,247	2,650
Total deliveries	150,076	138,870	146,195

Source: Sugar Statistics, vol. 1, pp. 38-57, Production and Marketing Association, U.S. Department of Agriculture (Washington, June 1983).

centage quota of 55 9% of estimated requirements, but not less than 3.715,000 short tons, for domestic sugar producing areas, including United States territories Suspension reinstatement and extensions followed during and after World War II The Sugar act of 1948 (as amended and extended in 1951) differed from that of 1937 in that it established fixed, instead of percentage, quotas of 1,800,000 short tons raw value for domestic beet areas, 500,000 tons for mainland cane, 1 052 000 tons for Hawaii 1,080,000 tons for Puerto Rico and 12,000 tons for the Virgin Islands The Philippine quota was set at 952,000 short tons of commercial sugar Additional amounts needed to meet consumption estimates would be allocated, o6% to Cuba and 4% to full duty countries, with provision for supplemental allocation of short falls Also the steps whereby the secretary determines annual requirements of sugar consumers were rather fully spelled out These determinations langed between 7,000,000 and 8,700,000 tons, and were sometimes amended during most consuming years.

Trade in sugar is so largely under agreement of one sort or another that a true world price is difficult to define. The price of 96° nw sugar f ob. Cuba is an approximation. When transportation and duty are taken into account the world price is sometimes above and sometimes less than the raw sugar prices at New York Markets in both spot sugar and futures are available in New York and spot markets are maintained in most producing countries.

Studies indicate that the elasticity of demand for sugar is low and has remained fairly constant from period to period. A reduction in price of 1% tends to be accompanied by an increase of 0.3% to 0.4% in consumption, with some tendency for the demand curve to shift downward after the early 1920s.

Consumption and Cookery.—Sugar priovides a high energy value per unit of weight (about 1,79¢ kilocalorise per pound) in addition to providing a degree of sweetness that is highly valuable for improving the palatability of other foods. Furthermore, by virtue of other important properties, sugar serves as a preservative agent for other foods (e.g., int., iriti products) and also provides a physical basis for fabrication of various food products (e.g., confectionery). It is also valuable for making desirable modification in the properties of food products, such as controlling teature and relection of medisters, as in the halfing mediatry. Finally, continued to the control of 
The requirements for sugar in the diet of virtually all peoplehave been better met as a result of constant increases in production which have permitted sugar to be removed gradually from the class of a medicine and an expensive luxury and allowing the to become established as one of the more economical sources of nourishment for the human body.

Relatively little sugar, particularly in the high-consuming counters, is consumed directly and by lixelf, though the population of such countries may obtain one-suth or more of their total calories from that food. Instead, it is used to increase nutritive value and to impart a satisfaction to the taste of a long list of other foods and beverages. In the United States of an annual average consumption of about 95 lb per person something like half is used directly in the home of in restaurants, and the remander is first processed with other foods or drinks. Table VI indicates a general breakdown in respect to United States consumption

In other countries wide variations in the amount of sugar consumed have been reported. The variations are associated with changes and differences in the level of national income, the retail prices established for sugar, the general standard of living, living conditions in the country, etc.

As sugar is an important soluble carbohydrate and is easily assoluble, it is valuable in the diet. Candy contains a high proportion of sugar (or glucose), but no dish for the table should do so. In adding sugar to fruit, more is needed if it is cooked with the fruit than if added when the cooking is completed.

Cane and beet sugars (sucrose) are the principal sugars used in cookery. They dissolve in one-third their own bulk of cold water, and in a smaller amount of hot water. Their melting point is

320° F If cooled at that point, they become barley sugar; if cooked beyond that point they become burnt sugar or caramel

Fine granulated or cator sugar is generally used in cookery, For icings, menngues and whisps, prowdered or pulverized (icing) sugar as used, the finest form being confectioners' sugar. All granulates to collect and sirtled fine before using These sagars are all pure white refined products. Brown and yellow sugars, which are produced by evaporation, are also used in cookery when there is no objection to a dark colour, and some of them have a delicious flavour. They vary in both colour and flavour, the best known being Demerara or coffee sugar, and dark hown or Barbadess sugar.

Other sugars such as glucose are less sweet than sucrose, and the commercial form is chaeper. It is used in many manufactured candies, jams and syrups to economize, but is not much used in the home. Commercial grape sugar is a dextose Maple sugar (sucrose) is much prized for its special flavour, but is made in comparatively small quantity, as is also palm sugar. Ame is a Japanese sweetening material that contains dextrin and maltose. Saccham is not a sugar, and has no food value, but it is very sweet and is sometimes substituted for sugar, usually on a physical's order.

Caramel or burnt sugar is marketed ready prepared, for use as "browning" for sauces, gravues, stews and the like, and also as flavouring in such dishes as caramel custard (custard with caramel below or around it). It can be prepared at home by melting granulated sugar in a saucean over a low fire, with constant stirring

It may be used at once as it is, or after removing from the fire, boiling water (d. cup water to r cup sugar) may be added very slowly, again with constant stirring Return this mixture to the hre and cook to a rich dark brown (eight to ten minutes) This hardens on standing, but can be melted over hot water. (See also TERACLE, HONEY)

TEEACLE, HONEY)

BIRLIOGRAPH'—Noel Deert, The History of Sugar, 2 vol (London, 1949 and 1950), R. McGimins, Beet-Sugar Technology (New York and London, 1951); A. Van Riook, Sugar, 1.15 Production, Technology (New York and London, 1951); A. Van Riook, Sugar, 1.15 Production, Technology (Sugar Research Foundation, New York, 1950); O. Lyle, Technology or Sugar Refinery Workers, and ed (London, 1950); Koy A Ballion, Sugar Ling World War II," U.S. Department of Agriculture, War Records Monegraph 3 (June, 1964); B. C. Swerling, International Control of Sugar, 1918-24, "Commodity Policy Studies No." (Standon of Sugar, 1918-24, "Commodity Policy Studies No." (Standon Sugar Policy Studies No.").

SUGAR-BIRD, the English name commonly given in the West Indian Islands to birds of the genus Certhiols (belonging to the Passerine family Coerobidae) for their habit of frequenting the cumpg-houses where sugar is kept, attracted thither by the lifes In their figure and motions they resemble a nuthatch, while their colouration—black, yellow, olive, gray and white—recalls a titmouse.

SUGER (c. 1081-1151), French ecclesustic, statesman and historian, was born of poor parents either in Flanders, at St Denis near Parus or at Toury in Beauce. About 1091 he entered the abbey of St Denis Until about 1104 he was educated at the priory of St. Denis de l'Estrée and there first met his pupil, King Louis VI. From 1104-06 Suger attended another school, perhaps that attached to the abbey of St. Benoit-suc-loite. In 1106 he became secretary to the abbot of St. Denis In 1107 he was made proved of Remeal in Normandy, and in 1100 of Toury.

provost of Berneval in Normandy, and in 1100 of Toury. In 1178 he was sent by Louis VI to the court of Pops Gelasius II at Maguelome and lived from 121-22 at the court of his successor, Calktus II. On his return from Italy Suger was appointed abbot of St. Denis In 1137 he accompaned the future king, Louis VII, into Aquitaine on the occasion of that prime's marriage to Eleanor of Aquitane, and during the second crusade was one of the regents of the kingdom (1147-49). He was bitterly opposed to the king's divorce, having himself advised the marriage. Although he disapproved of the second crusade, at the time of his death, on Jan, 31, 1315, he was preaching a new crusade

Suger was the friend and counsellor both of Louis VI and Louis VII. He urged the king to destroy the feudal bandits, was responsible for the royal tactics in dealing with the communal movements and endeavoured to regularize the administration of

justice. He left his abbey, which possessed considerable property, enriched and embellished by the construction of a new church built in the nascent Gothic style

Suger was generally considered to be the foremost historian of bis day. He wrote a panegyric on Lous VI (Vist Ludous: regus), and contributed to Historia gloriou regis Ludovici (Louis VII). In his Liber do rebus in administratione sua gestis, and its supplement, Libellius de consecratione ecclesiae S. Dionysin, he treats of the improvements he had made to St. Denis, describes the tiessure of the church and gives an account of the rebuilding Suger's works served to imbue the monks of St. Denis with a taste for history, frequently resulting in quasi-official chronicles.

Bibliography — O. Cartellien, Abt Suger von Samt-Denis (Berlin, 1898), A Luchaire, Louis le Gros (Paris, 1890), F. A. Gervaise, Histoire de Suger (Paris, 1721)

SUGGESTION, as popularly used, involves psychologically two features the stimulus, or suggestion in the strict sense, and suggestibility, or susceptibility to response Technically, then, suggestion is the stimulus to induce, by words or gestures, then, attitudes and verball or overt responses in another without his recourse to logical argument or critical analysis Suggestibility refers to the form and content of the inner readness—often taking the nature of attitudes—to accept a suggestion uncritically.

The origin and operation of the suggestion-suggestibility component of the personality lie distinctly in the self-other or interactional processes. Within this frame of reference both heterosuggestion, or stimulation by another, and autosuggestion fall into a common larger category Autosuggestion can be understood in terms of role taking, the individual subvocally, or by other imagery, stimulates himself to some kand of response

Suggestion and suggestibility, moreover, should not be confused with imitation (q, v) with which they are obviously allied. The two former fall within the area of stimuli and inner readmess to react, the latter has its proper emphasis in action itself.

The function of suggestion and suggestibility in perception was early recognized as various studies in visual and auditory illusions showed. Later the relation of suggestion and suggestibility to social perception was indicated. The former tends to emphisize the passivity and uncriticalniess of the respondent, the latter, the effects of the disposition of the individual to see and respond to objects in terms of his psychodynamic history.

Heterosuggeston may be divided into prestige and nonprestige categories. The latter is illustrated in the use of sensory-perceptual stimuli of a material or social sort in which there is no appeal to status or authority. Such are the classic experiments on judgments of the length of lines and lifted weights, presented in such a way as to constitute suggestions of graded differences, not necessarily present in all instances. (A. Bintet, 1900. C. Bird, 1940.) In the field of mass behaviour, the suggestion effects of large numbers of persons which induce in the individual participant a sense of power and the "impression of universality" is another example. (F. H. Allport, 1924.)

Suggestions may be either direct or mdirect. In the former, the recipient is aware of the intention of the speaker, performer, printed matter or other stimulus, and often the suggestion effect is carried by emotional appeals, manner of presentation or other devices which lead to uncritical acceptance. In indirect suggestion the aim and the source—person or institution—emain hidden Indirect suggestion is the size quanton of veiled propaganda. (See also Pseuchology)

Prestige suggestion is the better known because it is so widely used. A speaker may easily sway an audience because of his great name; people flock to the cinema, or view television, to see and hear a famous motion-picture star though the drama is second-rate; eminent men in nuclear physics win attention for some of their political views because of their pight status as scientists. A number of experiments have shown that even faulty statements allegedly held by experts in contradiction to views held by the general public have the greater influence on listeners. Vet the general public have the greater influence on listeners. Vet the greater in the positive or negative. In reactive to such stimuli, one tends to be either all for a given suggestion or all against it. (G.H. Estabrooks, 1920.)

The reason for the potency of prestige suggestions is the conditioning in deference to authority and high status which begins in the parent-child relations This training is reinforced as one grows up in a world of class and other group differences in which

the struggle for power is so important
Hypnosis is largely an extreme form of prestige suggestion in
which the inner symbolic checks are blocked and the action system

which the inner symbolic checks are blocked and the action system of the individual comes under the verbal and gestural control of the hypnotist (C L Hull, 1933) The hypnotic effects of the rabble rouser are classic Then, too, some aspects of both social perception and autosuggestion are akin to hypnosis as when the individual stimulates himself in terms of conscious or unconscious wishes An example is the idealization of the person with whom one is in love.

Suggestibility may be specific to a given stimulus or it may be generalized . In fact, specificity or generality of suggestibility are doubtless closely linked to similar aspects of attitude (qv).

Both common sense and research have demonstrated a variety of factors which influence suggestibility Physiological changes induced by fatigue, certain drugs, ill health, intense emotional disturbances and prolonged undernourishment facilitate suggestibility. On the psychological side, differences in sex, age, intelligence and education are important influences. With few exceptions, experiments in modern societies show girls and women to be more suggestible than boys and men No doubt differentials in cultural training rather than innate physiological variations account for these facts Within the limits of social-cultural conditioning, children are more suggestible than older persons. Yet the very young, not being fully socialized, are less given to suggestion than those of school age However, children are not as uncritical as many believe Regarding intelligence, the feebleminded, except for the very lowest grades, are in general more open to suggestion than are normal persons. A somewhat similar contrast holds between the educated and uneducated Yet education, which prepares individuals to be highly critical in some matters, in other things merely reinforces the conformity and copying patterns first laid down in the home. In this way, the school fosters suggestibility and imitation. In truth, suggestibility is an asset in the socialization of the individual. A person's docility and deference, born of earliest parent-child relations, makes it possible to train him not only in many skills and much practical knowledge, but to indoctrinate him with the moralreligious codes of his culture and make him into a conforming, cooperating member of his society But if not balanced on the other side with critical understanding of the world and of the importance of individual independence, the exploitation of docility, deference and suggestibility by those in power may make for inflexibility. In the long run this may reduce the rate of cultural betterment and the fuller satisfactions which come to a unique and free personality.

and Iree personality.

Brillionary F. H. Allport, Social Psychology (Boston, 1944); F. Aveling and H. L. Harpreaves, "Suggestibility with and without Prestage in Children," British Fournal of Psychology, vol 11, pp. 53–57.

Faul and C. Paul (London, 1944), A. Binet, La. Suggestibility (Person); C. Brit, Social Psychology, vol. 14, pp. 140–140.

Faul and C. Paul (London, 1944), A. Binet, La. Suggestibility (Person); C. Brit, Social Psychology, vol. 5, pp. 197–23, (1929); S. Ereck, Group Psychology, vol. 5, pp. 197–23, (1929); S. Fered, Group Psychology, vol. 5, pp. 197–23, (1929); S. Fered, Group Psychology, vol. 5, pp. 197–24, (1929); J. School, 197–24, (1929); C. L. Hull, Hypnosis and Suggestibility (New York, 1933); G. Murphy, L. B. Murphy, and T. M. Newcomb, Experimental Social Psychology, rev. ed. (New York, 1934); M. Sherti, The Psychology of School Norms (New York, 1944). Sidis, The Psychology of School Norms (New York, 1945), S. Sidis, The Psychology, and ed. (New York, 1948), S. Sidis, The Psychology, and ed. (New York, 1948), S. Savon, Germany, on the Lauter, in

SUHL, a town in Prussian Saxony, Germany, on the Lauter, in the Thurfingian Forest. Pop. (1939) 4,26-27. Sull, which obtained civic rights in 1527, formed a part of Saxony assigned to Prussia by the Congress of Vienna in 1815. The armourers of Sull, mentioned in the 9th century, enjoyed their highest vogue from 1550 to 1634. Later, in the 19th and 20th centurnes, Sull became famous for its sporting guins.

SUICIDE.—Suicide is the act of voluntary and intentional self-destruction. This definition, however, is subject to legal

SUIDAS 533

Tabii. I - Death Rates from Suicide per 100,000 Total Population in Certain Countries for Specified Venre

Country	Year	Suicide rate	Country	Year	Sincide rute
North America			Ireland, Republic of	1010	2.7
Umted States	1052	10.3	Israel	1010	7.1
Canada	1950	17	Italy	1050	71
Lurope			Netherlands	1050	5.5
Austria	1050	238	Norway	1010	7 1
Belgium	1040	136	Portugal	1051	100
Denmark	1050	23.3	Scotland	1050	5 2
England and Wales	1050	10 2	Spain	1050	1 84
Linland	1050	156	Sweden	1010	10.2
France	1051	151	Switzerland .	1050	23.5
Germany (Berlin)	1201	346	Asia	1930	-,,,
Germany, Federal		54.	Tapan	1050	197
Republic of	1050	10 2	Other Countries	-93-	
Iceland	1950	110	Australia	1949	08
Ireland, Northern	1050	41	New Zealand	1050	0.7

Primary Source Demographic Yearbook 1952, 4th issue, Statistical Office of the United Nations, Department of Economic Affairs (1952)

qualification Thus, in England, the term covers an act of selfdestruction committed only while the deceased was of unsound mind otherwise, suicide, termed felo-de-se, is a cume which entails penalties against the deceased's estate. In the United States, only a few states regard suicide as a criminal act, although it may be criminal to influence or assist in a suicide In some oriental countries in the past ceremonial suicides were decreed for certain occasions, as hara-kiri, or disembowelling, by which a Japanese aristocrat defended his honour, or the suttee of the Hindu widow on the funeral pyre of her husband Ceremonial suicides declined in the 20th century, but personal suicides tended to increase

International Comparisons .- Many futile attempts have been made to explain different national rates of suicide as shown in Table I In general Catholic countries have low rates (Ireland, Italy, Spain), however, the rate for France is double that of other Catholic countries Israel (Jewish) has a low rate. Protestant countries vary from low (Norway, Scotland, the Neth-

erlands) to high (Denmark, Sweden)

In all countries, suicide rates tend to increase during economic depressions and to decrease during times of war and prosperity, as Table II shows Long-term trends vary from nation to nation In general the trend has been upward for most European countries, Norway and Denmark are exceptions with generally downward trends In the New England states, the only part of the United States for which long-term rates are known, the rates have tended to increase

Age, Sex, Marital Condition,-Studies made in Europe and the United States at widely different periods of time all show that virtually no children below the age of 15 commit suicide and that the rate for the later teens is low The rate tends to increase steadily into old age. Table III for the United States is illustrative, the rate m old age is approximately four times the rate in young adulthood

The rates for males are consistently higher than the rates for females, in different countries, at widely different periods of time

Table II -Annual Suicide Rates per 100,000 Total Population in

				.30	3864	ea Coun	tries from	1 2910 1	0 1932		
		Yea	ır			United States	England and Wales	France	Germany	Italy	Sweden
1910 1912 1914 1916 1918 1920 1922 1924 1926 1928 1930 1932 1934 1936 1938 1938						16 0 16 0 16 6 14.2 12 2 10 2 11 9 12 8 13.6 15 6 17 4 14 9 14 2 15 3	10 0 9 9 10 0 7 3 7 5 9 0 10 0 9 6 11 4 12 4 12 7 14 3 13 7 12 4	21,8 22 9 21 8 15 5 15 8 18 9 ** 19 0 20 6 21 4 19 5	21.6 22.5 21.2 21.2 21.3 21.5 21.5 22.5 22.5 24.6 25.0 26.7 26.7 26.7 26.7 26.7 26.7 26.7 26.7	845 899 7531 905 905 907 772	18.1 18 3 15 9 13 2 10 0 14.7 14 4 14 5 14 8 14 0 15 8 17.7 15 3 16,7
1944 1944 1916 1918	:	:	:	:	:	12 t 10.0 11 6 11 2	02 8.9 10.5 11.0	14.2	* * *	5,2 # 6.3 6.5	14.5
1052			٠			103	*	•			1 *

\*Not available

and at all ages Usually the male rate is approximately four times the temale rate. Women, however, make more unsuccessful attempts at suicide than do men

As early as the 1860s and 1870s, data from a number of European countries showed that divorced persons had the highest suicide rates and the widowed second highest Married people and those who never married had much lower rates, with sometimes one group and then the other having the lowest. The same relation of marital status to suicide rates was repeatedly found true in the United States

Urban-Rural Rates .- In both Europe and the United States cities have higher rates than adjacent rural areas. Within large cities, according to studies made in the United States, suicide rates are highest in disorganized slum areas and lowest in well-organized residential areas

Table III -Suicide Rates per 100,000 Population for the United States by Age, 1952

Age				 Rate	A	ge	 	_	Rate
1-11 15-24 25-31 35-44 45-54		:		00 42 82 126 186	55-64 65-74 75-84 85 and over	:	:	:	23 5 29.5 27.4 32 4

Source Vital Statistics, Vol. v. No. va. July 1052

TABLE IV -Changing Importance of Means of Suicide in the United States from 1001 to 1052

Means	1952	1936	1916-30	1911-15	1001-05
Fotal Suicides Firearms Hangane Fotaling Fotaling Fotaling Cutting or postering instruments Drowning Jumpang from high places Crecking Other means	100 0% 42 5 21 4 10 0 11 8 3 7 4 5 3 2	100 0% 37 0 19 3 15 1 13 1 4 4 5 0 3 8 1 0	100 0% 35 I 18 I 16 3 14 8 5 4 5 2 3 I	100 0% 30 0 14 6 27 3 12 6 6 4 5 6 1 9	100 0% 24 4 15 0 34 1 8 0 5 7 5 1 1 2 4 6 1

Means of Suicide.-Means of suicide vary with time and place In the United States after 1901-05 firearms, hanging and gas increased in frequency while the use of poison decreased, perhaps because of greater restrictions on its sale. Table IV shows the trends in the United States

Suicide and Other Types of Violent Death.—Suicide outranks homicide as a cause of death, being anywhere from 2 to 25 times as high in different countries in Europe and North America. There seems to be no correlation, however, between high suicide and high homicide rates In the United States motor vehicle deaths are slightly more than double suicides, and other acci-dental death rates are approximately four times the suicide rates.

Interpretations.-Although suicide rates differ with various social conditions, the explanation does not lie in external forces but in the attitudes and emotions of people. Through family training, religion and education, some people acquire strong inhibitory attitudes against suicide, regardless of the stresses of life, Others, with a different philosophy, turn to suicide as a way out of difficulties Some persons, whether because of temperament or training, are able to adjust more readily than others to frustrations and hardships, it must not be overlooked also that the privations of life differ from time to time and place to place; some people are subjected to greater social pressures than others Finally, some countries provide more adequate guidance and counselling facilities than others, to which the harassed person may turn for help. (RH S C.)

SUIDAS, Greek lexicographer. Nothing is known of him, except that he must have lived before Eustathius (12th-13th century), who frequently quotes him. Under the heading "Adam" the author of the lexicon (which a prefatory note states to be "by Suidas") gives a brief chronology of the world, ending with the death of the emperor John Zimisces (975), and under "Constantinople" his successors Basil and Constantine are mentioned. It would thus appear that Suidas lived in the latter part of the 10th century The lexicon of Suidas is arranged alphabetically with some slight deviations. It partakes of the nature of a dic-

# SUI-FU-SUKHOMLINOV

d encyclopaedia. It includes numerous quotations from iters, the scholiasts on Aristophanes, Homer, Sophocles dides are also much used. The work deals with scripell as pagan subjects, and doubtless the writer was a A prefatory note gives a list of earlier dictionaries the work is uncritical, interpolated, and very unequal,

much information on ancient history and life minesps, by Demetrius Chalcondyles (1490), later editions ler (1795), T Gasford (1834), G Bernhardy (1814-51) for (1854), see A Daub, De S Biographicorum origine et and Studern zu den Biographia des S (1882); and J E. st of Classical Scholarship (1906), p. 407

U (SU-CHOW-FU), a Chinese river port at the junc-Minking and the Kin-sha-kiang, in south-west Szechhe south of the province are favourable conditions for he wax insect on the insect trees. The insects are taken of April, travelling by night along the hillsides, to secure nd delay hatching, to the district of Kia-ting-fu, on the north of Sui-fu, where the insects are put on the trees, contract a disease and secrete wax The wax is dealt fu. The town receives medicinal herbs and extracts, , from Tibet, and metals from Yunnan, it exports cotchiefly to Yunnan. A recent estimate of the population al of 125,000

-SUNAYE (sand-picture-on-water): see Bon-seki. a group of non-ruminating artiodactyle ungulate typified by the swine and peccaries, but also including otamuses (Hippopotamidae), and certain extinct forms. ODACTYLA: HIPPOPOTAMUS; PECCARY; SWINE )

CKI (stone-in-water): see Bon-seki

(Suite de pièces: Ordre, Partita), m music, a group unes in melodic forms (see SONATA FORMS) It consists of four principal movements with the insertion of one thter movements between the third and the last

it movement is the allemande, in slow common time owing rhythm, beginning with one or three short notes first full bar

ond movement is the courante, of which there are two French courante begins with one or three notes before eat, and is in a triple time (3) which, invariably at the ind sometimes elsewhere, drops into a crossing triple twice the pace (\$\frac{a}{4}\$). In homage to Couperin, Bach the French courante, but he is happier with the Italian prente, a brilliant continuously running piece in quick a (3 or 3).

abande is a slow movement in triple time beginning on ar, and with at least a tendency to the rhythm

Handel's aria Lascia ch'io pianga is a familiar example. abandes are among the most simply eloquent and charme the galanteries, from one to three in number. These

of his smaller compositions.

nly suite-movements (except some of Couperin's counich can have an alternative section and a da capo. The it galanteries are: (1) the minuet, often with a second nich is called "trio" only when it is in real three-part t is a little faster than the stately minuet in Mozart's anni, and it always begins on the full bar. (2) The lively dance in a not too rapid alla breve time; the lways begins on the half-bar. A second alternating frequently founded on a pedal or drone-bass, and is d musette. (3) The bourrée, which is not unlike the ut quicker, and beginning on the last quarter of the bar. assepied, a lively dance in quick triple time, beginning ird beat. These dances are not always cast in binary there are famous examples of gavottes and passepieds

u. Other less common galanteries are: (5) the loure, nce in 4 time and dotted rhythm; (6) the polonaise, a riple-time piece, with cadences on the second instead of er polonaises) the third beat of the bar; (7) the air, a rement, quietly flowing, in a more florid style than its

name would suggest. It sometimes precedes the sarabande.

The suite concludes with a gigue, in the finest examples of which the melodic binary form is combined with a light fugue style The gigue is generally in some triplet rhythm, eg, d, & & &. but examples in a graver style may be found in slow square time with dotted rhythms, as in Bach's first French suite and the sixth Partita of the Klavierubung In Couperin's first volume of Ordres, the gigue is followed by an enormous number of pieces which cannot have been intended to be all played on the same occasion, though they were all in the same key

Suites on a large scale begin with a prelude in some larger form Bach's French Suites have no preludes, his English Suites all have a great first movement which, except in the first suite, is in full da capo concerto form. His Partitas cover a wider range both in their preludes and their other contents. Some large suites have finales after the gigue, the great chaconne for violin solo



The later uses of the word "suite" comprise almost all sets of pieces mainly in forms smaller than those of the sonata, especially such pieces as have been selected from ballets or from incidental usic to plays. (D F T)
SUK, JOSEF (1874-1935), Czech violinist and composer,

was born at Křečovice, Bohemia, on Jan. 4, 1874. He studied at Prague conservatorium, taking composition with Dvořák, whose daughter Ottilie he afterwards married He was a member of the celebrated Bohemian Quartet. He became (1924) director of the Conservatorium at Prague. His principal works are the symphonic poems: Prague, op. 26, Asrael, op. 27, Summer Tale, op 29, and Zrani, op. 34 (1924); incidental music to the dramatized fairy-tale, Radus and Mahulena; Meditation on the choral St. Wenceslaus, Legend of Dead Victors (a war work); piano pieces, settings of Serbian folk-songs, and chamber music, including a

string quartet op. 35a. SUKHOMLINOV, VLADIMIR (1848-1926), Russian general and war minister, was born in 1848 He took part in the Russ-Turkish war as a staff officer (1877-18), and was head of the officers' cavalry school in St. Petersburg from 1886-07, being now promoted general. He was Russan war minister from 1909-16, and it was under him that the Russian orders for mobilization were given at the outbreak of World War 1. He played a diastrous role in the administration of the Russian army, but it was only in 1916, under pressure of public opinion, that the Tam Nicholas II dismissed him from office. He was finally tried and sentenced to penal servitude on the charge of treason, but was freed by an annesty granted by the Bolsheviks and went to Finland In 1921 he began the publication of his memories, which were completed in 1924.

SUKHUM-KALEH, a Russian seaport on the Black sea. It is in the Abkhazain ASSR. Pop (1933) 28,136. Sukhum bay is shellered by mountains and is never frozen, but the anchorage is poor A railway links the city with the interior. The site is marshy and malarial. It is the ancient Greek Dosskuras, and was in Turkish possession until 1829, after which it was Russian except for temorary Turkish occupation in 1824 and 1879.

SUKKUR, a town and district in Sind, Bombay, India. The town is on the right bank of the India 24 mi. SE of Shikarpur Pop (1941) 66,466 The river is now crossed by a cantilever bridge carrying the North-Western railway to Kotri

The District or Sukruw was created in joor out of pat of Shikard pur district, the remainder of which was formed into the district of Larkania Area, 5,550 s am; joo (1947) 692-56. It is chiefly alluvial crops are wheat, millets, nee, pulses and oil seeds Earthen, leathern and metal ware, cotton cloth and tussore silk are manufactured, also pupe-bowls, mill-boxes and sissons Lines of the North-Western railway serve the district, and there is a banach from Sukkur towards in 1943 and completed in 1943. The barrages, about one mide in length, crosses the Indus and feeds four main canals on the left bank and three on the right The dischage into canals is 4,5763 cusses or 45,760 gallons per second and the total length of water-course served the control of the control

15 1,300,000 ac SULA ISLANDS, a chain of islanos (Sulla, Xulla, Dutch Soela), east of Celebes, Netherlands Indies, really an extension of the eastern peninsula of that island. There are three large islands, Taliabu, Mangola and Sula Besi, and several smaller ones. Taliabu and Mangola, very long and narrow, extend west and east (with Lisamatula), 135 miles Both are mountainous, thickly forested, and thinly populated. Taliabu, the largest in area, very little known, is said to contain mountains from 3,000 to 4,000 ft. high, and hot springs. Mangola, which is much narrower than Taliabu, has Mt. Buja in its western part. Sula Besi, the smallest of the three, is well populated and cultivated Wallace considers there is an approximation between the birds of the Sula isles and those of Buru, indicating that intervening land has disappeared. The babirusa and crested baboon of Buru are found in the Sula islands. Weber's Line, suggested as an alternative division between the Oriental and Australian zoological regions, in place of the Wallace Line, passes east of the Sula Islands, but west of Burn. The islands produce good timber for shipbuilding and the natives are good navigators. Damar is collected in the foresty, ree, makes, fobucco and sugar-cane are grown on Sula and the sage palm is common, forming the staple food on Tallaband Mangola. Coal of inferior quality is found on Sula Best, where the natives weaves acrops and plair nats. The prophiction of the production of th place of the Wallace Line, passes east of the Sula Islands, but

ous and well forested, with bays affording anchorage, but also with reefs. They furnish trepang and tuttle. The people, who are mostly pagan, though Mohammedans live along the coast, are post and miserably housed Vessels call at Banggal The Sul and the sides once formed part of the territory of the property of the sides once formed part of the service of the property of the sular of the possessions. The Sula Islands were occupied by Japan m World War I. (E. E. L. X.)

SULCI, an ancient town (mod S Antioco), on an island on the south-west of Sardinia and of Carthagman origin Its walls, of sectangular blocks of stone, can be traced for more than a mile Phoenician and Roman antiquities, including statues, inscriptions, gems and a cistern of fine masonry, perhaps dating from the Punic period, have been found. The Phoenician tombs are cut in the rock, each measuring about 14 ft. square and 8 ft. high, and approached by a staircase some are converted into dwellings. Curious sculptured stelae found in these tombs are in the museum of Caghari The goddess Tanit is represented, often in a form resembling Isis The Roman tombs are simply rock trenches. There are catacombs originally Punic tombs, connected by passages in which was discovered the body of the martyr St. Antiochus, from whom the modern town takes its name. The church is cruciform, with heavy pillars and a dome it is Byzantine. A fort occupies the highest point-the acropolis of the Punic period The isthmus which, with bridges, connects the island with the mainland, is in part artificial At Tratalias, on the mainland is the fine Romanesque church of S. Maria (12th-13th cent ), formerly the cathedral. At Sulci, the Carthaginian admiral Hannibal took refuge after his defeat by C. Sulpicius, but was crucified. In 46 BC. the city was punished by Caesar for having helped Pompey's admiral Nasidius. (T. A.)

SULEIMAN: SEE SOLIMAN.

SULEIMANIYE, an Iraqi town on the Iranian frontier, on the caravan route from Baghdad to Tabriz. Pop (mostly Kurds) probably over 30,000. There was formerly a large trade with Iran. The town gives its name to the administrative division

SULFONAL GROUP, THE. The group of compounds known as study sulfuens were first prepared in 1885 and introduced into therapeutic sthree years later by Eugen Baumann and Alfred Kast. Formerly very popular as hypnotics, these agents are now seldom used. Sulfonmethane (sulfonal) is slowly absorbed from the intestinal tract and its effects are also in appearing. Depression after awakening is common and may be severe Because the drug is slowly excreted, cumulation may occur during continuous administration producing toxic effects and poisoning. Death from overdosage is due to failure of respiration and circulation. Chronic poisoning causes mental and gastro-intestinal symptoms and urinary changes. Other manifestations may make their appearance in the skin, liver and kidneys. The average dose is 0.75 to 1.0 gram in capaules or hot drinks.

Suifamethylmethane (Trional) and Sulfondiethylmethane (Tetronal) are other representatives of the sulfonal group. Trional is absorbed more rapidly than sulfonal, Tetronal more slowly.

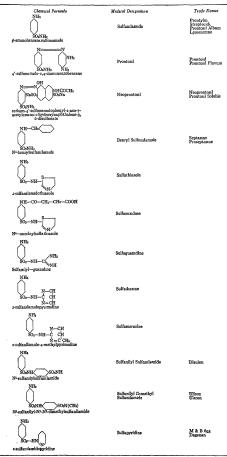
(A. E. Sr.)

SULFONAMIDES, THE. The sulfonamides consist of a group of chemicals which have as their basic structure p-numbenzenesulfonamide. From the parent substance, designated sulfanilamide, varous related compounds were made, usually by substituting or adding various groups to the sulfon radical. (See accompanying formulae)

No group of drugs had ever attracted wider attention in medical therapeutics, since they became responsible for the saving of many lives, for decreasing the total number of days of illness in many thousands of cases and for the prevention of some infections.

The historical development of these chemicals as drugs is of great interest, since p-aminobenzenesulfonamide was not developed as a drug but rather as a chemical for the dye industry. In 1908, the synthesis of p-aminobenzenesulfonamide was announced by P. Gelmo. and a vear later three investigators of the

'This spelling has been adopted by the editors of Emyslopadia Britannica in preference to "Sulphonamide" because of its general acceptance not only in the United States but in other English-speciang parts of the world, especially after the drugs' widespread see an all battlerous in World War II.



FORMULAE, MEDICAL DESIGNATIONS AND U.S. TRADE NAMES OF THE SULFONAMIDES

IG Farbenindustrue of Germany (Heinrich Horlein, Oscar Dressel and Richard Kothe) described the preparation of a group of dyes (azo dyes) in which a double atom of hydrogen is replaced by a double atom of nitrogen and combined with sulfonamides They were searching for a mordant for their dyes and found that p-aminobenzenesulfonamide fuffilled that requirement It was their opinion that the sulfonamide was responsible for the close union of the dye with the protein of the wool

At this time, no one expressed any interest in sulfanilamide or any of the azo dyes as antibacterial agents for the treatment of disease. During the next decade, several new azo dyes were developed which were known to possess antibacterial properties outside of the body, but so far as can be ascertained they were not tested in human infections. Philipp Eisenberg knew that the dye chrysoidine was bactericidal, and Michael Heidelberger and W. A. Jacobs. working at the Rockefeller Insti-tute for Medical Research in New York, published expenments demonstrating that pamınobenzenesulfonamide hydrocupreine was a potent antibac-terial agent, but here again there is no evidence that it was tried in the treatment of infections in man.

man.
Another ten years passed, and very little information about these azo dyes as antibacterial agents developed However, on Christmas day in 1932, the German patent office issued a patent for "Prontosil" and other sulfonamide-containing azo dyes to Fitz Metexah and Josef Klarer of the I.G. Farbenmotustrie. It was not until Dec. 1934 that this patent was disclosed, and it was not published until Jan. 1935. As the story unfolds, however, it seems clear that experimental work had been going on in the study of infections in man and animals for at least two or more years before the patents on

Prontosil were announced.

On Feb 15, 1935, there appeared in the Deutsche Medistrikehe Wochenschrift an article by Gerhard Domagk on "Ein Bettrag zur Chemotherape der Bakteriellen Infektionen." He stated that during Christmas week of 1932, the same time that the patents were issued to Mietzsch and Klarer, he carried out some experiments in mice,

using Prontosil to treat streptococcic infections. He pointed out clearly that Prontosil was a red dye of low toxicity and when it was exhibited to mice infected with streptococci it prevented death. This red dye was also effective in controlling the course of staphylococcic infections in rabbits, but it was infefective in pneumococcic and other experimental infections.

Scaphylococcu mfectons in man are responsible for boals carbundes and mfectons of bone, and if the organisms invade the blood stream, septicaemus occurs and the fatality rate is high Pneumococcu infections are responsible for most case of typical lobar pneumonas. Domagk called attention to the fact that Prontoils is a true chemotherapettic agent only in the living animal. That is to say, it had very little demonstrable bacterical (falling) effect on bacteria as studied in the test tube.

In spite of the fact that the results of these important experiments were not published until several years after they were made, there is evidence that Prontosil had been distributed to certain physicians for climical investigation as early as 1933. In May 1933 a report of using Prontosil in the treatment of staphy-lococcic miection was made in Germany, and within the next two years a number of favourable reports appeared in the German literature concerning its effect in streptococcic infections such as ervision such as ervisional such as expended.

The next chapter in the story turns to France. It is recorded that after several unsuccessful attempts to obtain Prontosal from Germany, it was finally synthesized by A. Girard and called "Rubasol." If was tested in animals and the earlier observations of Domage were in large part confirmed Then J. Teffond, F. Nittl and D. Bovet made the suggestion that azo dyes were changed in the issues and broken at the azo linkage to paramice benzelesulfonamide They went further and suggested that the active principle in Prontosal's its laster compound This view was soon confirmed in experimental animals, but sulfanilamide was not used therapeutically in man until sometime later.

The attention of British physicians was attracted by the reports about these antibacterial agents which were coming from the continent of Europe, and Leonard Colebrook, who had had a wide experience in the treatment of infections following childbirth in the Queen Charlotte hospital in London, began his important studies In 1936 he and Meave Kenny reported their results, which were eminently satisfactory, and indeed most impressive. Other important contributions to the subject were soon made by G A. H Buttle, W H Gray and Dora Stephenson, who confirmed the value of p-aminobenzenesulfonamide as well as Prontosil in experimental infections in animals.

These observations of the British physicians aroused great interest in the subject of chemotherapy in both England and the United States, and within a short time several groups of investigators in the United States became actively engaged in the study of these compounds in experimental infections in animals and in infections in man. P. H. Long and E A. Bliss in Balti-more, R R Mellon, Paul Gross and F. B. Cooper in Pittsburgh and S. M. Rosenthal and Hugo Bauer in Washington began their studies, which aroused a tremendous amount of interest. The clinical observations on patients were soon placed on a sound basis by E. K. Marshall and his associates through the development of chemical methods for determining the amount and distribution of these drugs in the body after they were given by mouth, or injected into the blood stream. To Marshall and his colleagues belongs the credit for placing bacterial chemotherapy on a sound and rational basis, since by using their methods of chemical analysis and knowing the pharmacology of these substances, patients could be followed with objective methods in the treatment of disease.

The first paper on this subject to arouse widespread interest and excitement in the American medical profession was that of Long and Bluss. They described their experimental work in summars and their results in the treatment of patients with various infections, and these results were just as remarkable as those reported in England and disewhere. All these observations were soon confirmed and later extended by Long and Bluss and others.

The original experiments in animals of all investigators sug-

gested that the sulfonamides would have their greatest field of application in the treatment of streptococcic and perhaps staphylococcic mfections It soon became apparent, however, that streptococci were much more susceptible to these drugs than staphylococci, and that sulfanilamide was of little or no value in the treatment of pneumonia due to the pneumococcus. Thus it was found that erysipelas, streptococcus meningitis and infections following childbirth were influenced in the most favourable way. It was not long, however, before it was discovered that sulfanilamide had a profound effect on meningococcic and gonococcic infections-that is, the organisms causing cerebrospinal meningitis and gonorrhoea-and the results of treatment in these infections were most favourable. In meningococcic meningitis, the fatality rate was greatly reduced and the course of the disease shortened In gonococcic infections, the course of the disease was greatly shortened in more than half the cases

Af first it was a great disappointment that sulfanilamide had no favourable effect on the commonest form of pneumona—pneumococic, pneumona—since here was a common acute inction of the lungs with a high fatality rate which frequently attacked people in the prime of life and for which some simple ofform of treatment was needed it was not long, however, before A. J. Ewiss and M. A. Phillips synthesized sulfapyridine in England and showed that this was an effective agent in pneumococic pneumona. The fatality rate in this disease fell promptly from an average of 35% to 20% to between 3% and 10%. Here, then, was another important disease that was influenced favourably by these drugs

After 1936, the subject of chemotherapy advanced at a rapidpace, and scarcely a year went by that one or more new devatures were not discovered and tested. There were available by 1943 a large number of drugs which had been tested and found to be effective, including sulfapyridne, sulfathuszole, sulfadiszne, sulfapyrapiae, sulfamerazine, sulfatundine and sulfassusdine

It is a striking fact that the sulfonamides have such a wide field of application in the treatment of infections. The outstanding results achieved in the treatment of streptococcic, pneumococce, meningococcic and genoecocci infections were no less than phenomenal when compared with those gained from previous forms of treatment. Aside from the results obtained in the above infections, striking advances were made in the treatment of infections of the kindey and bladder, and dyentery (epidemic diarrhoes), and in wound milections and burns. Many lives were saved in World War II from there use in all sorts of infections saved in World War II from there use in all sorts of infections tables when they entered any theatre of military operation, and they were instructed how to use them if they became wounded. Many infections which were prevalent in other wars were reduced, and the duration of many illnesses was shortened.

Mode of Action.—The precise mode of action of the sulfonamides remains obscure. It is plain that the sulfonamides inhibit the growth of the organisms, but they do not kill them by any direct action. That is to say, they are agents which retard the growth and reproduction of the organisms which, however, are still able to survive. This is in stiking contrast to the bectricadal (killing) agents, of which the various antiseptics such as phenol and cresol are examples. The body defense mechanism is extremely important in the recovery process of all infections, so that this mechanism must be taken into account in assessing the outcome of the illness as well as the mode of action of the sulfonamides. This deceases mechanism consists of active and viable white blood corpusacies tense mechanism consists of active and viable white blood corpusacies tense mechanism consists of active and viable white blood corpusacies stances which develop in the body and antagoainze the growth of bacteria. The sulfonamides do not interfere with the development of antibodies nor with the activity of the ceils which destroy baccinessing its efficiency and infections are overcomed to a better chance of increasing its efficiency and infections are overcomed.

Toxic Effects.—All the sulfonamides are capable of producing signs of drug intoxication, and many patients become hypersensitive to them, so that serious reactions may follow their use a second time. It is advisable, therefore, that these drugs be taken only under the supervision of a physician, and for an short a period of time as is necessary. The commonest signs of drug intoxication are nauses and vonuting and mental confusion. In the case of sulfamhamde the skin and the mucous membranes often become blue due to the presence of a blee pigment in the haemoglobin of the blood. This is a harriless type of the sign of introviction are assemined due to the description of the sign of the sign of introviction are described by the struction of the white blood corpusels. If introduce of the white blood corpusels If intrinsic of the kindrey and obstruction of the white blood corpusels. If intrinsic in the value of the sign of the s

As a rule these reactions are transitory and dasappear when the rule are agreed as denoting as denotin

SULGRAVE MANOR, the early English home of the ancestors of George Washington Stutated 2½ ml. N.W. of Helm-don in Northamptonshire, England, it is a notable shrine Laurence Washington, twice mayor of Northampton, bought the property from King Henry VIII in 1530, on the dissolution of



SULGRAVE MANOR, NORTHAMPTONSHIRE, THE ANCESTRAL HOME OF

the smaller religious houses. It had previously belonged to the priory of St. Andrew, Northampton. Laurence Washington, from whom George Washington was seventh in direct descent, and his children and grandchildren lived in the manor house until 1610

Sugrave Manor was purchased, in Jan. 1914, for £3,00, by the British committee for the celebration of 100 years of peace between Great Britain and the United States (£84,4-914,) and is vested in three ar-officio trustees: the American ambassator in London, the British ambassator in Washington and the regent of the Mount Vernon Ladies' Association of the Union. It is partly restored to its original condition, and furnished with choice furniture of the period. A formal reopening took place, on June 21, 1921. In 1927 the restoration was completed by the ribuilding of the western wing, which had been demolished in the 18th century. The funds were collected by the American Society of Colonial Dames, which body had, two years previously, raised at permanent endowment of over £30,000.

On the gable of the central porch are the royal arms of the Tudors; and in the right spandrel of the arch of the main doorway, the Washington arms, three mullets and two bars, which

were reputedly the origin of the Stars and Stripes, the American national flag. The furnishings are gifts from British and American donors, and include an original Gilbert Stuart pointrait of George Washington and many other treasures. (L of F.)

SULIDAE: see GANNET

SULIMAN HILLS, a mountain system on the northwest frontier of India The chief mass of the range is known as Takhl-1-Suliman or Solomon's thorne. The legend of the mountain is that Solomon visited Hindostan to marry Balkis, and that as they were returning through the air, on a throne supported by genin, the bride implored the bridegroom to let her look back for a few moments on her beloved land Solomon directed the genif to scoop out a hollow for the throne on the summit of the mountain. The hollow is a cavity some 30 ft square cut out of the solid rock, at the southern extremity of the mountain and is a place of plagrimage for both Hindus and Mohammedans as The shrine is about 2 mi. S. of the highest peak. The whole mountain culminates in two points, incop ft and it, also of the understanding the solution of the solid with the solution of the solid rock, at the southern extremity of the mountain and is a should be solved the solution of the sol

SULINA, the second Black sea port of Rumana, and the only free port for imports Pop (1930) 5,924. Grain is brought down the Danube for ocean-going steamers The port was formerly under the European Danube commission The depth of water at the Sulina entrance to the Danube is 24 feet. The mouth is gen-

erally blocked with ice in the winter

SULTIELMA, a mountain (6,558 ft.) on the fronter between Norway and Swoden. It is covered with a snowfield from which many glaciers descend. The mountain is famous as a source of pyrites, the nopper, which occurs as lodes in schists. From Sjonstan steamers on the Langvand and a light railway give communication between the sea and Furulund. the mining centre.

SULLA, LUCIUS CORNELIUS (138-78 BC.), surnamed Felix, Roman general, politician and dictator, belonged to a minor and impoverished branch of the famous patrician Cornelian gens. He was quaestor in 107 under Marius, for whom he commanded the cavalry in the Jugurthian war. The surrender of Jugurtha was made to Sulla, and was the beginning of the rivalry with Marius Sulla won the enthusiastic devotion of his troops. From 104 to 101 he served again under Marius in the war with the Cimbri and Teutons and fought in the last great battle in the Raudian plams near Verona In 93 he was elected practor after a lavish squandering of money and he delighted the populace with an exhibition of a hundred lions from Africa. Next year (92) he went as propraeto, of Cilicia with special authority from the senate to make Mithradates VI of Pontus restore Cappadocia to Ariobarzanes, one of Rome's dependants in Asia. This he did. subsequently receiving an embassy from the Parthians asking alliance with Rome In or he returned to Rome, now one of the leading men on the senatorial side. He outshone Marius in the Social War by defeating the Samnites and taking Bovianum.

Consul.-Sulla was consul in 88, and finished the revolt by the capture of Nola. Meanwhile he had obtained by lot the command against Mithradates; Marius wanted that, and in order to get it entered into a coalition with Sulpicius Rufus, who had a plan of revolutionary legislation to carry out. Sulpicius, quite unconstitutionally, transferred the command to Marius by vote of the assembly. Rioting took place at Rome at the prompting of the popular leaders. Sulla narrowly escaping to his legions in Campania, whence he marched on Rome, being the first Roman who entered the city at the head of a Roman army. Sulpicius was put to death, and Marius fled Sulla, leaving things quiet at Rome, quitted Italy in 87, and for the next four years he was winning victory after victory against the armies of Mithradates and accumulating boundless plunder. Athens, the headquarters of the Mithradatic cause, was taken and sacked in 86, and in the same year, at Chaeroneia, the scene of Philip II of Macedon's victory more than two and a half centuries before, and in the year following, at the neighbouring Orchomenus, he scattered immense hosts of the enemy with trifling loss to himself Crossing the Hellespont in 84 into Asia, he was joined by the troops of C. Flavius Fimbria, who soon deserted their general, a man sent out by the Marian, party, now again in the ascendant at Rome. The same year peace was concluded with Mithradates.

Sulla returned to Italy in 83, landing at Brundisium. Marius had died in 86, and the revolutionary party, specially represende by L. Cornelius Cinna, Cn. Papirus Carbo and the younger Marius, had massacred Sulfa's supporters wholesale, confiscated his property, and declared him a public enemy. They had large forces ready to meet him, but Sulfa's declaration that he did not intend to deprive the Italians of the franchise cut the ground from under their feet, and only the Samultes remained in arms

In the following year (32) he won a decisive victory over the younger Marius near Praeselse (mod. Palestrian) and then marched upon Rome, where again, just before his defeat of Marus, there had been a great massacre of his adherents, in which the learned jurist Q Mucius Scaevola persibed. Rome was at the same time in externe peril from the advance of a Samutic atmy, and was barely saved by Sulla, who, after a hardfough tattle, routed the enemy under Pontius Telesinus at the Colline gate of Rome. With the death of the younger Marius, who killed himself after the surrender of Praenest, the civil war was at an end, and Sulla was master of Rome. Then came the memorable "proscription," when for the first time in Roman was ready to the proscription of the control of the proscription was ready to the proscription of the p

and the control of the control was revived and some was not maked experience of Rome. After celebrating a splended trummpl for the Mithraduct with a great pumple as armane of "Fells" he control that the control of th

In 79 Sulla resigned his dictatorship and retired to Puteoli (mod. Pozucoli), where he dred in the following year, probably, from the bursting of a blood-vessel in a fit of passion. The "halflion, half fox," as his enemies called him, the "Don Junn of politics" (Mommsen), the man who carried out a policy of "blood and iron" with a grim humour, ansued himself in his last days with actors and actresses, with dabbling in poetry and completing his Memoirs; Gest H. Peter. Historicoum remonsorum reliculos.)

He was accorded a magnificent public funeral, his body being removed to Rome and burred in the Campus Martius. His monment bore an inscription written by himself, to the effect that he had always fully repard the kindnesses of his friends and the wrongs done him by his enemies. His reforms, mechanically excellent, were all failing to pieces before his death, except the quaestiones perpetuae, which became the basis of Roman criminal justice. He tried in van to put the clock back.

SULLIVAN, SIR ARTHUR SEYMOUR (128,2-79co), English composer, was born in Lambeth on May 13, 1343, being the son of a cultivated Lish musician who was bandmaster at the Royal Military college, Sandhurst, from 1343 to 1356, and taught at the Military School of Music at Kneller Hall from 1857 till his death in 1866. His mother, née Mary Coghlan (1321-1383), had Italian blood in her vens. Arthur Sullivan was brought up to music from boyhood, and he had learned to play every wind instrument in his father's band by the age of eight. He also had a fine treble voice, and became a chorister of the Chapel Royal, In 1856 he wan the Madelssonis scholarship at the Royal caded.

emy, where he studied under Sterndale Bennett, Arthur O'Leary and John Goss. In 1858 he was sent to study at Leipzig, where he had for teachers Moscheles and Plady for panoforte, Hauptmann for counterpoint, Rietz and Reinecke for composition, and F, David for orchestral playing and conducting

After two years' hard study he returned to London in April 1861 and at his instigation Schumann's first symphony was fin-troduced at one of the Crystal Palace winter concerts. The followen year his own Tempets muse was performed at the same concerts. Then followed his Kembsorh's canata (remembered chiefly for the charming duet, "How Sweet the Moonlight"), the Sapphire Neckleze overture, and the five beautiful songs from Shakespeare, which include "Orpheus with his Lute," "Oh Mises Mine" and "The Willow Song." His attractive personality, combined with his undoubted genus and brillnant promise, brought hum many friends. Costa, who was conductor at Covent Garden, gave him the post of organist, and in 1854 he produced there his showed his genius for light operatic music in his collaboration with F. C. Burnand in Cost and Box and in 1857 he first showed his genius for light operatic music in his collaboration with F. C. Burnand in Cost and Box and in 1850 rebondusts.

In 1821 Sullivan became acquainted with W. S. Gilbert (a.v.). and in that year they collaborated in a piece for the Gaiety theatre, called Thespis; or, The Gods Grown Old, which was a great success in spite of the limited vocal resources of the performers. In 1875 R D'Ovly Carte, then acting as manager for Selina Dolaro at the Royalty, suggested to Gilbert collaboration with Sullivan in a piece for that theatre. Gilbert had already suggested to Sullivan an operetta with its scene in a law court, and within three weeks of his completing the libretto of Trial by Jury the music was written. The piece succeeded beyond all expectation; and on the strength of its promise of further successes D'Oyly Carte formed his Comedy Opera company and took the Opera Comique theatre. There in 1877 The Sorgerer was produced. George Grossmith and Rutland Barrington being in the cast In 1878 H.M.S. Pinafore was brought out at the Opéra Comique. and ran for 700 nights. In America it was enthusiastically received and pirated right and left and the two authors, with D'Ovly Carte, went over to the U.S. in 1870, with a company of their own, in order to produce it in New York. To secure the American rights for their next opera, they brought out The Pirates of Penzance first at New York in 1879. In 1880, in London, it ran for nearly 400 nights. In 1881 Patience was produced at the Opéra Comique, and was transferred later in the year to the Savoy theatre. There all the following operas came out. Iolanthe (1882), Princess Ida (1884), The Mikado (1885), Ruddigore (1887). The Yeomen of the Guard (1888), The Gondoliers (1889). The vogue of the new type of light opera owed something to such admirable performers as George Grossmith, Rutland Barrington, Miss Jessie Bond, Miss Brandram, and later W. H. Denny and Walter Passmore; but these artistes only took advantage of the opportunities provided by the two authors. In place of the old adaptations of French opera bouffe they had substituted a genuinely English product, humorous and delightful, without a tinge of vulgarity or the commonplace. But disagreements arose between them which caused a dissolution of partnerments arose between them which caused a dissolution of partner-ship. Sullivan's next Savoy opera, *Haddon Hall* (1892), had a libretto by Sydney Grundy; and the resumption of Gilbert's collaboration in 1893 in *Utopia*, *Limited*, and again in 1896 in The Grand Duke, was not as successful as before. Sullivan's music, however, still showed its characteristic qualities in The Chieftain (1894)—largely an adaptation of Contrabandista; The Beauty Stone (1898), with a libretto by A. W. Pinero and J. Comyns Carr; and particularly in The Rose of Persia (1900), with Basil Hood.

In 1872 Sullivan's Te Deum for the recovery of the prince of Wales was performed at the Crystal Palace. In 1873 he produced at the Birmingham Musical festival his oratorio The Light of the World, in 1877 he wrote his incidental music to Henry VIII, in 1880 his sacred cantata The Marryr of Antioch, and in 1886 The Golden Legend was brought out at the Leeds festival. In 1891, for the opening of D'Oyly Carte's new English opera-house in Shaftesbury avenue, later the Palace theatre, he wrote his "grand opera" Ivankoe to a libretto by Juhan Sturgis. The attempt to put an English opera on the stage for a long run was doomed to failure, but Ivanhoe contains many admirable pages. In 1802 he composed incidental music to Tennyson's Foresters. In 1897 he wrote a ballet for the Alhambra, called Victoria and Merrie England Among his numerous songs, the best known are "Orpheus With His Lute." "Thou'it Passing Hence" and, most famous of all, "The Lost Chord" This last, hackneyed as it became, was probably the most successful English song of the 19th cen-The hymn tune "Onward, Christian Soldiers!" (1872) shows Sullivan in another light. In 1876 he accepted the puncipalship of the National Training School of Music, which he held for six years; this was the germ of the subsequent Royal college. He was conductor of the Leeds festivals from 1879 to 1808, besides being conductor of the Philharmonic society in 1885. He died on Nov. 22, 1900, and was buried in St Paul's cathedral Among works which he left unpublished may be mentioned a Te Deum, written for performance at the end of the South African War, and an unfinished Savoy opera to a libretto by Basil Hood, which, completed by Edward German, was produced in 1001 as The Emerald Isle Sullivan was the one really popular English composer of any artistic standing in his time One of the most agreeable companions, broad-minded and free from all affectation, he was intensely admired and loved in all circles of society; and though he suffered during many years from a painful ailment, he enjoyed life without being spoiled by success.

Bullonafier — A Lawrence, Sir Arthur Sullivan: Life Story, Letters and Remniscences (1899), H. Saxo-Wyndham, Arthur Seymour Sullivan (1926); Herbert Sullivan and Newman Flower, Sir Arthur Sullivan, Hit Life, Letters and Duries (1928).

SULLIVAN, JOHN (1740-1795), American soldier, was born in Somersworth (now Rollinsford), NH, on Feb. 17, 1740. He practised law at Berwick, Me., and at Durham, N H., was a member of the New Hampshire provisional assembly (1774), and also a member of the first continental congress In June 1775 he was appointed brigadier general in the continental army and aided in the siege of Boston. In the same year he took command of the American army in Canada and exhibited great skill in effecting a retreat from that province. Soon afterward, having been superseded in command by General Gates, he rejoined Washington's army and took part in the battle of Long Island, where he was taken prisoner In December he was exchanged, and succeeded Gen. Charles Lee in command as major general of the right wing of Washington's army. In the battle of Tienton he led an attack on the Hessians, and on Aug. 22, 1777, he led a night attack against the British and Lovalists on Staten Island. He commanded the American right in the battle of Brandywine and took part in the battle of Germantown. In March 1778 he was placed in command in Rhode Island, and in the following summer plans were made for his co-operation with the French fleet under Count d'Estaing in an attack on Newport.

The Indian raids in western New York, especially the atrocities in the Wyoming and Cherry valleys, caused a retaliatory expedition to be sent to "chastise and humble the Six Nations," and Sullivan was chosen to lead the expedition With about 4,000 men, he defented the Iroquois and their Loyaltst allies at Newtown (now Elman, N.Y.), humoul their Villaga and destroyed their orchards and cops. Although severity criticized for his conduct of the expedition, stigned from the army. Sulfivan was again a defeated to the confirmation of the control of the control of the confirmation of the control of the control of the confirmation of the control of the defeated the Iroquois and their Loyalist allies at Newtown (now

SULLIVAN, JOHN LAWRENCE (1858-1918), U.S. professional boxer, known as the "Great John L." and the "Boston Strong Boy." Born on Oct. 15, 1858, at Boston, Mass., Sullivan attended school there and for a time studied at Boston college. At the age of 19 he launched his professional boxing career. Sullivan was supreme at the rough-and-ready style, and in 1882 knocked out Paddy Ryan in nine rounds to win the championship.

He held the title until Sept 7, 1892, when James J Corbett knocked him out in 21 tounds at New Orleans, La In the last bare-knuckle fight of professional boxing, Sullivan knocked out Take Kiliain in 1880 in a 75-round battle that lasted 2 hr 15 min 25 sec Sullivan, who had earned more than \$1,000,000 as champion but dissipated it all, later became an advocate of prohibition and gave many lectures on the subject before his death in modest circum-(J.P.D.X.) stances on Feb 2, 1918

SULLIVAN, a city of southwestern Indiana, U.S., on federal highways 41 and 150, 26 ml. S of Terre Haute; the county seat of Sullivan county. It is served by the Chicago and Eastern Illinois and the Illinois Central railways. The population was 5,423 in 1950, 5,077 in 1940 and 5,306 in 1930 by federal census. It is in one of the principal coal fields of the state, and there are oil and gas wells in the county. The city was founded in 1842 and in-

corporated in 190

SULLY, JAMES (1842-1923), English psychologist, was born on March 3, 1842, at Bridgwater, and was educated at the Independent college, Taunton, the Regent's Park college, Gottingen and Berlin. He was Grote professor of the philosophy of mind logic at University college, London, from 1892 to 1903 An adherent of the associationist school, Sully wrote Sensation and Intuition (1874), Outlines of Psychology (1884); The Human Mind (1892); and An Essay on Laughter (1902). He died at Richmond, Sur, on Oct. 31, 1023

SULLY, MAXIMILIEN DE BÉTHUNE, DUC DE (1560-1641), French statesman, was born at the château of Rosny near Mantes on Dec. 13, 1560, son of François de Béthune, baron de Rosny (1532-75). Blought up in the Reformed faith, Maximilien joined the court of Henry of Navarre in 1571. He was taken to Paris by his patron and was studying at the college of Bourgogne at the time of the St Bartholomew massacre, from which he escaped by discreetly carrying a book of hours under his arm On the outbreak of civil war in 1575 he enlisted in the Huguenot army In 1576 he accompained the duke of Anjou on an expedition into the Netherlands in order to regain the former Rosny estates, but being unsuccessful he attached himself for a time to the prince of Orange Later rejoining Henry of Navarre in Guienne, he displayed particular ability as an engineer. In 1583 he was Henry's special agent in Paris In 1584 he marned Anne de Courtenay, a wealthy heiress, who died, however, in 1580 On the renewal of civil war Rosny again joined Henry of Navarre, and at the battle of Ivry (1500) was seriously wounded He counselled Henry IV's conversion to Roman Catholicism. but steadfastly refused himself to become a Roman Catholic.

Rosny became a member of the king's council of finance in 1506 and appears to have been sole superintendent as early as 1508. He authorized the free exportation of grain and wine, reduced legal interest from 83% to 64%, established a special court for trial of cases of peculation, forbade provincial governors to raise money on their own authority, and otherwise removed many abuses of tax collecting, abolished several offices and by his honest, rigorous conduct of the country's finances was able to save between 1600 and 1610 an average of 1,000,000 livres a year. His achievements were by no means solely financial. In 1599 he was appointed grand commissioner of highways and public works, superintendent of fortifications and grand master of artillery; in 1602 governor of Mantes and of Jargeau, captain-general of the queen's gens d'armes and governor of the Bastille; in 1604 governor of Poitou; and in 1606 duke and peer of Sully, ranking next to princes of the blood. He declined the office of constable because he would not become a Roman Catholic. Sully encouraged agriculture, urged the free circulation of produce, promoted stock raising, forbade the destruction of the forests, drained swamps, built roads and bridges, planned a vast system of canals and actually began the canal of Briare He strengthened the French military establishment: under his direction Évrard began the construction of a great line of defenses on the frontiers. Sully opposed the king's colonial policy as inconsistent with the French genius, and likewise showed little favour to industrial pursuits. although on the urgent solicitation of the king he established a few silk factories. He fought in company with Henry IV in Savoy (1600-1601) and negotiated the treaty of peace in 1602: in 1603 he represented Henry at the court of James I of England; and throughout the reign he helped the king to put down insurrections of the nobles, whether Roman Catholic or Protestant. It was Sully, too, who arranged the marriage between Henry IV and Marie de Médicis

The political rôle of Sully practically ended with the assassination of Henry IV on May 14, 1610 Although a member of the council of regency, his colleagues were not disposed to brook his domineering leadership, and after a stormy debate he resigned as superintendent of finances on Jan 26, 1611, and retired to private life The baton of marshal of France was conferred on him on Sept 18, 1634 He died at Villebon, on Dec 22, 1641

Sully was hated by Catholics because he was a Protestant, by Protestants because he was faithful to the king. He was an excellent man of business, mexorable in punishing malversation and opposed to the rumous expenditure which was the bane of European monarchies. He was implicitly trusted by Henry IV, and contributed greatly to the recovery of France.

Solly left a curous collection of memors bearing the title, Mémoire day singe et rysile occinomies l'étaid, demestiques, patiques, et des singes et rysiles occinomies l'étaid, demestiques, patiques, et de for the bistory of the time, though they contain fictious matter such as a misson by Sully to England in 160;, and the "grand deagn" for a Christian republic. The best efficient of the original is that in JF Michard and J J F Poujoulat, Noveelle collection des mémoires relatifs à l'hator et Proujoulat, Noveelle collection des mémoires relatifs à l'hator et Proujoulat, Noveelle collection des mémoires relatifs à l'hator et Proujoulat, Noveelle collection des mémoires relatifs à l'hator et Proujoulat, Noveelle collection des mémoires relatifs à l'hator et Proujoulat, Noveelle collection des mémoires et des l'économies de l'action de l' translation by Charlotte Lennox appeared in 1756 and was later revised and republished (4 vols, London, 1856).

SULLY, THOMAS (1783-1872), US artist, was born at Horncastle, England, on June 8, 1783. His parents, who were actors, took him to the United States, when he was nine years old. settling at Charleston, S C. He was first instructed in art by a French miniature painter Afterward he was a pupil of Gilbert Stuart in Boston, and in 1809 he entered the studio of Benjamin West in London. He returned in 1810, and made Philadelphia his home, but in 1837 again visited London, where he painted a fulllength portrait of Queen Victoria for the St George's Society of Philadelphia. Sully was one of the best of the early American painters. He died in Philadelphia on Nov 5, 1872. Among his portraits are those of Comm. Decatur (city hall, New York), the actor, George Frederick Cooke, as Richard III (Pennsylvania Academy of the Fine Arts, Philadelphia); Lafayette (Independence hall); Thomas Jefferson (U.S. military academy, West Point, N.Y.); Charles and Frances Anne Kemble and Reverdy Johnson

SULLY-PRUDHOMME, RENÉ-FRANCOIS-AR-MAND PRUDHOMME (1839-1907), French poet, born in Paris, March 16, 1839, was educated at the Lycée Bonaparte, where he took his degree as Bachelier ès Sciences An attack of ophthalmia interrupted his studies and necessitated an entire change in the course of his career. He found employment for a time in the Schneider factory at Creuzot, but he soon abandoned an occupation to which he was eminently unsuited. He subsequently entered a notary's office in Paris. It was during this period that he composed those early poems which were not long in acquiring celebrity among an ever-widening circle of friends. In 1865 he published his first volume of poems, which was favourably reviewed by Sainte-Beuve, to whose notice it had been brought by Gaston Paris. It was at this moment that the small circle of which Leconte de Lisle was the centre were preparing the Parnasse, to which Sully-Prudhomme contributed several pieces. In 1866 Lemerre published a new edition of the Stances et poèmes and a collection of sonnets entitled Les Epreuves (1866). From this time forward Sully-Prudhomme devoted his life entirely to poetry. It was in the volume of Les Epreuves that the note of melancholy which was to dominate through the whole work of his life was first clearly discernible. In 1869 he published a translation of the first book of Lucretius with a preface and Les Solitudes. In 1870 a series of domestic bereavements and a serious paralytic illness resulting from the strain and fatigue of the winter of 1870, during which he served in the Garde Mobile, shattered his health. In 1872 he published Les Écuries d'Augias. Croquis italiens, Impressions de la guerre (1866-72) and Les sufficient for the wholesale production of the explosive, picric

Destms, La Révolte des heurs in 1874, in 1875 Les vaines Tendresses, in 1878 La Justice, in 1886 Le Prisme and in 1888 Le Bonheur All these poems were collected and republished under the title of Poésies, occupying four volumes of his Oeuvres (6 vols , 1883-1904) After the publication of Le Bonheur he practically ceased to produce verse and devoted himself almost entirely to philosophy He published two volumes of prose criticism L'ex-pression dans les beaux arts (1884) and Réflexions sur l'art des vers (1802) Various monographs by him appeared from time to time in the philosophical reviews, and among them a series of essays (Revue des deux mondes, Oct 15th, Nov 15th, 1890) on Pascal, and a valuable study on the "Psychologie du libre arbitre" in the Revue de métaphysique et de morale (1906) He was elected to the academy on Dec 8, 1881. On Dec. 10, 1901, he was awarded the Nobel prize for literature, and devoted most of the money to the foundation of a prize for poetry to be awarded by the Société des gens de lettres. He was one of the earliest champions of Captain Dreyfus In 1902 he wrote, in collaboration with Charles Richet. Le Problème des causes finales. During his later years he lived at Châtenay in isolation, a victim of perpetual illhealth, and mainly occupied with his Vraie religion selon Pascal (1905). He had been partially paralyzed for some time when he died suddenly on Sept. 7, 1907 He left a volume of unpublished verse and a prose work. Le Lien social, which was a revision of an introduction which he had contributed to Michelet's La Bible de Phymanté

See C. Hémon, La Philosophie de Sully-Prudhomme (1907), Sully-Prudhomme by E. Zyromski (Paris, 1907).

SULMONA (anc Sulmo), a city of the Abruzzi, Italy. Pop (1936) 16,854 (town), 21,289 (commune). Sulmona is situated at a height of 1,322 ft above the sea on the Gizio, a tributary of the Pescara, which supplies water-power to its paper mills, fulling mills and copperworks. Its cathedral of San Panfilo has a 14th century portal, and an 11th century crypt. S. Maria della Tomba is a good Gothic church S. Francesco della Scarpa occupies the site of an older and larger church, the Romanesque portal of which still stands at the end of the Corso Ovidio, and forms the entrance to the market. Opposite is a picturesque aqueduct of 1256 with pointed arches, which supplies the Renaissance Fontana del Vecchio (1474) S. Agostino has a good Gothic portal. The Palazzo dell' Annunziata, begun in 1320, shows an interesting and successful mixture of Gothic and Renaissance styles In the court of the grammar school is a fine 15th century statue of Ovid, the most celebrated native of the town, whose memory is preserved among the peasants in songs and folk-lore, and outside is a good monument to him by Ettore Ferrari (1925) The Porta Napoli is a gate of the 14th century Innocent VII was a native of the town. In the vicinity of the town is Monte Morrone where Pietro da Morrone lived as a hermit and founded a monastery for his hermits, who after his elevation to the papacy as Celestine V (1204) took the name of Celestines; the monastery (S. Spirito) is a prison.

Sulmo was devastated by Hannibal (211 BC) It was famous for its ironsmiths. Charles V bestowed it on the vicerov of Naples, Charles de Lannoy, who had captured Francis I at the battle of Pavia. The town has suffered much from earthquakes. SULPHA DRUGS: see Sulfonamides, The

SULPHONIC ACIDS, organic acids containing sulphur and having the general formula, R.SO<sub>2</sub>H, where R is either an alkyl or an aryl radical. (See CHEMISTRY: Organic Chemistry.)

Aromatic Sulphonic Acids -The acids of this more important group are obtained generally by treating aromatic compounds with concentrated sulphuric acid, the process being called sulphonation. Such operations are frequently conducted on a manufacturing scale as in the preparation of the sulphonic acids of benzene (q.v.), naphthalene (q.v.) and anthraquinone (q.v.). The sodium salt of benzenesulphonic acid is of importance since on fusion with sodium hydroxide it yields sodium phenoxide, from which phenol is liberated by a strong acid. During World War I large quantities of synthetic phenol were made by this process in order to eke out the supply of coal-tar phenol, which was then inacid (q.v.). From then, the process retained its importance in consequence of the large demand for phenol in the manufacture of synthetic resins and plastics (q v). Benzenedisulphonic acid, made from oleum (fuming sulphuric acid) and benzene, yields by alkali fusion the unportant dive intermediate, resortion)

The sulphonic acids of naphthalene are manufactured on an extensive scale, for by alkali fusion naphthalene.—sulphonic acid, made by low-temperature sulphonation, yields \( \alpha \)—naphthol, whereas naphthalene-\( \beta \)—sulphonic acid, prepared at 165° C, when similarly treated, furnishes \( \beta \)—anaphthalene-\( \beta \)—sulphonic acid, prepared at 165° C, when similarly treated, furnishes \( \beta \)—anaphthalene-\( \beta \)—sulphonic acid, prepared at 165° C, when similarly treated, furnishes \( \beta \)—anaphthalene-\( \beta \)—sulphonic acid, and a similarly treated furnishes \( \beta \)—anaphthalene-\( \beta \)—sulphonic acid, and a similarly treated furnishes \( \beta \)—anaphthalene-\( \beta \)—sulphonic acid, and a similarly treated furnishes \( \beta \)—anaphthalene-\( \beta \)—sulphonic acid, and a similarly treated furnishes \( \beta \)—anaphthalene-\( \beta \)—sulphonic acid, and a similarly treated furnishes \( \beta \)—anaphthalene-\( \beta \)—sulphonic acid, anaphthalene-\( \beta \)

Anthraquaone, the oxidation product of anthracene (q.v.), when subplomated with oleum at high temperatures yields anthraquione, β-subplomated with eleum at high temperatures yields anthraquione, β-subplomated with eleum at the which ('silver sait') is an important intermediate used in the manufacture of aliazam (q.v.) and the indanthrene vat dyess (See Drss, Syntherica. Sulphonation of anthraquionoe is facilitated by a mercuric subplate catalyst, and in this way anthraquionoe.1-q. and -1:3ed silviphoma cards are also used as intermediates in the dye modistry Sulphonation may be effected by chlorosulphonic acid whereby sulphonyl chlorides are formed. (See SACHARN). In addition to direct sulphonation, the sulphonic group may be introduced into the anomatic nucleus through the disapproaches of the produced formed the sulphonation.

Sulphonic acids of aromatic hydrocarbons are very soluble in water and when obtained crystalline are extremely hygroscopic. With phosphorus pentachloride they yield sulphonyl chlorides, which are reducible to thophenols. On distillation with sodium cynaide or ferrocyanide the softium arylsulphonates give rise to utriles, and on fusion with sodium hydroxide, they lead to phenols (see above.)

Sulphanilic acid, a sulphonic acid of aniline, is sparingly soluble in cold water and is to be regarded as an internal salt.

# <sup>†</sup>NH₃.C₀H₄.SÕ₃.

Its amide is important as the simplest member of the medically important sulfonamides (q,v). Sulphanilic acid and the similar naphthylamine sulphonic acids are important due intermediates

Albhaic Sulphone Acids are less important than those of the aromatic series. They are obtained generally (1) by oxidation of meraptans, alkyl dissulphides, alkyl thiocyanates or alkyl sulphine acids. (2) by the interaction of alkyl indices and metallic sulphites, (3) by the action of sulphusyl chloride SO<sub>2</sub>Cl<sub>3</sub>, upon a saturated hydrocarbon in the presence of light and of a catalyst such as pyridine, (4) by the action of sodium bisulphite upon an oleine in the presence of oxygen or other oxidating agent. They are dither viscous liquids or crystalline solids, converted into suit.

phonyl chlorides by phosphorus pentachloride. Hydroaromatic Sulphone, deids — Camphor yields a characteristic sulphonic acidio — Camphor yields a characteristic sulphonic acid on sulphonation with sulphuric acid in acetic annydride. The optically active camphor sulphonic acids from dextro- and laevo-modifications of camphor have been very useful in the resolution of racemold bases. (See STREROCHEMISTER)

(G, T. M.; X.)

SULPHUR, a nonmetallic chemical element, was discovered

nn prehistoric times. Its name is derived from the Latin word subpharum. It is often called branstone (burning stone), and signified subphar is mentioned in the earlier records of many countries as having been used for religious ceremonies, for purifying (fungating) buildings and for blesching cloth. The Romans also used it in medicine and in warfare. During the middle ages the (plenishs regarded subpharus as the principle of combustibility (philostone).

It was first classified as an element by Antoine Lavoisier in 1777 but many of his contemporaries considered it a compound of hydrogen and oxygen. Joseph Gay-Lussac and Louis Thénard finally proved it an element in 1809

Occurrence.—The earth's crust, according to F. W. Clarke, contains oc69, of sulphur as sulphides, sulphates and elemental sulphur. As elemental or native sulphur, it occurs chiefly in sedimentary and volcant deposits. Most of the world's production of sulphur is from sedimentary deposits and the majority of that from the calcareous horizons of the cap rock of shallow salt domes in the coastal region of Texas and Louisana, U.S. Italy, chiefly Scilly, is the only other large producer from sedimentary deposits Volcanic sulphur, widely distributed throughout the world, occurs and the control of the cont

In combination, the element occurs chiefly as sulphides and subplates. The former are of importance as a source of sulphur,  $e\,E_j$  pyrite (FeS.), marcaste (FeS.), pyrrhotite (FeS.), chalco-pyrite (CuFeS.), galena (PhS.) and sphalerite (ZnS.). The chiefly sulphates are anhydrite (CaS.O.), gypsum (CaS.O.)+2H.O.) and that (BaS.O.) also known as barytes or heavy spar. Sulphur also occurs in organic substances,  $e\,E_j$ , hair, wool, albumen, garlic, mustard, horse-radish, cabbage and many proteins.

Production.-Ancient producers described their method of obtaining sulphur from its ores as purification by fire Similar methods are still used in Sicily where native sulphur ore, mined by conventional methods, is piled in open cylindrical kilns (calcaroni), covered with spent ore and ignited Heat from burning about one-third of the sulphur melts the remainder which drains from the kilns and is cast into blocks. Somewhat better sulphur recovery is obtained in other kilns (Gill furnaces) constructed so that combustion gases from one kiln can be used to preheat the ore in In Japan, sulphur is usually distilled from the ore in another retorts Sulphur ores may also be heated with steam or superheated water in autoclaves. The sulphur melts, drains from the gangue and is recovered in the liquid state. Some sulphur is recovered by this method in the western part of the United States but after 1903 nearly all U.S sulphur was produced by the Frasch process from the deposits located near the Gulf of Mexico in Texas

All the sulphur deposits mined by the Frasch process occur at dopths of soo ft. to apoo ft. in the cap role of said domes. In horazontal section, the domes are circular to elliptical in shape. Surrounding and overlying the domes are clay, said and gupbo. The upper portion of the dome consists of a porous cap rock which. The upper portion of the dome consists of a porous cap rock which is largely limestone and calcute, with an occasional trace of the carbonates and sulphates of the other alkalme earths. The sulphur occurs in the porous limestone in the form of rhombic crystats. Below the limestone is a stratum of massive anhydrite which in turn overliges the rock-sail core of the dome.

Crystalline sulphur melts at about 116° C. The Frasch process takes advantage of this fact and fuses the sulphur underground by pumping water heated above this temperature into the deposit,

Table I .- Production of Native and Elemental Sulphur

	(Met	ric tons)			
Country	1938 1944	X947	1948	1949	1950
Argeatus Colle Funce Indoness Indoness Italy Indoness Italy Inpa Inpa Inpa Inpa Inpa Inpa Inpa Inpa	21,205 30,736 142 1,037 10,141 20,000 307,152 77,102 220,013 78,000 110,501 60,632 110,501 1,037 110,501	13,209 11,003 8,562 10,000* 10,7074 20,130 3,251 82,341† 702 7,543 27,234 14,2001 2,636 4,512,495	10,000* 13,471 0,755 10,000* 180,007 40,603 2,134 79,157 9,698 10,333 2,571 4,947,361	10,000 7,035 8,000* 10,000* 208,066 62,400 1,016 81,184† 275 9,507† 38,504 10,000*† 3,005 3,821,171	10,161 15,240* 10,000* 229,165 92,400 1,016 95,170† 250* 14,430† 39,722* 10,000* 5,275,519
Total "Free World"	3,260,307 3,650,650*	4,803,810*	5,366,008#	5,276,044*	5.875.457*

"Entinated, Sulphus recovered from pyrines. Including sulphus recovered from pyrites. Survey. The shows that a between the sulphus recovered from pyrites. Survey. The shows that a between the sulphus recovered from pyrites. Survey. The shows that a between the sulphus recovered from the survey of the sulphus sulphus recovered from the survey of the sulphus sulphus recovered from the sulphus recovered from the sulphus sulphus sulphus sulphus recovered from the sulphus sulphu

The melted sulphur, which is almost chemically pure, flows away from the gangue and is pumped to the surface

In mining, wells are drilled into the sulphur formation using rotary rigs such as those employed in the petroleum industry. The wells are equipped with pipes of various sizes placed concentrically which reach from the surface of the ground into the sulphur deposit A 6-in, pipe extends through the sulphur-bearing stratum and rests in the upper portion of the underlying calcium sulphate or gypsum A 3-in pipe is placed inside the 6-in pipe, reaching nearly to the bottom of the sulphur-bearing rock but resting on a collar that is set within a 6-in, pipe and seals the annular space between the two. Finally, a 1-in air pipe, inside the 3-in, pipe, extends to a depth slightly above the collar The 6-in, pipe is perforated at two levels, separated by the collar, the upper set of holes permitting the escape of hot water and the lower the entrance of molten sulphur

Hot water is pumped down the annular space between the 6-in and 3-in pipes and discharged into the porous formation through the perforations already described. The entire region through which the water circulates is raised to a temperature above the melting point of sulphur The melted sulphur, being heavier than water, settles and forms a pool around the foot of the well and, entering the lower perforations, rises in the 3-in pipe Compressed air, released at the bottom of the central 1-in, pipe, raises the liquid sulphur to the surface. Then the molten sulphur is pumped from the wells to near-by sumps, and from them to vats (bins) to solidify A completed vat, consisting of a solid block of sulphur, may be 1,200 it long, 50 ft. high and 160 ft to 200 ft wide and contain 500,000 tons of sulphur.

The sulphur production described is that obtained in elemental form from natural deposits After 1920, various schemes were devised for extracting sulphur from pyrites, coke-oven gas, smelter fumes and hydrogen sulphide By-product sulphur, as this type of sulphur is called, has been produced in Canada, Germany, Norway, Portugal, Spain, Sweden and the United States.

### PHYSICAL PROPERTIES

The element sulphur, chemical symbol S, exhibits nonmetallic properties, has an atomic number of 16 and chemical atomic weight 32 of It occupies the position immediately below oxygen in Group VI of the periodic table Four stable isotopes are known, each with a nucleus containing 16 protons, but differing by having 16, 17, 18 and 20 neutrons respectively. The respective mass numbers are 32, 33, 34 and 36, and the normal composition of sulphur is given as S<sup>32</sup> (95%), S<sup>38</sup> (074%), S34 (4 2%), S28 (0.016%). Two radioactive isotopes S31 (half life 3 2 sec ) and Sat (half life 87 1 days) have been prepared. The arrangement of the electrons in the outer shell of all atoms is represented as follows: 152, 252, 2p6, 352, 3p4.

Pure solid sulphur has a pale yellow colour but its naturally occurring forms may be sulphur yellow, straw or honey yellow, yellowish brown, greenish or reddish to yellowish gray Just above the melting point sulphur is a transparent yellow liquid which, with increasing temperature, turns dark red and becomes black at 230° C. At the boiling point (444.6° C) vapours are generated which turn deep red at 500° C. and a straw yellow at 850° C.

Sulphur is tasteless and odourless. It has no action on the skin. It is insoluble in water, highly soluble in carbon disulphide, moderately so in aromatic solvents and indifferently so in aliphatics. The liquid density varies from 1.808 g per millilitre at 115° C. to 1.599-1.614 g per millilitre at the boiling point. At 200° C. (reduced pressure) the vapour density corresponds to Se molecules, at 600° C. to Se, at 1,000° C. to S1 and at 4,000° C. to monatomic Increased pressure decreases the dissociation of the sulphur. Increased pressure decreases the dissociation of the vapour. The critical temperature is 1,040° C. The latent heat of vaporization decreases from 84.8 cal. per gram at 120° C. to 68.r cal. at 360° C. and then rises to 73.9 cal. at 540° C. The latent heat of fusion is 9 21 cal. per gram (x18.9° C.).

Sulphur is a poor conductor of both heat and electricity and becomes charged negatively if rubbed with glass, fur, silk, wool or hard rubber. On Mohs' scale, its hardness varies from 1.5 to 2.5. The vapour pressure varies from 0.0002 mm. of mercury at

50° C to 3,824 mm at 570° C The coefficient of thermal expansion continuously increases with temperature for the solid while that for the liquid passes through a minimum value. The bond angle, the interatomic distance and the atomic radius for crystalline St are 105°, 2 12Å (Å, the Angstrom unit=10-8 cm.) and 1 04 Å, respectively For the Sagas the bond angle is 100° but the other two values are the same as for the solid The ignition temperature of sulphur in air is 261° C.

Allotropic Modifications.—A number of crystalline forms of sulphur have been identified by their external appearance and optical properties These, according to D M Yost and H Russell. Ir.

arranged in their suggested order of stability are:

 $S_{\theta}$  (tetrahedial) $\rightarrow S_{\theta}$  (monoclinic) $\rightarrow S_{\eta}$  (monoclinic) $\rightarrow$  $S_{\rho}$  (monoclinic)  $\rightarrow S_{\rho}$  (monoclinic)  $\rightarrow S_{\theta}$  (the usual

monoclinic sulphur) = Sa (rhombic sulphur)

These forms differ in external appearance, crystal structure and physical properties, e g , density, solubility and melting point. Of the allotropic forms, the two most important are rhombic (a, S., or S,) and monoclinic (B, SB, or SI)

Thermodynamically, rhombic sulphur is stable at room temperature and is readily obtained by crystallization from solution in carhon disulphide It is a yellow solid with a density of 207 g per millilitre and melting point 112.8° C. (if heated rapidly) Above 95.5° C, the transition temperature, the crystals become opaque and consist of aggregates of the monoclinic form An X-1ay investigation of rhombic crystals has shown that the unit cell is composed of 16 puckered rings of St molecules arranged approximately

in layers perpendicular to the C-axis

Monoclinic sulphur is obtained when molten sulphur is cooled slowly On breaking the surface crust and pouring off the still liquid sulphur, the interior of the cooled mass will be found to be filled with needlelike, monoclinic crystals. The density of the monoclinic sulphur is 1 96 g. per millilitre and its melting point is 119° C Under higher pressures, the two forms can only coexist at a definite temperature for any particular pressure (i e., the transition point is raised), and if the pressure is raised while temperature is kept constant, the rhombic form is produced since it is the more dense This balanced state of affairs continues to 151° C. and 1,288 atm.; above this temperature and pressure the monoclinic form cannot exist. The atomic heat of transition is on call

On standing at room temperature, monoclinic sulphur slowly changes into rhombic sulphur but the outward monoclinic crystalline form is preserved, each monoclinic crystal consisting of an aggregate of very small crystals of rhombic sulphur Commercial varieties of sulphur such as ordinary brimstone, roll sulphur and flowers of sulphur consist mainly of the rhombic form and a small amount of insoluble or amorphous sulphur.

Carbon disulphide dissolves both rhombic and monoclinic sulphur, 100 g, of it dissolving 50.4 g, of rhombic sulphur at 25° C., 100 g. at 40° C. and 376.1 g. at 80° C. At 0° C., however, the monoclinic form is 1,28 times as soluble as the rhombic and at 25.3° C. it is 1.4 times as soluble. The molecular weight of both forms in this solvent corresponds to Sa Another very good solvent for rhombic or monoclinic sulphur is sulphur monochloride, SiCl2.

Rhombic sulphur melts at 112.8° C.; monoclinic sulphur melts at 119° C. but the natural melting point of commercial sulphur is a few degrees lower. This is because liquid sulphur consists of a mixture of two or three molecular species and time is required before equilibrium is established between them. At 120° C. liquid sulphur has a viscosity of approximately 10 centipoises; further heating causes the viscosity to drop to a minimum at about 157° C At 159° C to 160° C, the viscosity increases rapidly to a maximum of 932 poises at 186° C, to 188° C after which it again decreases

Various explanations have been given for the peculiar viscosity of liquid sulphur. At lower temperatures near the melting point it is supposed that the Sh or Sh molecule predominates. As the temperature is increased to 160° C., the eight-membered ring molecules rupture, giving an equilibrium mixture of rings and eightmembered chains. The increasing concentration of these eightmembered chains causes polymerization to long complicated chains In addition to the long straight cham, it is highly possible that side chains of varying lengths exist. A maximum chain length of 12,000

SULPHUR 542

atoms to 27,000 atoms is attained at approximately 187° C, above which the polysulphur chains break into shorter chains In addition to Sx or Sx, and Sw or Sx, still another molecular species of sulphur S, or S4, is believed to exist in both the liquid and in the rapidly cooled solid. The percentage of S, at 120° C is approximately 3 5% and at 170° C., close to the temperature of maximum viscosity, it reaches a maximum of approximately 68%. Sx is soluble in carbon disulphide while S, and S, are not

If hot, molten sulphur is poured into water it forms a clear, soft, sticky, elastic mass known as plastic sulphur X-ray analyses show a fibre diagram and it is believed that long chains of sulphur atoms are arranged parallel to the direction of stretching. The stressstrain curves for these elastic strings appear very similar to those given by raw rubber Plastic sulphur becomes opaque and brittle after a few days because of the conversion of most of the S, and some of the S, into crystalline rhombic sulphur When treated with carbon disulphide, only part  $(S_{\lambda})$  of this hardened sulphur will dissolve, leaving amorphous or insoluble S., and S.

Other allotropic forms have been reported, such as gamma sulphur (γS, Muthman's S<sub>111</sub>, nacreous sulphur) This form, mixed with S<sub>a</sub> and S<sub>B</sub>, is prepared by the crystallization of molten sulphur as it is cooled to 90° C. It is also formed by the slow diffusion of aqueous solutions of sodium thiosulphate and potassium hydrosulphate The vellowish-white monoclinic crystals have a mother-of-pearl lustre with axial ratios different from those of beta sulphur, Colloidal sulphur (delta sulphur, Muthman's Siv), showing no sign of crystal structure, is formed when hydrogen-sulphide gas is passed into a saturated aqueous solution of sulphur dioxide at o' C or when an alcoholic solution of sulphur is poured into water Other forms reported are theta sulphur (0S), which is an unstable pale-yellow tetragonal form; zeta sulphur (\$8), which is a colourless rhombic plate crystal, and eta sulphur ( nS ), which is colourless, double refracting hexagonal plates

### CHEMICAL PROPERTIES

All the metals except gold and platinum combine with sulphur to form sulphides and, in most cases, heat is given off during the union. Moist sulphur is slowly oxidized at ordinary temperatures to sulphuric acid In combination with metals and hydrogen, sulphut has a valence of -2, forming compounds like HiS, FeS, CuS and HgS In combination with nonmetals, however, the valence or oxidation state may be +4 or +6 as in SO2 and SO2 respectively. Sulphur is therefore an oxidizing agent as well as a fair reducing agent. Its oxides are acid-forming,

Sulphides,-Hydrogen sulphide (H2S) is formed by the reaction of hydrogen with molten sulphur at 200° C. to 400° C and with sulphur vapour at temperatures up to 800° C. It is also formed by the action of acids on metallic sulphides such as ferrous sulphide, FeS+2HCl-FeCl2+H2S, by putrefaction of organic substances containing sulphur; by the destructive distillation of ceal; and by heating sulphur with hydrocarbons such as paraffin,

petroleum oil, methane, etc.

Hydrogen sulphide, a colourless gas having the odour of rotten eggs, is fairly soluble in water giving a feebly acidic solution which slowly deposits sulphur when exposed to air. This gas, poisonous when inhaled, burns in air with a pale-blue flame to give sulphur dioxide and water. It can be liquefied at 18° C. by a pressure of 17 atm., the liquid boiling at -60 1° C under atmospheric pressure and solidifying at -82 9° C. Hydrogen sulphide, often used as a reducing agent, is oxidized by the halogens to sulphur, excess halogen oxidizing the sulphur to sulphuric acid; by hydrogen peroxide to thiosulphate and finally, to sulphate; and by concentrated sulphuric acid to sulphur and sulphur dioxide

Hydrogen persulphide, H<sub>0</sub>S<sub>4</sub>, density 1.3339 (20° C.), melting point -89,6° C., boiling point 70.7° C. (± .5), is prepared by decomposing a polysulphide with a strong acid, as by treating Na2S2-5 with hydrochloric acid. Hydrogen trisulphide, HaSs, may be ob tained as a by-product in the reaction. The compounds H2So and H2Se have also been described. The persulphides all dissolve

readily in organic solvents.

The hydrogen atoms in hydrogen sulphide can be replaced by metals to form the normal sulphide, MaS, or the acid sulphide,

MHS. Sulphides of the alkali metals dissolve readily in alcohol. and in water and are used in the paper and leather industries Many sulphides, those with high heats of formation, can be made by grinding the metal and sulphur Others require heating; in some instances a high temperature is necessary to start the reaction Sulphates, especially those of the alkali and alkaline earth metals, can be reduced to the sulphides by heating with carbon Heavy-metal sulphides, which are all highly insoluble in water (being among the most insoluble of all substances), can be made also by passing hydrogen sulphide through solutions of metal salts This precipitation with hydrogen sulphide is used in qualitative analysis

The sulphides of the heavy metals have a characteristic appearance and colour Some are volatile at moderate temperatures, mercuric sulphide subliming at 446° C They can be iodized in air, and many are hydrolyzed by water with the evolution of hydrogen sulphide Some metallic sulphides containing small amounts of heavy-metal salts are phosphorescent. Zinc sulphide is used in luminous paints and, combined with traces of a radium sale, it is used for painting the figures on luminous watch dials.

Thio Salts .- Metallic sulphides react with sulphides of the more negative elements (3Na<sub>2</sub>S+P<sub>2</sub>S<sub>5</sub> >2Na<sub>2</sub>PS<sub>4</sub>) to give thio salts or sulpho-salts This reaction is used analytically to separate

As, Sb, Sn from Cu, Pb, Bi, Cd and Hg

Polysulphides.-Sulphur combines with simple sulphides like Na2S or NaSH to form polysulphides having the general formula Na2S, in which x values from 2 to 5 (Some Na2Se is formed in liquid ammonia solution.) The polysulphides, well-crystallized hygroscopic solids which are oxidized by air to form thiosulphates. are used by the tanning industry. Lime-sulphur solution, consist me of calcium sulphide and polysulphides, is made by boiling sulphur with a suspension of lime and is used both as an insecticide and as a fungicide

The sulphides of carbon, silicon and boron are obtained by direct union of sulphur with these elements at high temperatures. CS2 is unimolecular It boils at 46 25° C., while SiS2 and B2S2 are solid compounds which are difficult to volatilize Both of the latter, in contrast to CS2, burn in oxygen with difficulty SiS2 and B2S3 are hydrolyzed by water CS2 is important commercially. being used in the preparation of viscose rayon and carbon tetrachloride and as a solvent. Other sulphides such as CS, CaS2 and SiS are also known. The former, a solid, is prepared by the action of a silent electric discharge on the vapour of CS2. Carbon and silicon also form sulphides which contain oxygen or a halogen Carbon oxysulphide, COS, is always formed when carbon, oxygen and sulphur are brought together at high temperatures physical properties, carbon oxysulphide is intermediate between CO2 and CS2 It is a colourless, odourless gas which condenses to a hquid at -47.5° C.
Nitrogen Sulphides.—Another series of compounds is the sul-

phides of nitrogen. Nitrogen sulphide, NS2, is a red liquid. The tetrasulphide, N4S4, a yellow or orange-yellow solid, melting point 179° C., is prepared by passing ammonia through SCl2 dissolved in benzene or by dissolving sulphur in liquid ammonia at -15.5° C. The material explodes when struck. The pentasulphide, N<sub>2</sub>S<sub>5</sub>, a red liquid with a melting point of ro° C., is obtained when the tetrasulphide is boiled with CS2 Nitrogen tetrasulphide has been suggested for use as an ignition promoter in diesel fuels and as an insecticide and fungicide.

Oxides of Sulphur .- Sulphur burns readily in air to form  $SO_2$  and traces of  $SO_3$ .  $SO_2$  may also be easily prepared by treating sulphites or bisulphites with a strong acid:  $Na_2SO_3+2HCl \rightarrow$ 2NaCl+H2O+SO2. It is available in the liquid form, boiling point -8° C., melting point -72.7° C., at low cost in steel cylinders. It finds many important commercial uses, being used as a bleaching or reducing agent, a refrigerant and a solvent.

Sulphur monoxide, known only in the gas phase, may be prepared by subjecting a mixture of SO2 and sulphur vapour at a pressure of from 1 mm to 10 mm, to an electric discharge. It may be condensed to a solid at liquid-air temperatures but on melting it converts into SO2 and sulphur.

Sulphur trioxide, SO3, is formed by heating SO2 and oxygen in

the presence of a catalyst such as finely divided platinum, nickel or cobalt sulphates, or the oxides of vanadium, tungsten, molyb denum, chromium or iron This reaction is the basis of the contact process for the manufacture of sulphuric acid (q v) may also be prepared by heating anhydrous ferric sulphate, Fes-(SO4)3, to 600° C to 700° C or by allowing SO2 and ozone, O2, to come together at room temperature Two other oxides of sulphur, S2O3 and SO4, are known, and S2O7 has been described sesquioxide, S2O3, is formed on adding powdered sulphur to liquid sulphur trioxide at 15° C It is a blue to blue-green solid which decomposes slowly into SO<sub>8</sub>, SO<sub>2</sub> and S Sulphur tetroxide, SO<sub>4</sub>, a white solid, is prepared by subjecting a mixture of SO2 and O2 to a silent electric discharge In the gas phase, SO2 consists of monomeric molecules but in the liquid state, boiling point 46° C, it consists of a mixture of SO2 and S4O9 molecules and perhaps others It also exists in several solid modifications the alpha or icelike modification, the beta or low-melting asbestoslike modifications and the gamma or high-melting asbestoslike form molecular composition of liquid and solid SO2 has not been completely investigated. SO2 reacts energetically with organic matter to form sulphonic-acid derivatives of carbon and SO2, and with basic oxides to form sulphates In liquid form it combines with NO2 to form oxynitroso sulphuric anhydride, (NO2SO3)2, and with water to form a series of hydrates of sulphuric acid

The oxides of sulphur dissolve in water to form acids The following list from Yost and Russell's Systematic Inorganic Chemistry of the Fifth-and-Sixth-Group Nonmetallic Elements (copyright, 1944, by Prentice-Hall, Inc. New York) contains all the definitely established oxyacids of sulphur Where the free acid is not known, the fact is indicated by giving the formula of a known salt of the acid in parenthesis In each case a method of prepara-

tion of the acid or salt is given.

H,SO<sub>2</sub> H,S<sub>2</sub>O<sub>4</sub>

H<sub>2</sub>SO<sub>1</sub> H<sub>2</sub>S<sub>2</sub>O<sub>8</sub>

actu of san is given;

(JRSO.) Sulphoxylic SO<sub>2</sub>Cl<sub>2</sub>+Zn in ether solution

Hyposulphurous. NaBSO<sub>2</sub> (aq.) +Zn

Sulphurous SO<sub>2</sub>+Wate

(K.S.O.) Pyrosulphurous From solution KHSO<sub>2</sub>+SO<sub>2</sub>

Dithionic SO<sub>2</sub>+aq suspension MnO<sub>3</sub>

Sulphuric SO<sub>4</sub>+HSO<sub>2</sub> (too(y)). Salts, e.g.

Pyrosulphure SO<sub>4</sub>+HSO<sub>2</sub> (too(y)). Salts, e.g. H.SO

H<sub>2</sub>S<sub>2</sub>O<sub>8</sub> H<sub>2</sub>S<sub>2</sub>O<sub>8</sub> H<sub>2</sub>S<sub>2</sub>O<sub>8</sub> H<sub>2</sub>S<sub>3</sub>O<sub>6</sub>

Suprimic SO<sub>2</sub>+HisO<sub>2</sub> (100%). Salts, e.g. NasSO<sub>2</sub>, formed by strongly heating NaHSO<sub>4</sub>. (NaSO<sub>2</sub>) Thosulphuir NasO<sub>2</sub>+S (NaSO<sub>2</sub>) Thosulphuir NasO<sub>2</sub>+S (NaSO<sub>2</sub>) Thosulphuir Sections HisO<sub>3</sub> Peroxymonosulphuire. Electrolysis of KHSO<sub>4</sub> solution Polythonic, n=3, 4, 5, 6 In Wackentoder's solution, SO<sub>2</sub>+HisP-water.

The sodium salt of hyposulphurous acid, sodium hyposulphite, is an article of commerce and is used as a reducing agent in the dye industry Sulphurous acid and its salts are excellent and cheap reducing agents and are also used as disinfectants and food preservatives Calcium bisulphite and magnesium bisulphite are used to extract lignin from wood in the preparation of wood pulp Thio-

sulphates are used extensively in photography.

The Halides and Oxyhalides of Sulphur.—The halides and oxyhalides of sulphur, as described by Fritz Ephraim, possess certain properties in common. They are all readily prepared, usually by several methods. All are either gases or volatile liquids. Except for the fluorides, which exhibit great stability, all hydrolyze readily to give acid products which are irritating to mucous membranes. Again, except the colourless, tasteless fluorides, these compounds possess a pungent odour. As one might expect, the physical properties, reactivity and stability of these materials vary regularly with the position of the halide in the periodic table as illustrated in Tables II and III. Sulphur monochloride and sulphur dichloride are used to vulcanize rubber. The oxychlorides are useful reagents for the introduction of sulphoxide, sulphone or chlorine groups into organic molecules. Chlorosulphonic acid, HSO3CI, prepared by reacting HCl directly with sulphur trioxide, reacts readily with water to form sulphuric and hydrosulphuric acid. It fumes in air and has found application as a smoke producer in military operations Its most useful application is in organic chemistry where it serves as a sulphonating agent,

Organic Chemistry of Sulphur.-The organic chemistry of sulphur may be divided into reactions which occur under reducing conditions and reactions which occur under oxidizing conditions. TABLE II -Properties of Sulphur Halides

Compounds		Molecular	Melting	Boiling		
Name	Formula	weight	point C	point C.		
Sulphur monoduoride Sulphur monochloride Sulphur monochromide Sulphur dichloride Sulphur tetrafluoride Sulphur tetrafluoride Sulphur pentafluoride Sulphur pentafluoride	SaBra Scla SCla SCla SF4 SCl4 SaF10 SF6	102 12 135 03 223 95 102 97 108 06 173 89 146 06	-105 5 -80 -80 -10 -78 -124 -30 -53 -50 8	-90 138 135 6 54 59 decomposes -40 -15 decomposes 20 -63 8 sublimes		

Sources Compiled in part from Don M Yost and Horace Russell, Jr., stematic Interface Colombia, Compiled Interface Colombia, Compiled Interface Colombia, Disposal Col

Table III -- Properties of Sulphur Oxyhalides

Compounds		Molecular	Melting	Boring
Name	Formula	weight	point C	point C.
Through fluoride Through chlorofluoride Through chlorofle Through bromochloride Through bromode Through bromide	SOF <sub>2</sub> SOCIF SOCI <sub>2</sub> SOBrCI SOBr <sub>2</sub>	86 06 102 5 118 97 163 13 207 89	-129 5 -139 -99 5 -50 -52 to -50	-43 8 ± 0 r 12 2 ± 0 r 75 7 115 decomposes 137 138 at 733 mm pressure 68 at 40 mm pressure
Thionyl tetrafluoride Sulphuryl fluoride	SOF:	124 I	-107 ± 0 5 -136 7	-48 s -55 4
Sulphuryi chlorofluoride	SO <sub>I</sub> CIF	102 06	-120 -1247	~52 7 I 7 6
Sulphuryl chloride	SO <sub>2</sub> Cl <sub>2</sub>	, ,	-54 1	601
Pyrosulphuryl chloride	S <sub>2</sub> O <sub>2</sub> Cl <sub>2</sub>	134 97	-54 1 -37 5	69 I 153
Sulphuryl bromofluoride	SO <sub>2</sub> BrF	215 O3 163 O	-30 to -37	140 40

Sources. Compled in near ferm Dan M. Yout and Hirses Fowell, Proprietment Interpretate Chemistry Congress, 1946, 1959.

1959, 1951, 1957, by permyssion of the publisher, C. D. Hodgman, Proprietment Publisher, C. D. Hodgman, C. C. Brown, C. C. Brown, C. C. Brown, C. C. Brown, 
The first type is encountered when elemental sulphur is heated with petroleum hydrocarbons, rubber or other organic substances, The organic material is sulphurized and hydrogen sulphide is formed as a consequence of sulphur's action as a dehydrogenation agent The hydrogen sulphide, being a reducing agent, may induce further reactions particularly with unsaturated compounds, to yield mercaptans and thiophenols which in turn may be alkylated to sulphides, e g, mustard gas. All such sulphur compounds are analogous to similar compounds of oxygen, but differ from them because of dissimilarities in the respective molecular weights and electronic structures. The additional shell of electrons possessed by sulphur may lead to the formation of polysulphides such as the thickol-type synthetic resins. The resistance of these resins to attack by gasoline has led to their use as linings for aircraft fuel tanks The aromatic sulphur compounds, usually nitrogen derivatives, find extensive uses as accelerators in the vulcanization of rubber. The second type of reaction, oxidation of organic sulphur compounds, yields materials which, with the exception of the disulphides and the peroxides, are not analogous to oxygen compounds with respect to structure. The most important of these compounds are the sulphonic acids and their derivatives which are used extensively as medicinals (sulfa drugs), detergents, lubricants and dyestuff intermediates Sulphones, sulphoxides and sulphinic acids are less useful but give promise of greater utility in the future.

### COMMERCIAL FORMS AND USES

Crude Sulphur or Brimstone.-The form of crude sulphur on the United States market is 99.5% to 99.9% pure and free from arsenic, selenium and tellurium. As shipped, it contains about 50% fines with lumps 8 in. or more in diameter. Italian sulphur was marketed in four grades known as best seconds, best thirds. good thirds and current thirds and ranging in sulphur content from 99.5% down to 96.0%. Japanese sulphur was usually marketed in the form of cylindrical bars, each containing slightly more than one cu. ft. of 99.8% to 99% sulphur and weighing 130 lb. to 150 lb. Broken-rock bilmstone is sublimed or refined sulphur broken and sold as a mixture of lumps and fines — It has uses similar to roll sulphur.

Colloidal sulphur is sulphur in such small particles that it remains suspended in water. Colloidal sulphur may be prepared by intensive grinding but is usually prepared by chemical means. The uses are mainly pharmaceutical.

Commercial flour sulphur is produced by grinding crude sulphui Its fineness is 50% to 99% through 200-mesh or 99% through 300-mesh Uses vulcanizing rubber, dves, gunpowder, insecticides

and fungicides

Flowers of sulphur is crude sulphur refined by sublumation. It contains from 25% to 30% "amorphous" sulphur, and 90% of it will pass through a roo-mesh sieve Uses chemicals, vulcanizing rubber, insecticides, fungicides and pharmaceuticals (especially after washing with ammonia to remove all traces of acid.

Lac sulphur, precipitated from polysulphide solutions by sulphuric acid, contains up to 45% calcium sulphate. The uses are

mainly pharmaceutical

Precipitated sulphur is precipitated from polysulphide solution by hydrochloric acid and washed to remove all calcium chlonde. The uses are mainly pharmaceutical. Roll Sulphur is refined sulphur cast into convenient sizes, also

known as stick or cannon sulphur Uses chemical, burning for cuing, fumigating and preserving or bleaching effects

Uses .- The uses of sulphur are many and varied Often it is considered, along with salt, coal and limestone, as being one of the four basic raw materials of the chemical industry. The major portion of it is burned to form sulphur dioxide for use in producing wood pulp, for bleaching and for conversion to sulphuric acid, But sulphur, because of its interesting properties, is also applied to many other uses Combined with an aggregate, it is used to make acid-resistant cements. It is used to impregnate paper and other porous materials to produce useful articles of commerce Sulphur ointments have been used in treating skin affections and sulphur compounds are used to treat a variety of diseases. It is used as an insecticide or fungicide in the control of insects and fungus diseases of plants and animals. A further use, not commonly recognized, is as a plant food Sulphur and its compounds are used both as direct and indirect fertilizers. As indirect fertilizers, sulphur and its compounds have various functions, including the correction of alkali soils, reaction with soil constituents and release of the nutrient elements, soil amelioration resulting from the flocculating effect and the control of the reaction of the soil.

## ANALYTICAL METHODS

Free Sulphur is determined by extraction with carbon disulche. Amorphous sulphur, present in sublimed sulphur, is not soluble in carbon disulphide but is rendered soluble by heating samples at 10°°C. to 10°°C for 18 hr. Moisture in Commercial Sulphur is determined by drying a

Moisture in Commercial Sulphur is determined by drying a 50 g, sample at 80° C. for it 6 hr. in a wide-mouth weighing bottle. Ash in Commercial Sulphur is determined by burning 10 g, to 50 g, of the sulphur in a porcelain crucible using sufficient auxiliary heat to keep the sulphur burning and finally igniting the crucible to destore all organic matter.

Arsenic, Selenium and Tellurium in Sulphur are determined by first oxidizing the sulphur to sulphuric acid through the use of bromine and nitric acid. Arsenic is then determined by the Gutzeit method, selenium by reduction with hydrazine sulphate and tellurium by reduction with stannous-chloride solution.

Combined Sulphur may be determined by converting it to a soluble sulphate and precipitating it as barium sulphate by the

addition of barium chloride,

Bouncou of Bartun Guerrie.

\*\*Binacousary-F. W. Clarke, The Data of Geochemitry, Bull. 770, ght ed. U.S. Geological Survey, Dept of the Interior (1924); Williams Haynes, Tak Store Plate Burns (New York, 1943). Dom M. Yost and Haynes, Edwisell, Jr., Systematic Integrate Chemistry of the Fifth-and-State-Great Normalial Edwards (New York, 1944), Fritz Sphraim, Paregine Chemistry ed. by F. C. L. Thome and E. R. Roberts (London, 1944).

SULPHUR, SPECIAL APPLICATIONS OF. Sulphur is a convenient source of sulphur dioxide was which is the basis

for the manufacture of sulphuric acid and sulphite pulp. In a number of industries sulphuri plays an essential part and his substitute. This is also the case, moreover, in various agricultural and horticultural fields, it being used in insecticides and funges, and for the making of time-sulphur solutions. Among the properties of sulphur are fusibility, acid resistance, a number of plays cal forms, extremely low electrical conductivity and general chemical resistance. There are few solvents for sulphur and it is acid resistance. There are few solvents for sulphur and it is acid them acid upon by water, but for certain purposes its inflammability is detrimental.

As an Impregnant.—All forms of pulp and paper products can be impregnated with motion sulphur and the more absorbent types take up three or four times their dry weight. Preformed uplu and paper articles, when impregnated with sulphur become very strong, weather resistant and converted into much denser and harder maternals. Among the applications of such paper products are flat fibre boards so treated as to prevent warping and make them resistant to acid and other destructive agencies. Spoolheads, advertising signs and other articles of paper, fibre or pulp can be hardened and weatherproofed by sulphur impregnation

Practically all species of wood may be impregnated with molten sulphur under proper conditions, the more resistant species requiring the application of vacuum and pressure procedure is very similar to that so widely used for the creosoting of wood, but the effect is quite different. With sulphur there is very little change in colour, but a marked increase in weight and a phenomenal hardening and strengthening effect. Pieces of soft wood with a high sulphur content appear almost as though petrified. It converts a soft wood into a very hard and durable product, comparing favourably with the heaviest and densest tropical woods. By the addition of various sulphur soluble dyes, attractive colours are imparted Wood so treated is much less absorbent to moisture and withstands the action of acid and other destructive agencies. Tests made on wood structures in contact with the ground indicate that sulphur acts as a preservative even though not in itself particularly toxic. Its toxicity toward wood-rot fungi may be increased by the addition of certain substances that are recognized preservatives and which have been found to be miscible with molten sulphur The applications for sulphur-treated wood are numerous and include floor blocks, especially where acids are used, fence posts, railway ties, etc. Stone and concrete are likewise subject to sulphur impregnation.

Textiles and fabrics may likewise be impregnated with sulphur and have the advantage of being readily formed or shaped before processing. Fabric coverings saturated with molten sulphur may be spirally wound on metal pipes or other objects in order to

produce extremely dense, impervious coverings.

Sulphur Introders.—The term "introder" has been applied to certain organic substances having a most peculiar effect on the penetrance of molten sulphur. They may be used to advantage in practically all the examples of sulphur impregnation heretofore described and are also valued in making certain sulphur compositions. Some of the substances which not only increase the rate but the ultimate limit of penetrance of molten sulphur are naptialene, its chlorinated and hydrogenated derivatives, anthracene, tripheral phosphate and other community.

triphenyl phosphate and other compounds.

Other Special Uses.—In view of the fact that one of the problems of the steel industry is the removal of sulphur, it is interesting
to note that it is deliberately added to steel for special purposes,
notably for the making of screw stock. Likewise, in petroleum remining, sulphur compounds present in many crude oils must be removed to make them fit for refining. But for some uses an oil containing sulphur is desirable. This is the case with metal-cutting
oils, used largely by the metal-working industries for thread cutting, turret lathes and other machine work. Sulphur is mcorporated with an animal or vegetable oil base and subsequently added
in proper portion to a petroleum oil.

Sulphur cements which are applied hot, consist of sulphur with various inert mineral fillers and are useful for anchoring metal in stone, such as bolts in engine foundations, iron railings and the securing of chains to grantie blocks for buoys, setting electrical insulator pine doorhouds and a great many other numeass. They are particularly useful for pointing up acid proof blick in order to protect lime mortar, cementing floor blocks in acid-pickling rooms, the pouring of pipe joints both water and acid, and for setting bushings in abrasive wheels

Other uses for sulphur are the manufacture of sulphur colours, as a preservative for dried fruits and, in the form of tapers, for locating ammonia leaks and sulphuring wine casks In colloidal form, sulphur is valuable as an intravenous injection for the treatment of certain diseases, and as a recognized curative agent in dermatology, especially for scabies, ringworm, acne, favus, prungo and psoriasis The boiling point of sulphur, 444.6° C. is used in thermometry for scale determination, while molten sulphur is an excellent heating medium. Synthetic resins result from the interaction of sulphur or sulphur chloride with phenol, and it imparts the dark amber colour to glass bottles. Sulphur is used in making sheep and cattle dips, while it is admixed with the salt given to stock It is also used for the stoving of wood, and the sulphuring of hops, silks, sponges, feathers and other commodities and is employed for making plaster cast moulds. Sulphur compounds are used for the so-called oxidation of silver, bronze and other metals, as well as for the bleaching of brooms, straw, wicker furniture and the tanning of leather

Sulphur in its more complex phases, especially organic, is of industrial as well as biologic interest. Allyl isothiocyanate, a sulphur compound, is found in mustard oil and is responsible for the irritating action of the ordinary mustard plaster. An important derivative dichloroethyl sulphide, was brought into prominence during World War I as mustard gas Sulphur may be responsible for the efficacy of certain organic compounds used as flotation oils in the recovery of valuable ores. This is notably the case with the various xanthates. Cellulose xanthate is one of the products in the process of manufacturing artificial silk, or viscose rayon An alburninoid substance known as keratin occurs in practically all animal and human appendages such as hair, hoof, horn, fur, wool, feathers and nails, and, since the keratins are very high in cystine, human hair containing about 14%, its importance is readily seen, Various complex organic sulphur compounds play an important part in the human body, and are vital to our welfare and probably to life itself (WHK)

SULPHURIC ACID, HSO<sub>0</sub>, one of the most important and essential of all commercial chemical substances, is made from air, water and sulphur. Although rarely used or even seen by the layman, sulphuric acid is employed in some stage of the manufacture of practically all industrial products. The annual consumption in the United States by the 150s had reached approximately 13,000,000 tons, and, because of its extensive use, the quantity consumed from year to year serves as an accurate and sensitive index of general business conditions.

Sulphuric acid occupies its unique position of usefulness because it has an unusually wide range of properties and at the same time is one of the cheapest of the industrial chemicals to produce. It serves as a dehydrating and carbonizing agent, as a catalyst, solvent. absorbent, electrolyte and oxidizing agent. It is used in varying concentrations from the extremely dilute solutions for the control of acidity or alkalinity to the highly concentrated, fuming acids for the manufacture of drugs, dyes and explosives. It is made in various grades from those of high purity for the rayon and pharmaceutical industries to those of relatively low grade for the manufacture of superphosphate and ammonium sulphate for the fertilizer industries. The same acid is often used repeatedly. After initial use in the petroleum, explosives, drug or dye industries it is frequently recovered in a form too weak or impure for reuse in the same process but quite suitable for use in steel pickling or in the fertilizer industry. It may be made by two quite different processes, the contact and the lead-chamber process, while a large variety of sulphur-bearing raw materials are available for use in either process.

Properties.—Pure (100%) sulphuric acid is a colourless liquid which is sometimes called monohydrate of sulphur trioxide because its anhydride, sulphur trioxide (SO<sub>4</sub>) and water are combined in exactly equal miolar quantities (H<sub>2</sub>SO<sub>4</sub>=H<sub>2</sub>O+SO<sub>2</sub>). Its specific gravity is 1.893 at 15.6° C. (60° F.), freezing point 10.37° C.

100

(50°F) and at one atmosphere pressure it boils at about 340°C (644°F) but undergoes decomposition into subplur troaxed and water. The former escapes as a vapour until the concentration has fallen to §6 34% which is the composition of the constant totaling mixture of subplure acid and water at atmosphere pressure. The solution then distils at 317°C. (663°F), its boiling point. The freezing point of the acid is greatly affected by the addition of either subbut troaxed or water.

The existence of the crystalline phases H<sub>2</sub>SO<sub>4</sub>, H<sub>2</sub>SO<sub>7</sub>, H<sub>2</sub>SO<sub>1</sub>, H<sub>2</sub>O<sub>2</sub> 2H<sub>2</sub>O and H<sub>2</sub>SO<sub>4</sub>, H<sub>2</sub>O has been established by a study of the freezing temperature changes The physical characteristics of the acid at several other concentrations are included in a later section.

in a later section Sulphuric acid is dibasic, that is, its molecules each contain two hydrogen atoms and ionize in two steps H2SO4=H++HSO4and HSO4" = H+ + SO4" The first stage of dissociation proceeds to a degree comparable to that of other strong acids but is exceeded slightly by the more highly dissociated hydrochloric and perchloric acids. The second stage of the dissociation is moderately weak, the constant being coro at 25° C. Solutions of various concentrations of the acid therefore may contain in addition to hydrogen ions (H+ or H2O+), molecules of the acid (H2SO4), bisulphate ions (HSO4-), and sulphate ions (SO4-) in proportions which vary with the dilution In very dilute solutions the concentration of the SO4= ion is equal to the stoichiometric concentration, that is, there is a SO4 ion for practically every molecule of H2SO4 which was originally added to the water. As the concentration of the solution is increased, the concentration of the HSO,rises rapidly; that of the SO4= increases more slowly and reaches a maximum value of two molar at a stoichiometric concentration of about seven molar. It then decreases to a very small value. virtually zero, in a solution of high concentration (14 molar) At this same high concentration (14 molar) the HSO4 is at a maximum value of 14 molar, that is, practically all of the acid has undergone primary ionization but no secondary ionization. At still higher molarities the HSO4- ion concentration diminishes as the H2SO4 increases

As a result of these variations in the concentrations of the various molecular species, the properties of aqueous sulphuric acid solutions undergo interesting changes, at the specific conductance reaches a maximum in the 4 miles of the specific conductance reaches a maximum in the 4 miles of the surface tension reaches a maximum with one of the surface tension reaches a maximum with the surface tension reaches a maximum when the surface tension concentration curved at about one molar concentration curved at about one molar concentration of the surface tension-concentration curved at about one molar concentration of the various components which result from the dissociation of the Ms50, molecules.

Dilute sulphuric acid reacts with the more electropositive metals such as zmc, magnesium and iron with the evolution of hydrogen. It also reacts with metal oxides, hydroxides and salts of the weaker acids, e.g., carbonates, acctates and sulphites forming sulphates.

In subburic acid the sulphur is at its maximum oxidation state of 6+; it may herefore function as an oxidizing agent and be reduced to the 4+ ( $SO_2$ ), zero (S) or  $z - (S)^-$  state. The ditute acid is not an effective oxidize but the hot concentrated acid oxidizes less active metals,  $e_{S}$ , copper and silver, as well as the non-metals, carbon to carbon dioxide, sulphur to sulphur dioxide and is itself reduced to sulphur dioxide, with stronger reducing agents as zinc or todiced it is reduced to hydrogen sulphide which under favourable conditions may escape before being oxidized by more of favourable conditions may escape before being oxidized by more of sulphides present in petroleum and dation the tars and organic sulphides present in petroleum and dation that the randition the sulphuric acid alkylation processes involved in the manufacture of high-octane aviation gasoline.

Because of its low aqueous tension and the stability of its laydrates the concentrated acid has great avidity for water and serves as an excellent drying agent and as a dehydrating agent, removing not only moistum from gases and liquids which do not react with the acid, but extracting water from compounds. Thus it chars many organic compounds such as wood, paper, cloth, starch and sugars For the same reason the acid becomes brown in colour if it comes in contact with traces of oil, grease or atmospheric dust. It is essential in the mainfacture of explosives, cellulod, lacquers, etc., for the nitration processes involved in these processes bherate water which is removed by the sulphuric acid thereby permitting the reactions to go to completion. Its value to organic chemistry is due also to its reaction with many aromatic compounds to form sulphonic acids (See Carbolic Actip.) PURS Synthetic Naphiti Hallowship.

Because of its high boiling point the concentrated and is used to manufacture volatile acids, some of them stronger than sulphuric and, from their sails. If liberates hydrogen chloride (hydrochoric acid in water solution) from sodium chloride, intra acid from intrates, and hydrofluoric acid from calcium fluoride. It is also used to convert calcum phosphate to a more soluble and phosphate for fertilizer and in solution displaces numerous weak ands, e.g., acide and born cards from their respective sails. Since brounde ion and odded ion are oxidized by the concentrated acid, it cannot be used for the manufacture of hydrobromic and

hydriodic acids.

Sulphates.—Since sulphuric acid is dibasic, it forms both normal or neutral salts (Na2SO4) and acid salts (NaHSO4). The latter show acid properties in solution due to the ionization of the HSO4- ion and are sometimes employed for purposes requiring moderate acidity The common sulphates are soluble in water with the exception of those of lead, strontium, barium and calcium, Many of the sulphates have important industrial uses, barium and lead sulphates in the manufacture of paints, sodium sulphate in the manufacture of paper, and its hydrate, Na<sub>2</sub>SO<sub>4.10</sub>H<sub>2</sub>O (Glauber's salt), in medicine; copper sulphate, CuSO, 5H2O, in insecticides and its solution as an electrolyte in the electrolytic refining of copper, gypsum, CaSO4.2H2O, and plaster of Paris, (CaSO4)2. H2O, in the building industries. The sulphates of potassium and aluminum crystallize from solution as a double salt, K2SO4 Al2- $(SO_4)_3$  24H2O which is called alum (q v). The term is also applicable to other double sulphates of similar crystalline form in which the potassium ions are replaced by other univalent ions, e.g., those of sodium or ammonium, and the aluminum ions by other trivalent ions, e.g., those of chromium or iron.

Grades and Terminology.—Since the concentration and density of subpaint acid are proportional in the range from 0% to 93,19%, the concentration may be determined fairly accurately with the aid of an hydrometer. The Baumé hydrometer, American modulus, is used by the industry in the U S, while in continental Europe it is employed with, a different modulus. The Twadedl hydrometer is used in the United Kingdom although there is an increasing tendency to express the concentration directly in per cent of R5SO, or of SO, rather than in the degrees of the hydrometer scale. Temperature corrections must be made for all hydrometer scale.

ter readings.

The 100%  $H_2SO_4$  is rarely shipped because of its high freezing point (see above); the 98%-99% acid which is produced in the contact process is frequently used and because of its somewhat lower freezing point may be shipped if care is exercised.

The 93.0% acid is a syrupy, oily liquid with a specific gravity of 1835; freemp point —34°C. (—39°F.), boling point 28°C. ((188°F.) and has a viscosity at 15.6°C. (60°F.) which is 24 times that of water at the same temperature. It is one of the most popular shupping concentrations because of its low freezing point and the fact that it does not substantially react on and corrode the conomnal steel containers at atmospheric temperatures. The name, oil of vitriol (ox) is used in the U S to designate this concentration of the acid because of its appearance and "biting" characteristics. In the United Kingdom and Europe, however, the term is used more generally to mean simply sulphuric acid. Thus, in the British Isles the following designations are used: brown oil of vitriol (b.o.v.), ordinary commercial 77%—80% acid; best brown oil of vitriol (b.o.v.), ordinary commercial 77%—80% acid relatively free from arsenic and other impurities; concentrated or rectified oil of vitriol (c.o.v., or t.o.v.), 39%—69% acid and wusually made by the contact process rather than by concentration or rectification of the more dilitic chamber acid. The term isamber acid may

sefer either to any acid produced by the lead chamber process or to the acid of the particular concentration 5c%-68% similarly produced. This more dilute acid sects with steel containers and as therefore rarely shipped in quantity. The term 5c% lead of (5c 18%) is frequently used for statistical purposes in the US Acids of still lower concentrations are sometimes prepared by dilution but must be shipped in the more expensive glass carboys or bottles.

Another popular shipping strength is the approximately 78% and because it is the maximum strength made by the chamber process and because its freezing point, — 10 8° C (12.6° F), is low. In cold climates the shipping concentration is often changed to 76% which acid has a still lower freezing point. The 76%—78% acid is not seriously corrosive to steel tank cars or tank trucks. The fertilizer midustry, one of the largest consumers of sulphunc acid, requires acid of only 68% concentration for the manufacture of supernhosbate

Oleum or furning sulphuric acid (also known as Nordhausen acid) is a solution of sulphur trioxide, SO3, in 100% sulphuric acid Its concentration is usually expressed as "per cent oleum," ; e , the percentage of free SOs dissolved in the acid and occasionally as the total percentage of SO<sub>3</sub> which includes both the free oxide and that combined with water in the HoSO4 Thus 100 lb. of 40% oleum contains 40 lb of SO3 and 60 lb of 100% H2SO4, or a total of 80 lb (80%) of SO2 free and combined. Addition of a lb, of water to the 100 lb of 40% oleum yields 100 lb of 100% HoSO4 For this reason oleum has an equivalent acid concentration greater than 100% H2SO4, that of the 40% oleum being 109% acid As sulphur trioxide dissolves in sulphuric acid in all proportions, the resulting oleums may have a wide range of concentrations When the two combine in equimolar proportions, pyrosulphuric acid, H2S2O2, is formed. This acid has the maximum melting point, 36 C. (96 8° F.), of all the compounds of the H<sub>2</sub>O-SO<sub>8</sub> system.

Sulphuric acid may also be designated by terms which refer to its purity, origin or use rather than to its concentration. Thus battery acid and electrolyte refer to acid of a quality suitable for accumulators or storage batteries, in the US the concentrations sold are either 50% Hi<sub>2</sub>SO<sub>4</sub> (specific gravity 14 0,0 73 g.10% (specific gravity 14 0,5). Brimstone or sulphur acid refers usually to acid produced from sulphur rather than from less pure 1 wm. acid produced from sulphur rather than from less pure 1 wm. acid produced from sulphur rather than from less pure 1 wm. acid produced from sulphur rather than from less pure 1 wm. acid produced from sulphur rather than from less pure 1 wm. acid produced from sulphur rather than from less pure 1 wm. acid produced from sulphur rather than from less pure 1 wm. acid produced from sulphur rather than from less pure 1 wm. acid produced from sulphur rather than from less pure 1 wm. acid produced from sulphur rather than from less pure 1 wm. acid produced from sulphur rather than from less pure 1 wm. acid produced from sulphur rather than from less pure 1 wm. acid produced from sulphur rather than from less pure 1 wm. acid produced from sulphur rather than from less pure 1 wm. acid produced from sulphur rather than from less pure 1 wm. acid produced from sulphur rather than from less pure 1 wm. acid produced from sulphur rather than from less pure 1 wm. acid produced from sulphur rather than from less pure 1 wm. acid produced from sulphur rather 1 wm. acid produ

terials such as pyrites, spent oxide, etc.

Mixed acid consists of intric acid and oleum or concentrated sulphuric acid. Spent acid is that which has been used once and is usually dilute and impure Studge acid is the residue of the acid used in the refining of petroleum. It is contaminated with organic impurities and is frequently made usable by further dilution to separate as many as possible of the impurities followed by concentration; or it may be decomposed by heat, the organic material oxidized and the sulphur dioxide recovered for use in the manufacture of more acid. Spent allylation acid is a by-product of sulphuric acid alkylation processes for the manufacture of most octane aviation gasoline. It is of a higher purity than sludge acid, usually contaming 85%—50% HaSO4 and is frequently reused in the petroleum refinery.

Like other chemicals, sulphuric acid is graded by standards stupulated by the appropriate scentific societies or industries. The technical grade is usually intended for large scale industrial use and need not be of high purity. The U.S.F. label designates acid which meets the specifications of the United States Pharmacopoca while C.F., chemically pure, refers to acid of a higher grade usually prepared by distillation of a commercial grade acid. The purest grades, suitable for analytical and research purposes, are designated as regent, analyzed, etc.

Materials of Construction.—Of the common metals, only lead is satisfactorily resistant to cold sulphuric acid of nearly all concentrations up to rooys and to hot acid of concentrations up to about 70%. Generally the metals are less resistant to the hot and the more concentrated exicls, but steet and cast rron are exceptional in that they are resistant to cold acid of concentrations above approximately 78% because of the formation of a protective scale and are attacked with increasing vigor as the concentration decreases. Cast iron is more resistant than mild steet

to acid of most concentrations and has a satisfactory life even with very hot acid, provided its concentration is above oo%. However, cast iron should never be used as a container for oleum or for sulphur trioxide gases for it may crack with explosive violence when in contact with sulphur trioxide Mild steel should not be used at temperatures in excess of approximately 49° C (120° F) regardless of the concentration of the acid but it has a satisfactory life for acid of concentrations above 20% oleum even though hot Cast steel, malleable iron and many resistant alloys are available for specific concentrations, temperatures and applications, in some instances acid-resistant brick linings are used, eg, for hot oleum below 20%

The US Interstate Commerce commission issued regulations in 1946 permitting the use of rubber-lined metal containers for acid of not over 42° Be (about 50%). Lead-lined containers may be used for acid up to and including 93 2% Steel tank cars and tank trucks may be used for acid of not less than 52° Be (about 65%), but steel drums or barrels which are made of thinner metal may not be used for acid below 60° Be (about 78%) and even then only if the acid has no greater corrosive effect than 93% acid at 37 7° C. (100° F)

Moisture should be carefully excluded from iron or steel containers as the dilution of the acid at any point causes rapid corrosion. Sparks or open flames must be kept away from any closed vessel which should not be opened unless it is previously washed and the residual acid neutralized The vapour space over the acid may contain explosive hydrogen and poisonous arsenic, nitrogen or sulphur compounds.

Manufacture.- The date of the discovery of sulphuric acid is lost in antiquity, it was originally prepared probably by Arabian chemists in the 8th century and was apparently well known to the alchemists Near the end of the 15th century Basil Valentine described a method of preparation in which the acid was distilled from a mixture of green vitriol (FeSO4.7H2O) and silica and another method whereby the acid was obtained by burning sulphur with saltpetre (NaNOz). The older of the two commercial methods, the lead chamber process, was introduced in England in 1746 although the principles of the process had been used much earlier It was first manufactured on a commercial scale from weathered pyritic shales in Bohemia and at Nordhausen in Ger-

The first step in the manufacture of sulphuric acid is to prepare sulphur dioxide (SO2) gas by burning sulphur or sulphur-bearing materials such as iron pyrites, copper and zinc ores, spent oxide from gas plants and coke ovens, hydrogen sulphide from natural gas and petroleum refinery gas. It is also obtained by decomposition of various sulphates gypsum (CaSO<sub>4.2</sub>H<sub>2</sub>O), anhydrite (CaSO<sub>4</sub>), ferrous sulphate (FeSO<sub>4</sub>) from waste pickling liquors, sludge acid and spent acid The raw material used by a particular plant is determined by a number of considerations of great complexity which may include the location, the kind of process employed, the grade and concentration of acid to be produced and the cost. In the U.S. about 75% of the reported production of new acid at mid-20th century came from sulphur, 15% from pyrites, pyrrhotite and coal brasses, 9% from copper and zinc smelters and 1% from hydrogen sulphide In the U.K. approximately 40% of the production came from sulphur, 28% from pyrites, 20% from spent oxide, 12% from zinc blend and minor quantities from anhydrite and hydrogen sulphide

The next step in the production of the acid is to oxidize the SO2 to SO3. This is done by two different processes both employing catalysts. The lead chamber process yields acid of a concentration not more than 78%, and unless a pure raw material, e.g., sulphur, is used, the product is impure. The newer contact process was developed on a commercial scale during the last decade of the 19th century and is used to produce acid of any desired concentration and of high purity regardless of the quality of the raw ma-

Because of the increasing demand for acid of high concentration and purity, the latter process has steadily gained and by mid-20th century about 80% of the acid produced in the U.S. and more than one-half of that produced in the U.K. were manufactured

by the contact process. The two methods, however, remained competitive under certain circumstances

Contact Process -- Contact plants are of two main types. The newer and simpler type, often known as a raw gas or hot gas purification unit, was developed especially for use with vanadium pentoxide (V2O3) or other catalysts immune to impurities in the gas stream, and with sulphur as the raw material The other kind, known as the cold gas purification or simply the purification type, is used when the SO2 gas contains dust and other impurities from the ores which constitute the raw material.

Sulphur Burning Contact Plants .- In these plants the sulphur is melted to remove moisture and to permit the major portion of the dust or ash which may be present to settle. The molten sulphur with or without subsequent filtration is pumped to the burner Combustion air, 1e, air which has been dried by concentrated sulphuric acid, is supplied to the burner by a blower operating under a pressure between 1.5 lb, and 3.5 lb per square inch greater than that of the atmosphere thus preventing the infiltration of moist air into the plant. The SO2-air mixture containing 8%-11% of SO2 leaves the sulphur burner at temperatures which range from about 760° C to 1,200° C. (1,400° F. to 2,200° F) the temperature being proportional to the percentage of SO2 in the gases and to the amount of heat in the combustion air. Except in very small plants the gas is usually cooled by means of a waste heat boiler to approximately 400° C. (750° F ), and in some instances is passed through a hot gas filter to remove any remaining dust or ash before it comes in contact with the catalyst.

The catalyst is placed in layers on shelves or packed in vertical tubes in an insulated steel tank or tower called a converter. The reaction, 2SO2+O2=2SO3+45 k cal takes place at an almost imperceptible rate without a catalyst. However, the rate is greatly increased by the surface catalysts, vanadium pentoxide and finely divided platinum and further accelerated at elevated temperatures Practically all substances have some degree of catalytic action at high temperatures but the two mentioned are the most effective and, because of its immunity to impurities, the use of vanadium pentoxide after 1925 gradually replaced that of platinum in nearly all plants The fraction of the SO<sub>2</sub> converted to SO<sub>3</sub> decreases at excessively high temperatures. The temperatures at which the catalysts function effectively to give quickly the maximum yield of SO<sub>3</sub> are above about 400° C (750° F.) for vanadium pentoxide and 360° C (680° F.) for platinum To prevent excessively high temperatures from the exothermic reaction, which would diminish the yield of SO3, the conversion is carried out in stages with removal of part of the heat of reaction by waste heat boilers or other means between the stages The gas leaves the final layer of catalyst usually at temperatures between 438° C (820° F ) and 460° C. (860° F). In the development of the many types of converter with various arrangements and amounts of catalyst a high efficiency has been achieved whereby 95% to more than 98% of the SO, is converted to SOs.

The SO3 gas from the converter is cooled and passed into the absorption system where it is absorbed in 98%-99% sulphuric acid. It combines with the free water in the acid solution to form more H2SO4 thus increasing the concentration to any desired value up to 100% or to higher than 40% oleum. The SO2 is more readily absorbed by concentrated sulphuric acid than by water, for with the latter fog particles consisting of minute drops of HoSO, are formed and can be recovered only with great difficulty and expense. Lower concentrations of the acid may be prepared by dilution of the 99%-98% acid with water. The contact process may also be used to fortify spent acid or the more dilute acid produced in a chamber plant.

Sulphur-burning contact plants with capacities in single units

up to 600 tons per 24 hours and requiring only one operator have been built. Considerably more than a ton of high pressure, saturated or superheated steam may be generated for every ton of 100% acid produced. The required electric power is usually less than 35 kw per ton of 100% acid and the cooling water about 4,000 U.S. gallons per ton of acid. No buildings are needed for the housing of equipment.

Purification Type Contact Plants .- For the production of SO2

furnaces or roasters are available. It is desirable to select a roaster which will remove the maximum quantity of sulphur from the raw materials with a minimum carry-over of dust into the effluent gas and will produce gas with a maximum SO2 concentration at minimum operating and repair costs. It is also desirable to avoid the oxidation of SO2 to SO3 in the burner and the consequent formation of the acid mist. The concentration and purity of the SO, gas from the furnace determines the size, quantity and cost of subsequent gas purification equipment.

The gas usually leaves the roaster at temperatures between 650° C (1,200° F) and 1,100° C (about 2,000° F) and may be cooled by bare steel or cast iron pipe or by waste heat boilers It is important to remove the dust at this stage to prevent its deposit in subsequent equipment This is done by various methods about 80%-90% may be removed in cyclone centrifugal collectors and 90%-99% of the remaining dust in electrical precipitators which operate at 50,000 v to 70,000 v and at 150° C .- 430° C (about 300° F-800° F.). Precipitators have the advantage of low pressure drop, low power consumption and of recovery of dust in dry form but at the disadvantage of relatively high cost This equipment may be built of steel or of steel lined with firebrick, as the gas is normally so hot that no corrosive acid can condense. Some plants have replaced precipitators with proprietary gas washers which have as high or higher efficiencies in removal of dust and have the additional advantages of removing a large portion of other impurities such as metallic fume, arsenic and acid mist while simultaneously cooling the gas They have the disadvantage of relatively high pressure drop, as do cyclone dust collectors They necessitate recovery of dust in the wet condition but in many cases this is considered an advantage. Smaller and older plants occasionally use dust-settling chambers or scrubbing towers of various types instead of precipitators or gas washers.

After removal of the dust the gas must be cooled to permit removal of other impurities such as metallic fume, acid mist and fluorine, chlorine or arsenic compounds. They must be removed to the point where they do not clog or damage subsequent equipment and do not adversely affect the quality of the product acid for the purpose for which it is to be used. Such purification is necessary regardless of the type of catalyst used but the purification equipment need not be quite so carefully designed and operated when using a catalyst like vanadium pentoxide which is immune to all common impurities except fluorine compounds Cooling of the gas is necessary not only to remove impurities but also to condense and thus remove part of the water vapour in the gases If all of the water vapour were allowed to remain in the gas, it would cause the product acid in many cases to be more dilute than desired

After cooling and removal of impurities, the SO2 gas is dried with concentrated sulphuric acid Equipment after the drying tower is much the same as in sulphur-burning plants with the single exception that waste heat boilers cannot be employed to recover the heat evolved in the converter. As a result of its purification, the gas in this process is cold, instead of hot as in sulphurburning plants, and must be heated to the temperature at which the catalyst begins to function. The heat evolved in the converter is utilized for this heating by passing the hot SO2 gas and the cold SO2 gas through a series of insulated tubular heat exchangers built of steel. The SO2 gas is thus heated and the SO3 gas cooled

Contact plants of this type have been built with a single purification line capable of producing 300 tons of 100% acid per 24 hours and serving two 300-ton conversion and absorption lines. The labour, cooling water, power and maintenance requirements are much higher than in sulphur burning plants because of the additional roasting and purification equipment. However, in many cases the SO<sub>2</sub> gas is obtained at little or no cost from copper and zinc smelters or from other low-cost raw materials and the cost of the product acid may be substantially less than that from sulphur burning plants.

· The Lead Chamber Process .- This process derives its name from the use of large chambers of sheet lead and differs radically from the contact process, particularly in its use of gaseous oxides of

from low grade sulphur-bearing materials a large variety of nitrogen whose function may be considered to be catalytic. The chemical reactions which occur in the lead chamber process are more complex than those in the contact process, and there is not unanimity of opinion as to their mechanisms. It is thought that the catalyst reacts with SO2 gas, oxygen and water vapour to form the intermediate compound, nitrososulphuric acid (ONHSO4) which in turn reacts with water to form sulphuric acid and the oxides of nitrogen (NO and NO2) Thus the catalyst goes through repeated cycles, combining with the SO2, O2 and H2O to form the intermediate compound and being set free again with the simultaneous formation of H2SO4

The SO2 gas is generally produced in the same manner as in the contact process. However, if it is impure, se, obtained by the roasting of ores or by the burning of spent oxide, the purification is carried out only to the extent where the dust and other impurities are not present in quantities sufficient to clog the equipment This less efficient purification obviates the necessity of cooling the gas which is needed in the next stage of the process at a high temperature, preferably in excess of approximately 600° C (1,100° F.) and is necessarily at the expense of the quality of the product acid

After the hot sulphur dioxide-air mixture has undergone the necessary purification, it is passed in succession upward through the Glover tower, through the lead chambers and upward through the Gay-Lussac towers, nearly all of the SO2 being removed in the first two steps The Glover tower is a large masonry structure in some instances sheathed outside with lead It is packed with lumps of loose quartz, acid resisting brick or ceramic shapes so that the hot gases are brought into intimate contact with acid which trickles

downward through the packing,

The Glover tower has two main functions: (1) to concentrate the approximately 65% acid made in the chambers to 78% acid, the water vapour thus released entering the chambers with the gas stream; (2) to remove the nitrogen oxides from the 78% acid, nitrous vitriol (which has been used in the Gay-Lussac tower to absorb these oxides released at the end of the process and to return them to the cycle). The denitrification is accomplished by dilution of the 78% nitrous vitriol with the less concentrated chamber acid and by the elevation of the temperature of the mixture by the entering hot gases. The gases also begin to react and a substantial amount of sulphuric acid is formed in the Glover tower The 78% acid drawn off at this point is hot and contains only traces of the oxides of nitrogen After cooling, part of it is transferred to the Gay-Lussac towers where it is used to absorb the oxides of nitrogen released from the chambers The balance of it represents the production of the plant and is delivered to steel storage tanks

The cooled gases leaving the Glover tower proceed to the rectangular boxlike lead chambers which may vary in size from 5,000 to 500,000 cu ft, and in number from 1 to 20 The large chambers afford sufficient space and time for the gases which do not mix rapidly to react completely. The additional water necessary for the reactions is supplied through atomizing nozzles in the tops of the chambers. The sulphuric acid forms as a rain, drops to the bottom of the chambers and is pumped to the Glover tower. A large amount of heat is evolved by the reactions and is dissipated by the natural circulation of air around the chambers which are set well above the ground. The chambers are usually housed in a building to lessen the effect of varying atmospheric conditions on the operation As the gases pass through the Glover tower and the chambers, their SO2 content gradually decreases to 0.1% or less, this amount being desirable for the optimum recovery of the nitrogen oxides in the Gav-Lussac towers

The Gay-Lussac towers, usually two arranged in series, are similar in construction to the Glover tower but are tailer and of smaller diameter. They have thinner walls and linings because they receive relatively cool gases. Their only function is to recover the nitrogen oxides in the spent gases and for this purpose cool 78% acid is used The recovery is incomplete, and usually 10%-15% of the oxides are lost, constituting an appreciable item of expense. Hence, fresh oxides of nitrogen must be constantly supplied to the process. In some plants the fresh nitrogen oxides are made

from sodium nitrate and 78% sulphuric acid which is heated in an iron pot either by the hot SO, burner gases or by fuel. This method is obsolete at most plants and "nitre pots" were superseded by ammonia oxidation units Such units produce oxides of nitrogen by catalytic action of an incandescent platinum alloy gauge on a mixture of air and ammonia (about 9%) The oxides of nitrogen are then introduced into the process usually at the Glover tower inlet or outlet The gases may be propelled through the chamber plant by the natural draft created by the final Gav-Lussac tower and its exit stack but usually one or more lead or alloy fans are employed. Such a fan may be located between the Glover tower and the first chamber, after the last chamber or at both points

Because of the considerable lead and space requirements of the chambers, the lack of efficient cooling and the necessity for a large building, many variations of the process are in existence in which the boxlike chambers have been superseded by towers or by chambers of other shapes designed to promote more intensive gas mixing Some are water cooled externally while some depend on cooling by the internal circulation of large quantities of acid. The principal successor in the U.S. is the Mills-Packard water-cooled chamber constructed in the shape of the frustum of a cone, and first developed in England in 1914 By this means the chamber space required was reduced from 6 cu ft to o cu ft per pound of sulphur burned, in the case of air-cooled box chambers, to 2 o cu ft to 3 5 cu ft No building is required for the Mills-Packard chambers In the U K the Gaillard-Parrish chamber, another type, replaced the box chamber in some instances It is relatively tall but cylindrical in shape and is cooled by spraying 65% acid through the closed top by means of a horizontal, rotating disc called a disperser. The Gaillard disperser has also been used in the tops of box chambers to increase their acid-making capacity. Various processes have also been evolved in which a series of packed towers take the place of the box chambers and in which the oxidation of SO2 takes place largely in the liquid phase. Among these may be mentioned the Opl, the Kachkaroff-Guareschi and the Petersen processes, much used in Europe but not in America.

Concentration.-Concentration of sulphuric acid by evaporation of the water is practised intensively only at explosives and dye works or in petroleum refineries, where a dilute acid appears as a by-product which must be recovered and concentrated for reuse. A variety of types of equipment are used for this purpose, among which are the Cascade, Kessler, Gaillard, Pot, Simonson-Mantius and Chemico concentrators. They may be divided into three classes. (1) those like the Cascade process in which the acid is heated to its boiling point in acid-resisting basins by heat applied to the exterior of the vessel; (2) those like the Chemico drum concentrator in which the acid is brought into direct contact with a mixture of hot air and gases from the combustion of a fuel; and (3) those like the Simonson-Mantius concentrator in which the acid in a closed vessel under high vacuum is heated indirectly by steam. Concentrators in the first two classes operate at substantially atmospheric pressure and consequently the acid temperatures are high, especially where hot air in direct contact with the acid is used. The exit gases may contain appreciable quantities of acid mist which is recovered in coke-packed towers and electrical precipitators. Concentrators of the third class operate at relatively low temperature because of the high vacuum and create so little nuisance that precipitators are not required.

First Aid. The best first-aid measure for a sulphuric acid burn is "a lot of water quickly." Speed in removing the acid is of utmost importance, but small amounts of water must not be used because much heat is generated by dilution of the acid, and the burn is thus made more severe. Neutralizing agents and ointments are dangerous and should never be used until the burned area has been washed completely free of acid with water. After this has been done the burn may be treated in the same manner as a heat burn.

BIBLIOGRAPHY.—T. J. Kreps, The Economics of the Sulfuric Acid Industry (Stanford, 1938). A. M. Fairlis, Sulfuric Acid Manufacture (New York, 1936); Don M. Yost and Horace Russell, Jr. Systematic Inorganic Chemistry of the Fifth-and-Siath-Group Nonmetallic Ele-

(C M D , X) ments (New York, 1944) SULPHUR SPRINGS, a city of Texas, U S Pop (1950)

8,991, 6,742 in 1940 by the federal census. It is the largest dairy centre in southwestern U S.

SULPICIA, the name of two Roman poetesses The earlier, daughter of Servius Sulpicius Rufus and mece of Messala, lived in the reign of Augustus Her verses, preserved with those of Tibullus and for long attributed to him, consist of six short elegiac poems (bk IV, 7-12 in the Corpus Tibullianum, 40 lines in all) addressed to a lover called Cerinthus (seldom now identified with the Cornutus mentioned by Tibullus in bk 11, 2 and 3) and are preceded by five elegiac poems (bk. iv. 2-6) by another poet who comments sympathetically on the love affair The latter poet may be Tibullus, but Esther Bréguet argues, from a detailed study of the language and metre, that the poet of 2-6 was the young Ovid, imitating the style of Tibulius,

The younger Sulpicia, wife of Calenus, lived during the reign of Domitian. Martial (x, 35 and 38) praises her wifely devotion, which was the subject of her poems. An extant satire (70 hexameters), discovered in 1493 and attributed to her, is probably of much later date

BIBLIOGRAPHY.—For Sulpicia I see E Bréguet, Le Roman de Sulpicia (Geneva, 1946), editions of Tibullus by K F Smith (New York, 1913) and J P Postgate (Oxford, 1923); also M von Schanz and C Hostus, Geschikthe der romuschen Literatur, vol 11 (Munich, 1935) For the and J P Posignie (Oxford, 1929); also M von Schauz and C Hossus, Gaschickte der romuschen Literatur, vol u (Munch, 1935) For the satire attributed to Sulpica II see O Jahn's chiton of Juvenal and Pessus as revised by F Bucher (Berlin, 1933), E Bahrens, De Sulpicas quae vocatur satira commentation philologica (Jena, 1871), W S Teulid, Mittory of Roma Literature, Eng trans, revised (London, 1900), J. W. Duff, Roman Satire (Cambridge, 1937).

(L J D R)

SULPICIUS RUFUS, PUBLIUS (c 124-88 B C), Roman orator and politician, supported the reforms of his friend the younger M Livius Drusus (of BC) and inherited his policy of generous concessions to the Italian allies. Though he renounced his patrician status to become a tribune of the plebs, he had shown, by prosecuting the tribune Gaius Norbanus in 94, that his political attitude was moderate. In the Social War he served as legate to Gnaeus Pompeius Strabo (89). As tribune in 88 he introduced several laws (1) to unseat all senators owing more than 2,000 denarii: (2) to recall all men exiled under the Varian law of 90 BC (a measure which he himself had opposed earliei); (3) to transfer the command against Mithradates from Sulla, the senate's nominee, to Marius, and (4) to distribute freedmen and the newly enfranchised Italians among the 35 tribes (so as to make their voting power effective). Sulpicius' chief aim was probably championship of the new Italian citizens, but to implement this he needed wide support, hence his other measures, which would secure for him the backing of the people, of Marius and the equites This bold challenge to the senate led to violence, and Sulpicius is said to have organized a group of 600 young equites and a larger bodyguard of 3,000 armed men The consuls, Sulla and Q. Pompeius Rufus, declared some form of cessation of public business (perhaps a justitium), which Sulpicius denounced as illegal. Disturbances followed in the Forum, and Sulla was forced to call off the justitium; he then joined his army in Campania At Rome Sulpicius' measures were carried. Sulla then marched on Rome and won the city. Marius and Sulpicius fled and were declared outlaws, and Sulpicius was caught and killed at Laurentum His laws were declared invalid, as passed "by force" Sulpicius' policy is obscure, but he may well have been a liberal optimate, whose championship of the Italians led his enemies to depict him as a revolutionary demagogue rather than as a moderate reformer forced by circumstances to go to greater lengths than he probably wished He was an outstanding orator of whom Cicero said (Brutus, 55) "He was by far the most dignified of all the orators I have heard. and, so to speak, the most tragic." Sulpicius published no speeches, those bearing his name being written by a P. Cannutius. He is one of the speakers in Cicero's De oratore,

Bibliography.—Appian, Bell. ctv. i 55-60, Plutarch, Sulla and Marius; Velleius Paterculus, ii 18; Lavy, Epit. 77; Auctor ad Herens. ii. 45; Ctero, De orat, and Brut

SULPICIUS RUFUS, SERVIUS (c. 106-43 B.C.), surnamed Lemonia from the tribe to which he belonged, was a Roman orator and jurist.

He studied rhetoric with Cicero and accompanied him to Rhodes in 78 B C. Finding that he would never be able to rival his teacher he gave in the hetoric for law (Cicero Britus, 41).

In 63 he was a candidate for the consulship, but was defeated by L Lacinius Murena, whom he subsequently accused of bribery,

in 51 he was successful.

In the Crui War, after considerable hesitation, he threw in his lot with Caesar, who made him proconsul of Achaea in 46 He died in 43 while on a mission from the senate to Antony at Mutina.

He was accorded a public funeral, and a statue was erected to his memory in front of the Rostra

Two excellent specimens of Sulpicius' style were preserved in

Cicero (4d Fam, iv. 5 and 12).

Qunnthian (Instit, x, x, 116) speaks of three orations by Sulpicus as still in existence, one of these was the speech against Murena, another Pro or Contra Aufdium, of whom nothing is known. He is also said to have been a witter of erotic poem.

It was as a jurist, however, that Sulpicius was chiefly distinguished He left behind him a large number of treatises, and he is often quoted in the Digest, although direct extracts are not found (for titles see Teuffel-Schwabe, Hist of Roman Lit., 174, 4)

His chief characteristics were lucidity, an intimate acquaintance with the principles of civil and natural law and an unrivalled power of expression.

See R. Schneider, De Servio Sulpicio Rufo (Leipzig, 1834), O Karlowa, Romische Rechtigeschichte, vol i (Leipzig, 1885); the chief ancient authority is Cicero.

SULTAN (an Atabic word meaning "victorious" or "a ruler," sultat, dominion), a title of honour borne by a great variety of rulers of varying powers and importance in Mohammedan Africa and the east

The word has thus no exact equivalent m English, and was early imported into the language in the Middle English form of soudan (from the Old French soudan, souldan).

This title was conventionally applied by foreigners to the ruler of the Ottoman empire, the sultan par excellence, the proper styles being, however, padishah (emperor) and "commander of the faithful" (see AMIR).

The feminine form "sultana" was derived from the Italian (fem. of sultano)

SULTANPUR, a town and district in Uttar Pradesh, republic of India The town is on the Gumti river, midway between

Benares and Lucknow. Pop. (1951) 17,496.

SULTANPUR DISTRICT has an area of 1,699 sq mi; pop. (1951)

1.282.160 There are two other Sultanpurs in Punjab SUMACH or Sumac, the name given to numecous shrubs and small trees of the botanical genus Rhus (family Anacardia-cae), which comprises about 150 species, natives chiefly in warm regions. They have a milky or resmous junce, simple or compound leaves; small flowers, with the parts in fours or sixes; and small, dry, one-seeded, often harry, sometimes highly coloured

fruits, usually in dense clusters. The name sumach is given also to the commercial preparation of the dried and ground leaves of the Sicilian or tanners' sumach (R. coriaria) of southern Europe, long used in making leather. In North America the sumachs are represented by about 15 species. Several have poisonous foliage, as the poison sumach (R, vernix) and the poison ivy (q.v); the nonpoisonous sumachs include some of the most attractive American shrubs. Among those found in the eastern states and Canada are the handsome staghorn sumach (R. typhina), sometimes 30 ft. high, and the smaller smooth sumach (R. glabra), sometimes 20 ft high, both of which in autumn display highly coloured fruit and foliage. The dwarf or mountain sumach (R. copdlima) is a small shrub in the north and a tree 30 ft. high in the south. Its leaves, as also those of the two preceding, were formerly much used in tanning. The aromatic sumach (R. aromatica), 3 ft. to 8 ft. high, with pleasant-scented foliage, occurs in the eastern states; its western counterpart, the skunkbush (R. trilobata), with ill-scented foliage, is found from Illinois to Oregon and southward. The mahogany sumach (R. integrifolia), the laurel sumach (R. laurina) and the sugarbush

(R ovata) are elegant shrubs, native to southern California The lacquertree (R vermaifera) of Japan yields Japan lacquer The wax-tree (R succedanea), also of Japan, furnishes wax used candle-making. R. chinensis of eastern Asia and R. typhina var



SUMACH (RHUS CORIARIA), FROM LEFT TO RIGHT FLOWER, BRANCH, SEED, FRUIT, CLUSTER OF FRUIT

dissecta, a North American form, are planted for their ornamental

SUMATRA, lying between \$° 39' N. and \$° 57' S, so that the equator divides it into two nearly equal parts, is the westernost and, after Borneo, the largest of the Great Sunda Islands of the Malay archipelago and forms part of Indonesa Its axis runs from southeast to northwest, from Sunda strat to Malacca passage, it is 1,110 mi in length, and its greatest width is 280 mi With its dependencies, Sumatra has an area of 180,380 sq mi (alone, 103,557 sq mi.) and is nearly four times as large as Java and almost as large as Soan

The economic development of Sumatra, though it is far behind that of Java, is much farther advanced than that of any other of the Indonesian islands

Physical Structure.-In relief, Sumatra consists of a high mountain chain which runs along the western coast, descending eastward to a huge tract of flat, alluvial land, seamed with many large rivers and their scores of tributaries Its great mountain chain is a link between the mountain system of Lower Burma, which is continued by way of Preparis and Great Coco Islands, the Andaman Islands and the Nicobars to Sumatra and thence to Java and on through the Lesser Sunda Islands to the Moluccas. The Sumatran chain extends for a distance of more than 1.000 mi. and contains numerous volcanic peaks of heights from 5,000 ft. to more than 12,000 ft The whole system, known as the Bukit Barisan ("Parade of Mountains"), consists in general of two or more folded chains running parallel to each other, with a valley between, which is broken up into separate sections by the intrusion of volcanic massifs. Along this valley lies a string of mountain lakes, from south to north-Ranau, Kerintii, Singkarak, Manindjau and Toba. By far the largest of these is Lake Toba, which is 45 mi. long and 15 mi. wide, with a depth of 450 m, and has a large island, Samosir

The line of volcanic peaks stretches across Sumatra from Abongabong (9,850 ft.) and the mountains of Achm to Krakatoa (q.v.) off the coast at the southern end of the island I includes Luser (17,000 ft.), Sinabung (6,040 ft.), Sibayuk (1,925 ft.), Pasaman (Mount Ophir, 9,844 ft.), Talang (8,521), Merpis (9,485 ft.), Singalang-Tandikats (9,446 ft.), Kerniqi ("the Peak of Indra-

pura," 12,484 ft.) and Dempo (10,365 ft.). In all, 90 volcanoes have been counted, 12 of them active

Sumatia, like Java and Borneo, is formed largely of strata of the Tertary period, although it contains also two schisces formations, one of which is anterior to the carboniferous period. The Tertary series are more complete than in Java, the volcances, so characteristic of the whole archipelago, are due to the Quaternary period. The western mountain system is composed largely of Archaean iocks, with occasional longitudinal bands of Jurissic and Creations or Kerney and eroson of the ranges exposes their mineral contents. The crystalline rocks of the properties of the work of the content of the properties of the proper

The river system of Sumatra is extensive and of great value to the country On the west coast, where the mountains approach the sea, the rivers run in valleys with a steep slope, have a very short lower course and are unnavigable, except near the mouth in the case of a few. The eastern rivers run through alluvial plans. have extensive drainage areas (they are often impeded by silt) and form the principal and often the only means of communication. South of 3° N, there are extremely important rivers, the first being the Asahan, which drains Lake Toba and is navigable by steamers for a portion of its length, next the Panai (Bila and Barumun), with a very wide mouth; then the Rokan, more than 120 mi, long and flowing into the Malacca straits through a wide. muddy estuary, navigable for 70 mi. inland, the Siak, with the port of Pakanbaru 100 mi, upstream, the Kampar, a very long river, navigable for ocean steamers for 18 mi, the Inderagiri, navigable for ocean steamers as far as Tjerinti; then the Hari, which springs from the peak of Indrapura, the largest of all the rivers of Sumatra, having a maximum navigability of just less than 500 mi., and then the Musi, on which ocean-going vessels can reach Palembang, 54 mi, upstream, while steam launches and motor boats can go 200 mi. inland and small boats 330 mi (below Palembang the Musi splits up into a number of channels which spread out amidst a vast unhealthy swamp and slowly denosit their mud among the mangroves, thus gradually creating new land)

On the coast, there are small semicircular bays, but few large indentations, immunity from the southwest monsoon being provided for harbours only between Tapanuli and Indrapura north coast has precipitous cliffs crowned with dense vegetation in some parts, in others sandy beaches and well-cultivated plains, while the bay of Oeleelheue gives shelter for shipping. The south coast consists, mainly, of two large indentations, Lampone bay and Semangka bay The eastern shore of Lampong bay is mountainous and little indented, the western is much cut up; the centre of the bay has a good harbour (Telukbetung). Semangka has a mountainous coastline, with little indentation. The whole of the east coast is formed of morasses and sandbanks, which break up into innumerable islands, large and small, particularly about the central portion; and the coastline is deeply indented in many places and very irregular. The indentations are not permanent, the coast is constantly advancing, and it is difficult to establish practicable ports or landing places

Sumatra has a chain of islands off the west coast which rise from the edge of the submarine platform and serve as a kind of outer barrier. They have an aggregate area of 5,769 sq.mi. Several are thickly populated, and some are of considerable size; most have rocky, reef-bound coasts, dangerous of approach.

Climate.—The climate of Sumatra resembles that of Java and is hot and extremely moist, but in most eastern costal districts and often for many miles inland the heat is tempered by cooling land and sea breezes, the wind generally being northeast by day and southwest by night all the year round. The wind system of northern Sumatra differs from that of the greater part of Indonesia, the northeast monsoon blowing from December to March, and the southwast monsoon from May to October. Durng the southwast monsoon strong squalls from the northwest, known as "Sumatras," which are accommanded by thunder, lightning and arin, blow in the

Malacca strait; they have been known also to occur during the northeast monsoon. On the west coast the influence of the northeast and southwest monsoons is felt as far south as 4° N Between 4° N and 2° N there is a region of calms and light variable winds, which have a westerly tendency from March to November, when the northwest monsoon is blowing along the remainder of the west coast (1 e, from 2° N to 5° 57' S), and an easterly tendency from May to September, the period of the southeast monsoon on the west coast. Southern Sumatra has the highest temperatures, and the mean annual temperature for the lowlands is about 80° F At Toba, in the Batak country (3,772 ft ), this is 69 6° F, and higher altitudes show a corresponding reduction. On the whole, temperature in Sumatra is slightly higher than in Java. March, April and May are the hottest months; January and February the coolest, but the difference does not exceed 2° The different wind distribution causes a variation of the seasons Thus in northern Sumatra October is the wettest month and February and March are the driest, while elsewhere the wettest months are December, January and February, and from July to September is the dry period. Accordingly the rainfall varies considerably. The annual average rainfall for northern Sumatra is 05.71 in, for eastern Sumatra 106 27 in., and for western Sumatra 122 32 in. The west monsoon gives the heavier rainfall and the fall is accentuated in western Sumatra by the high mountains.

Flora.-The flora of Sumatra bears a strong resemblance to that of India and of the Malay peninsula in the northern part of the island and to that of Java in the southern, but it has also many varieties distinct from either, and not only different varieties, but different genera from those of Java. The pine. Pinus merkusu, in the mountains of the north is not found elsewhere in the East Indies but occurs as far south as the equator One of the most striking flowers is the huge Rafflesia hasseltii, with blossoms 18 in. across, growing on big lianas on the ground in the forests There are immense areas of savanna country, covered with coarse grasses which stifle other forms of vegetation and give shelter to hordes of wild animals These tracts occur as low as within 700 ft of sea level Myrtles, bamboo, rhododendrons, moss-loving orchids and palms are common, and orders strongly represented are Dipterocarpaceae, Begoniaceae, Nepenthaceae, Oxalidaceae, Melastomaceae, Myristicaceae, Connaraceae, Gesneriaceae and Ternstroemiaceae There are zones of vegetation differing with altitude, but the general tendency is for all forms to grow at a lower level than is the case in Java. The Sumatran forest begins at a height of from 300 to 400 ft, and extends to all but the highest mountain peaks, giving a wealth of vegetation that produces very beautiful mountain scenery The forests contain the finest timber-producing woods in the archipelago, there is not only a great variety of trees, but they possess both stature and beauty. Deciduous trees such as the oak, chestnut, etc., grow on lower slopes than in Java, and apart from ebony, ironwood, camphorwood and sandalwood there

are also many species of resin and wild rubber-producing trees. Fauna.—Notwithstanding like proximity of the island to Java the fauna of Sumatra shows a greater resemblance to that of Bornee than to that of Java, this being particularly noticeable as regards the fauna of the east coast of Sumatra (that of the west coast and of the siands adjacent is more allied to the Javanese fauna). This striking difference in species between the fauna of Sumatra and Java led A. R. Wallace to assert that the first severance of Sumatra from Java is very ancient; that since the epoch of the first (volcance) disturbance several distinct elevations and depressions may have taken place, the islands having perhaps been more than once jounde with each other or with the manifor (of Asia) and again separated; and that successive waves of immigration may thus have modified the fauna and led to those anomalies in distribution which are so difficult to account for by any single operation of elevation or submergence.

The orangutan, common to Sumatra (in the northeast) and Borneo, is unknown in Java, the sananag (Hybobates syndactylate) is found in Sumatra and in the Malay peninsula but not in Borneo or Java, there are ape species common to Borneo and Sumatra, also the elephant (introduced into Borneo), tapir (indigenous also in the Malay peninsula) and Malayan bear, all of which are un-

known in Java, though, on the other hand, Sumatra shares the tiger with Java, while it is unknown in Borneo. The one-horned thinoceros of Java is known also in Sumatra, which shares a two-homed variety with Borneo. The Sumatra fluum also includes among primates the glibbon Hybotas lar, the bandel leaf monkey (Presbyts: mediolophias) and the pug-tailed macaque (Macaca nemastrina), both common to Borneo also, the silvered leaf monkey (P cristatus) and crab-eating macaque (M trus) common to Borneo and Java, the slow lors (Nytictebus), the tree shrews Thypia glis (in Borneo and Java) and T minor (in Borneo only), and the flying lemur, flying fox, bats, flying squrrels, ratis and mice; the simbar (Carvus simcolar) and the serow (Capricornis simuntarensis), wild dog; wild boar, and cevet cat.

There is no genus of birds peculiar to Sumatra but there are a few species and many subspecies The avifauna is very similar to that of the Malay peninsula, in the extreme south a few Javanese forms are found Among birds found in Sumatra but not in Java are the great Argus pheasant, the fire-back and other pheasants, and various partridges, the little Malay parrot (Psittinus cyanurus), the helmeted hornbill (Rhinoplay vigil), and the redbreasted bee-eater (Nyctiorus amicta) Other Sumatran biids include woodpeckers, pigeons and trogons Insects, which also show a marked difference from those of Java, comprise the beautiful Papilio memnon butterfly, the Papilio coon, and other species of this section, the Kallima paralekta (which attaches itself to and is able to imitate the leaf of a certain plant so closely as to secure itself from the attacks of enemies), flocks of Cyrestis, Melantis suradeva, a new species of Amnosia, Eurhima fulva, one of the prettiest species of Oecophoridae, two specimens of the curious genus Homopsyche, and the moth Pentacitrotus transversa Lizards, large and small, frogs, tortoises and turtles abound, crocodiles frequent the mouths of rivers and are also found upstream. there are many varieties of poisonous snakes, the rocks around the coast yield many kinds of shellfish and the sea, ponds and rivers numerous sorts of edible fishes (E. E L., X)

History.—Some authorities suggest that Sumatra, not Ceylon, may have been the Taprobane of Pliny By the end of the yth century the descendants of immigrants from India had made Palembang the seat of the powerful Hindu kingdom of Sri Vijaya. In the 13th century the Arabs invaded Achin and Mohammedanism took firm hold of some of the most important states. On ancient inscriptions discovered in the Padang highlands, the island was called "the first Java", Marco Polo called it "Java Minor"

It became known to Europeans as Sumatra through Ludovico di Varthema, an Italian, in 1505. The Portuguese established a trading post about 1509 and were driven out by the Dutch at the end of the century For the next three centuries the Dutch were engaged in costly efforts to establish supremacy in Achin (Atjeh); a 30 years' war, started in 1873, is estimated to have cost 250,000 lives and £50,000,000 sterling In 1602, the English first visited Achin, when Sir John Lancaster was well received, and 11 years later, to the annoyance of Dutch and Portuguese, they were given permission to start a factory The Dutch established their sover-eignty over Indrapura in 1664 and over Padang in 1666. In Palembang, where the Dutch had secured a modest concession in 1620, the sultans repeatedly sought to throw off the yoke: twice-in 1654 and 1819-the Dutch were actually driven out; and not till after a serious revolt in 1851 had been suppressed was their tenure secure. In Diambi the efforts of the sultans to escape the consequences of concessions were equally persistent. Throughout the 18th century Dutch and British maintained a constant rivalry in Sumatran waters Bengkulen, where the English acquired a footing in 1685, was among the sources of irritation to the Dutch and was handed over to them in 1824 in exchange for Malacca In Deli, in Menangkabau—whose princes claimed descent from Sultan Iskander (Alexander the Great)-and elsewhere, the Dutch established their authority in the teeth of repeated insurgence and generally as the result of the quarrels of native rulers who invoked their help and had to pay the price.

Except for certain regions of the interior (including almost the whole of Achin), Sumatra was occupied by the Japanese in World War II. After the defeat of Japan, the Dutch tried to re-establish

themselves, but left Achm alone Eventually the whole island was merged in the new state of Indonesia (q v), but the central government's control of vast parts of the interior was for some time only nominal the Achmese, the Batak and the Menangkabaus all demanded autonomy, the Achinese going so far as x to support their claims by armed revolt (x). H. x E x X is

Population —The population of Sumatra, which was returned as numbering 384,17,5 at the census of 1330 (when it included 26,354 Europeans and Eurasians and 280,592 foreign Assistes, anally Chinese), was estimated at the middle of the 20th century to have risen to 12,000,000. The Indonesian government in the 1905s sponsored the immigration of large numbers of people from Java (10,000 families to South Sumatra and 3,200 to the Djambi area of Central Sumatra in 1954).

The whole of the indigenous population had, probably, a common Malayo-Polynesian origin, but today all the races may be classified as Malay, in a wide sense, the pre-Malay blood of the country having been absorbed thoroughly. There is no race of true Negrito tyne.

Of these Malayan divisions the Achinese (qv) inhabit the ancient kingdom of Achin in the northwestern promontory and the whole of the north of the Gayo country

Gayos —The Gayos live in the northern central portion of the country, between the Achinese and the Batak, with the Alas on their west, living mainly in the valley of the Simpangkiri They are essentially a highland and insular race and form an ethnographical unit, all speaking one language. Alan to the Batak, they are agricultural and pastoral, a friendly and honest race, living in well-built houses of wood, in small scattered villages. Their chief crop is nec, maize, cotton and sugar cane are grown; horses and cattle are reared; and forest products are collected (there is an antimate substituting), between the contractions of the contraction of the co

Batak Groups -The Batak inhabit the mountainous region about Lake Toba and a part of the east coast. They are divided into several groups, differing considerably in language and customs Of Malay-Polynesian origin, the Batak are nearly one-third Mohammedan, more than one-third are Christian; the rest animist. Cannibalism (which was largely punitive and ritualistic) and slavery have disappeared The Batak possess a written language of their own; build compact houses on piles, with horned roofs, many families inhabiting one house; and have rice barns and a communal hall. The houses are beautifully decorated, the Batak being clever craftsmen in wood, Ivory and copper (they also understand iron smelting) The Batak are good agriculturists (rice cultivation, wet and dry, being their chief occupation, though maize, coffee, fruit and vegetables are grown) and real horses, cattle, buf-faloes and pigs They weave and dye cotton garments, make their own jewellery and pottery and can become keen traders and shopkeepers, teachers and even doctors.

Society is patriarchal, marriage exogamic, women are in a subordinate position, and polygamy is practised. There are village councils, a nobility, land belongs to a family, or village, but tenure differs.

Mesnanghebaus — South of the Batak, mt he Padang hughlands and vicmity are the Menangkabaus. At one time their ancient and powerful kingdom (which legend says, rose on the ruins of a Hindu empire) covered the greater part of Central Sumatra. They sent out emigrants to the Malay peninsula and represented the highest form of Malayan civilization.

Although converted to Islam, the Menangkabaus retained their ancient custom of the matriachate (i.e., descent and inheritance in the female line), which is said to be preserved nowhere in a puere form than among them: a wife remains after marriage with her kinsfolk on the mother's side, and the husband, having no home of his own, only visits his wife and resides in his mother's house; names, privileges and property derive from the mother's side; the cledest man of the elder female line is termed momak and is the keeper of all the possessions of the family Land is unalicable and always comes back into the possession of the family or village. Marriage between members of the same tribe is not allowed Houses, raised from the ground, are very ornate, with horned ridge poles and finely carved wooden fronts, sometimes painted Several families bearing the same patronymic live in the same house, and several houses, their rice bains, a communal house, a mosque, school, an inn and market form a village. There are priests and nobles, the people live by trade, agriculture, hunting and fishing. Their language is one of the chief branches of Malay (with a few words of Sanskrit origin), the Javanese script was once used but has been superseded by the Arabic

Other Peoples -South of the Menangkabaus, in the Indrapura region, live the Kerintjis, a small community, partly Mohammedan, partly animist; and east of these in Diambi, Malays using the term as denoting a seafaring race (Mohammedans), speaking Malay and having the usual Malay characteristics, not fond of work, prone to finery, devoted to sport and gaming, friendly and

intelligent and living in tribes
In the Redjang-Lebong area there are the Redjangs, a rather truculent people, who work in the gold and silver mines of their country, are Mohammedans, possess a script of Indian origin and

have Hindu antiquities scattered among them

In the south are the Lampongs, who were largely under Hindu influence and attained a high degree of civilization which they have retained Pepper culture is the chief occupation. Even before World War II. Javanese colonies were developed there Among the primitive tribes, there are the nomadic Kubus of the Diamoi mountains, almost dwarfs, with frizzled hair denoting Negritic blood All are extremely shy and isolated peoples, but quite peaceable, nomadic or seminomadic, primitively clothed, living by fishing and hunting and rude agriculture. (For "Island peoples" see NIAS; MENTAWEI, BATU ) Enggano people are animistic Malays, fishers and agriculturists. (E E L : X )

Provinces and Towns.-Sumatra is divided administratively into three provinces, North Sumatra, Central Sumatra and South At the head of each province is a governor, who is nominated by the Indonesian ministry of home affairs. The governor is assisted by a provincial council, one of whose functions

is to advise him on matters of local concern

The capital of North Sumatra is Medan, which is moreover the largest city of the whole island It is served by the port of Belawan Deli (see Belawan), which stands about halfway along the east coast of the province. The northern part of North Sumatra consists of the former government of Achin (qv), the capital of which was Kutaradja, with Oeleëlheuë (at the northwestern extremity of the island) as its principal port and Lho Nga, another major town, a few miles to the south Along the west coast of North Sumatra stand Meulaboh, Tapatuan, Singkil, Barus, Sibolga (capital of the former residency of Tapanuli), Natal and, in the extreme south, Ajerbanggis Towns of the north coast, to the east of Oeleelheue, are Sigli, Meureudu, Bireuen and, on either side of the promontory of Diamond point, Lho Seumawe and Idi. Towns of the eastern coastal region are Langsa and Pangkalang Brandan, north of Medan and Belawan; and Tandjongbalai at the mouth of the Asahan and the fishing port of Bagan Siapiapi on the estuary of the Rokan. The major towns of the interior of North Sumatra are Takingeun, Kotatjane, Blangkeredjen, Rantauprapat and Padang Sidimpuan Simuloee, Bandjak, Nias and the Batu Islands are included in the province

The capital of Central Sumatra is Bukittinggi (formerly Fort de Kock), between the lakes of Manindjau and Singkarak, near the magnificent Buffalo canyon (with walls 200-300 ft. high) in the Padang highlands behind the great port of Padang (q v.) on the west coast. Also in the hinterland of Padang are Pajakumbuh (beyond Bukittinggi), Solok, Sawahlunto and Sidjungdjung; Padangpandjang stands between Padang and Bukittinggi. Towns on the west coast are Priaman (north of Padang), Painan, Balaisalasa and Indrapura (toward the southern border) wide lowlands between the Bukit Barisan and the east coast of Central Sumatra have few towns of importance other than Djambi, capital of a former residency (see James), in the far south; Rengat in the Inderagiri basin; and the inland port of Pakanbaru, 100 mi. up the river Siak. On the islands of the Malacca strait included

1 Jan

in the province, however, are Bengkalis and Tandjongpinang The Mentawer Islands (qv) off the west coast are also part of Central

The province of South Sumatra has its capital at Palembang on the Musi (see Palembang) Its other great ports are Bengkulen on the west coast and Telukbetung, capital of the former residency of the Lampongs (q v), on the Sunda strait in the south, there are also the smaller ports of Bintuhan and Kru south of Bengkulen Inland, Batuadia stands northwest of Telukhetung and southwest of Palembang, and Lahat hes at the foot of the mountains, on the opposite side from Bengkulen The islands of Bangka and Billiton (Belitung) are included in this province

Communications -In North Sumatra there is railway connection between Kutaradia and Belawan Deli via Medan, this line branches into the hinterland of Medan and is continued southeastward from Medan to Rantauprapat, with a westerly branch to Padang Siantar and an easterly one to Tandjongbalar In Central Sumatra, Padang is connected by rail on the one hand with Sungailimau (via Priaman) and on the other with Padangpandjang, whence lines run via Bukittinggi to Pajakumbuh and via Solok to the mining area of Sawahlunto. In South Surnatra the railway from Palembang has two lines, one running southward via Baturadja to Tekukhetung, the other westward to Muaraenim and thence northward to Lubuklinggau Communications from east to west across the Bukit Barisan are of necessity by road. The importance of rivers as a means of communication, particularly for Central and for South Sumatra, has already been ex-

Internal air communications were in process of development by the middle of the 20th century, when airports had been established at Medan, at Pakanbaru, at Tandjongpinang, at Rengat, at Palem-

bang, at Branti, at Bengkulen and at Sibolga

Agriculture .- Volcanic effusion has enriched the soil over large areas of the island, and irrigation, sponsored by the government, brings water with a high mineral content to the less fortunate regions where its fertilizing properties are required. Agriculture in Sumatra is of two types indigenous, in the hands of smallholders; and European, on large estates.

The smallholders' main crop is rice, which is the staple food of the island and is grown entirely for home consumption. Even so, large quantities of rice have to be imported, as Sumatra's own crop is not sufficient to feed the population. Both wet (sawsh) and dry (ladang) methods of cultivation are practised. In the hope of increasing the yield, the Indonesian government established a pool of equipment whence smallholders could borrow tractors and other sorts of machinery. Maize is also grown by smallholders (by the Batak as a primary crop) for home consumption smallholders' crops are copra, spices (pepper, cloves and nutmegs), coffee, tobacco, betel nuts, groundnuts, coconuts, kapok, cotton and gambier. Ebony, sandalwood and ironwood are cut in the forests, which also yield wild rubber, rattan and resins

European agriculture on large estates is concerned principally with rubber, tobacco, tea, palm oil and hard fibres (sisal and ramie), and to a lesser extent with cinchona bark (for quinine). coffee, gambier and coca.

Rubber is grown in all three provinces of the island, but the greater part of the yield comes from the large estates: of Indonesia's 719 rubber estates, Sumatra has 242 These large estates. planted with Heven trees and concentrated predominantly in North Sumatra (between Lake Toba and the east coast) produced 183,-938 metric tons of rubber in 1952. The most important tobaccogrowing area is also in North Sumatra, around Medan and Belawan Deli (the leaf is fine and silky-looking and 18 particularly suitable for the outer wrapping of cigars). The output of tobacco amounted to 8,700 metric tons in 1952. The intensive cultivation of trees for palm oil, again mainly in North Sumatra, began in the 20th century; by the 1950s production in a normal year was about 240,-000 metric tons, but adverse circumstances might reduce it considerably (e.g., to 145,565 metric tons of palm oil, with 38,508 of palm kernels, in 1952). Tea is grown throughout the island, but again most extensively on the estates of North Sumatra; the crop suffered gravely from the onset of blister blight in 1949, which necessitated the widespread use of fungicides, the yield in 1952, amounting to 9,123 metric tons, was less than half of what it had been in 1939 Hard fibres constitute the remaining major product of the North Sumatran estates, because, however, of the difficulties arising from the long growth-cycle of the Agave plant (from 8 to 10 years), the cultivation of sisal was to some extent being superseded, in the rosos, by that of ramie, which the government encouraged, total production of hard fibres amounted to 20,230 metric tons in 1052 Most of the island's cinchona bark comes from the west coast of Central Sumatra (estate production 199 metric tons in Coffee is grown by smallholders in the Lampong area of South Sumatra and also along the west coast as far north as the Tananuli region Most of the island's pepper crop comes from the Lampong area (around Telukbetung) and from the neighbourhood of Palembang, lesser quantities from Achin (in these areas the average yield of a single plant is 0 3-0 8 kg. of black pepper), on the island of Bangka a more intensive method of cultivation is in use

The muor smallholders' crops are found mainly along the west coast of the sland, beted nuts in North Sumatra, copra and nutmeps in North and in Central Sumatra; resins in Central Sumatra; resons in Central Sumatra; and and in South Sumatra, and celtral sumatra coronts in Central and in South Sumatra, and celtral sumatra in the index property of the sum of the s

Fisheries.—The great fishing port of Sumatra is Bagan Siapiaji, which is the largest in Indonesia outside Jaw, by the 1950s it was handling an annual catch of about 80,000 tons. There are also fisheries at Sungsang (on the coast north of Palembang), at Lampong (near Telukbetung), at Bengkulen and on Bangka Island, Dried fish are exported, shellish, trepangs (see-slugs) and prawns (from which the delicacy known as kraipids is made) are also

caught
Minerals.—The major mineral resource of Sumatra proper is netroleum, found predominantly around Palembang and in the Diambi region but occurring also in North Sumatra, it is refined at Palembang, which exported 5,537,629 metric tons of petroleum and petroleum products in 1952 On the islands of Bangka, Billiton and Singkep, however, there are rich deposits of tin, which by the 1950s had made Indonesia the second largest tin producer in the world, output amounted to 30,613 long tons in 1948 and to 35,003 m 1952 (65% of this total coming from Bangka, where the mines are government controlled) Bauxite is mined on the islands of the Riouw archipelago opposite Singapore and on the mainland in the Asahan valley inland from Tandiongbalai. The principal coal fields are at Bukitasam (southwest of Muaraenim on the railway inland from Palembang) and on the Umbilin river near Sawahlunto (in the Padang highlands): by 1952 the average annual production of coal amounted to 600,000 tons from Bukitasam and to 78,000 from the Umbilin mines (the deposits of coal around Bengkulen were hardly exploited). Gold and silver occur on the west coast in the Redjang-Lebong area and at Simau. There are also deposits of lead, copper, iron, antimony, cobalt, naphtha, sulphur, alum and saltpetre in the mountains

Exports.—The accompanying table indicates the export trade of the principal port of each of the three provinces of Sumatra.

Exports, 1952

		_	(Qua	ntit	in:	metr	tons)		
							Port of exit		
Product						Belawan	Padang	Palembang	
Rubber estate smallholders Tea coffee* Cinchona bark* Palm oil Paim kernels Hard fibres Tebacco Petroleum and petrole	:	pro	duct			:	157,000 9,814 4,884 212 120,035 36,243 18,803 2,080	16,671 1,468 690 625	87,413 180 6,504  310 

Mainly from smallholdings. Cf. estate production (1952) coffee 96 metric tons, ethchona bark 199.

BIBLIOGRAPHY—For general information on the geography, history and economy of Sumatra consult the books cited in the bibliographies to the articles Malay Architectago ; Indonesia. See also O. J. A. Collet, Terres et peuples de Sumatra (Amsterdam, 1925); and E. M.

Loeb, Sumatra Its History and Peoples (Vienna, 1935). W Marsden, History of Sumatra, 3rd ed (London, 1811), is still interesting (X)

SUMBA (Dutch SOEMBA), also known as Sandalwood, one of the Lesser Sunda Islands, Indonesia, area 4,306 sq mi island is dominated by heights of from 2,200 to over 3,000 ft Several bays on the north coast give good anchorage, the best heing that of Waingapu. The rivers, mostly unnavigable, are of importance for agriculture. A fertile soil and a fairly good rainfall (average 63 7 in annually) help to produce good forests, grazing ground and food crops The forests yield sandalwood (giving rise to the old name for the island), dye-woods, wax and wild connamon On the grazing grounds are bred some of the finest horses in the country-the sandalwood breed-and fine cattle (Ongole), both of which figured largely as exports, while rice is raised on sawahs and ladangs, and maize, coffee, tobacco, coconuts, vegetables and fruit are grown, copra being exported The pop. (1930) was 182,354, consisting, apart from the indigenous Sumbanese, of péople from Flores, Savu and Rotti. The Sumbanese are a Malayo-Papuan people of good physique Except in the interior, where clothing is far more primitive, the sarong and banu are generally worn by women, and sometimes by men Both sexes are fond of ornaments They cultivate the soil, fish, mostly in rivers, not being a sea-loving race, collect forest products, edible birds' nests and turtles, make fishing-nets and plait baskets There are workers in copper and iron, while the women weave, spin and dye, and make pottery. The natives are largely pagan (there are some Mohammedans) and make offerings on stone altars. A particular breed of horses is held sacred

The Sumbanese enjoy feasts, music and dancing Traditional customs include marriage by dowry and polygamy, fairly common among the upper classes. There is no written form of the Sumbanese language, which is allied to that of Savu. Sumba has numerous megalithic monuments.

The sandalwood of Sumba attracted attention to the island in the 17th century, when Sumba appears to have been a tributary of the state of Bima, in Sumbawa Later Sumba became independent of Sumbawa, and treaties were concluded in 1756 with Dutch. Between 1856 and 1874, new treaties were made, but there were frequent difficulties with the natives, due to piracy and slave raids The trouble continued and in 1901 the Dutch were compelled to land troops. Most of the cheefs of the tribes were bound by the "short declaration," but there were disturbances in Sumba (Lamboja), necessitating a Dutch armed force in 1914

Japanese forces occupied the island during World War II
(E. E. L. X)

SUMBAWA (Dutch SORMBAWA), one of the Lesser Sunda Islands, Indonessa, between Lombok and Flores, and separated from the former by Alas strait and from the latter by Sapeh strait and the Island of Komodo Sumbaw with relighbouring islands, has an area of 5,695 sym. From 30 to roo mi north are the Fenga and Sabaliana (Paternoster) Islands, small low of each of the peninsulas. There are only a few stretches of alluval land along the coast: off the southern shore great depths of water are soon reached in the Indian occur. The mountains, some volcanic, are highest in the north. Mt. Tamboro, 9,255 ft. high, was very severely dramaged in the cruption of 1815. No other volcances appeared to be active in modern times. The average annal rainfall (Bilman) in 9,311.

Agriculture is carried on, nce being raised on sameats and adargs, while maize, cotton, coffee, tobacco, coconuts, onions and other vegetables, and fruit are grown. Horse and cattle breeding are important industries. The forests yield dye-woods (chiefly sapanwood) and teak.

The pop. (1930) of Sumbawa was 314,843 The natives of the western peninsula (Sumbawa) are of Malayan stock and allied to the Sassaks of Lombok, and those of the eastern peninsula (Bima, Sanggar and Dompo), are Malayo-Papuan.

Vessels of the Royal Packet Navigation company ordinarily called at Bima, Sumbawa, and Taliwang, affording communication with Macassar, the other Sunda Islands and Java ports. Sumbawa consisted originally of six states, all owing allegiance to either

Papikat and Sumbawa, after the eruption in Tamboia in 1815 that state and Papikat ceased to exist. In 1701 the Dutch arbitrated between Sumbawa and other states in the island engaged in civil war, and in 1765 the Dutch made a separate agreement with Sumbawa, revised in 1875 and again in 1905, under which it has a certain measure of self-government A contract made with Bima in 1857 and again in 1886, on the lines of that made with Sumbawa, was revised in 1905 It allowed the state some selfgoverning powers Sanggar was subject to the sultan of Ternate originally, then to the sultan of Macassar, and after the Bongay contract of 1667 it became a fief of the Dutch A treaty made in 1858, and revised in 1905, defined its right of self-government Dompo gave up allegiance to Macassar after the Bongay contract was a party to the Sumbawa treaty of 1765 with the Dutch, and had its self-governing powers fixed by subsequent treaties. Sumbawa was occupied by Japan during World War II

(E E. L : X)

SUMBUL or SUMBAL, also called Musk Root, a drug occasionally employed in European medical practice. It consists of the root of Ferula sumbul, Hook, a tall Umbelliferous plant found in the north of Bokhara, its range apparently extending beyond the Amur. The action and uses of the drug are the same as those of asafoetida (q v)

SUMERIAN LANGUAGE. The language now called Sumerian was revealed about the middle of the 19th century to Sir Hemy Rawlinson and other scholars when examining the baked clay tablets which had formed the library of Ashurbanipal, king of Assyria. These had recently been discovered by Layard in the ruins of Nineveh and brought to the British Museum When the cuneiform script in which they were written was deciphered, it was found that certain of them contained works composed in a language entirely different from the Semitic tongue of the Assyrians, but sometimes provided with interlinear translations into Assyrian; other tablets were dictionaries in which the words of this strange language were assigned their Assyrian equivalents

It was many years before the study of Sumerian was firmly established, although its meaning could be so confidently interpreted from the Assyrian translations. This was due both to the impossibility of discovering cognate languages, and to the factitious obstacle of a paradox which was subsequently maintained, chiefly by Joseph Halévy, that Sumerian was no true language at all, but a purely artificial system of secret writing invented for mystification of the vulgar by the Assyrian priests. The second of these hindrances was ultimately removed by the discovery of monuments inscribed in this language, which evidently belonged to a time before the Semitic tongue was written in Mesopotamia; the problem of finding a cognate language re-

Its Speakers and Script .- The area covered by this ancient speech was probably never very extensive. It is, at any rate, found only upon the monuments from the country lying between the Euphrates and Tigris, extending somewhat to the east of the latter, and from about the latitude of Baghdad to the head of the Persian gulf, which has receded since ancient times Its main centre was apparently the region of Nippur, the seat of the chief Sumerian cult. To the north, in the country later called Akkad, a Semitic language prevailed from very early times. Of the race or original home of the Sumerians nothing can be confidently asserted, for they appear settled in this territory from the earliest intelligence we have of them, and their own tradition of a fabulous antiquity gives no hint of another home. In this habitation they invented (for there is no evidence of borrowing) the pictorial script which became by a long process of evolution the cureiform signs, later adapted by the Semites for the writing of their own language. The year 3500 B.C. may be taken as a round date for the beginning of this script, the development of which can now be somewhat exactly observed, from definite pictures into the purely conventional groups of wedges with which it ended in about the last century before Christ. Very early the stage was reached at which signs were used not only to express the idea which they represented as pictures, but also for the mere

Gowa or Macassar in Celebes-Bima, Dompo, Sanggar, Tambora, sound of the corresponding word in a context which did not involve the actual idea at all, thus the sign ka is the picture of a mouth, but it is also used to write a certain grammatical ending -ka which has nothing to do with the idea of "mouth." The Sumerian writing, then, is a mixture of pictorial and phonetic elements, the roots being generally written with a sign which in itself expresses the required idea, accompanied by other signs used simply to supply the grammatical modifications. Two difficulties are caused by the polyphony of signs, and the existence of homonyms, one picture (e g the "foot") having been used to express two connected but different ideas (e.g the "foot" itself, and "to go"), two phonetic values, or more, became attached to the sign On the other hand the language possessed many words, of different meanings, which chanced to be of similar sound, (eg, the word sig was both "low" and "to strike"). In modern works these homonyms are usually distinguished by discritical marks. Certain of the signs are also used as determinatives, ie, they are placed before or after words to assign them to a particular class of natural things, such as man, bird, fish, wood and several more

Outline of Grammar .- The 100ts of the language are generally monosyllables though a few longer words are found. These roots are not subject to internal change, since grammatical distinctions are made by grouping a number of elements together around the root, not by causing the root to assume different forms. In the case of roots having the form consonant-vowelconsonant the final consonant is often dropped when a consonant mmediately follows. In itself the root expresses a base idea only; thus dug means "good," and can appear not only as an adjective but (with the appropriate modifying elements) as a noun "goodness," or a verb "to be good." Nouns are mostly formed by adding prefixes, sometimes the vowels a or u, but more often nam or mg which form abstracts; thus, from dug, the noun "goodness" would be nam-dug. Sumerian has no gender, which is disregarded in places where it is indifferent and expressed where necessary either by prefixing the determinatives for "male" and "female" or by the use of entirely different words, such as adda "father" and ama "mother." Plural of nouns is not always indicated, but can be formed when required either by repeating the root (kur "land," kur-kur-ra "lands"), or by the addition of suffixes -ene (used of persons), -mesh or hi-a. There is no special form of the dual, though the number two can be written if essential The relation in which the noun stands to the rest of the sentence is shown by a rather elaborate set of suffixes, which may be treated either as postpositions or case endings. Of these -a generally expresses the accusative, -e the nominative, -da is "with," -ta "from," -ra and -shu "to," -gim "like," while the genitive is denoted by a suffix -ak, which has the peculiarity of doubling itself to correspond with the number of genitives to be expressed, though this doubling is often concealed by the omission of a final consonant. Finally, the noun always stands at the head of a complex of modifying elements, with which it combines to form a kind of composite unity.

A peculiarity of the verbs is that, besides the simple roots, there are also compounds formed by the prefixing of a noun, the whole making one idea (e.g., de "to pour" and gu-de "to pour out a voice, to speak"). Between the nominal and the verbal part of the compound root are placed such of the accompanying elements as normally precede the root. These accompanying elements may be classified into three kinds (a) subject prefixes, (b) conjugating elements and (c) infixes. The first merely indicate the subject, not expressing in themselves either number or person, and the force of the individual prefixes is still insufficiently clear Distinction of tense, number, person, mood and voice is effected by the conjugating elements, but the resources of the language for these purposes are not highly developed, and it is clear that some of the grammatical tablets compiled by Semitic scribes for their own use lent to the Sumerian verb a number of artificial refinements which are not observed in the native texts Extensive use is made of participial constructions, and there is a special form for the optative, and a corresponding prohibitive particle The infixes, which convey the direct or indirect object, as well as certain adverbial relations, are included in the verbal

forms as the result of a strong tendency for the predicate to gather into itself parts representing all the other members of the sentence. The order of elements in the verb-complex follows a strict rule. The numeral system was sexagesimal and decimal.

The native grammarians knew of five different "tongues" in Sumenian. These are assumed to have been dualects, but in act nothing is known of them except the eme-sal "broad (?)-tongue," in which a number of religious texts are composed. This is differentiated from the ordinary form chiefly by a weak-ening of certain consonants, particularly of g into m, and by a preference for phonetic witing Sumerian ceased to be spoken before 1500 n C, but was long used as a learned language.

oelore 1500 BC, jutt was iong used as a isatmen ianguage.
BERLIOGARIPS—S. H. Langdon, Sumerina Grommar and Christianis (1911), F. Delitzich, Grundiusge der sumericken Grommulie (1911), F. Delitzich, Grundiusge der sumericken Grommulie (1913); C. J. Gadd, Sumerina Reading Book (elementary, 1914), Anton Deimel, Sumerische Grommatik (1914) and Sumerische Exthon (1925). (C. J. G.)

SUMER IS ICUMEN IN ("Summer is come in,"), famous 13th century English round which occupies a unique place in the history of music as standing alone in respect of the advanced character of its writing, as well as of its musical beauty, among the compositions of its period. As Father Anselm Hughes has put the matter in Grove's Dictionary of Music, this astonishing composition is pre-eminent in six respects, for (1) it is the oldest known canon; (2) it is the oldest known harmonised music which is frequently performed and enjoyed by singers and listeners today; (3) it is the oldest known 6-part composition; (4) it is one of the oldest known specimens of the use of what is now the major mode; (5) it is the oldest known specimen of groundbass; (6) it is the oldest known manuscript in which both secular and sacred words are written to the music. The generally accepted belief is that it was composed somewhere about the year 1240, and it is ascribed to one John of Fornsete, who wrote the ms, which came from Reading Abbey. See article Music, section 3, where the music is reproduced.

SUMMANUS, properly an epithet (= "highest") of Jupiter (qv); afterwards god of the nocturnal heavens, thunderstorms at night being attributed to him, those by day to Jupiter. Sumanus had a temple at Rome near the Circus Maximus, dedicated at the time of the invasion of Italy by Pyrrhus, king of Epirus (278). Here searfice was offered every year to Summanus on June 20, together with cakes called summanulia baked in the form of a wheel

See G. Wissowa, Religion und Kultus der Römer, p. 122 (1912), W. W. Fowler, The Roman Festivals, p. 160 (1899).

SUMMARY JURISDICTION. (\*) Meaning: The phrase is now understood in English has as referring to jurisdiction, excised by justices of the peace, which may result in a summary conviction or order. Blackstone dwides the proceedings in courts of criminal jurisdiction into two kinds: summary and regular: and by regular he means such as involve trial by jury, the only mode of trial known to the Common law except in the case of contempt of court. In these regular proceedings there is only a preliminary hearing before justices, followed by either a dismissal or committal for trial by jury at Quarter Sessions or Assizes.

(a) History—Heing unknown to the Common law, this jurisdiction is entirely the creation of statutes. A brief sketch is to be found in Stephen's History of the Criminal Low, vol 1. ct. 4, of the growth of the criminal jurisdiction. Speaking generally this growth has shown itself in two distinct forms: (a) The concerning of exclusive jurisdiction in a vast number of minor offences, mainly involving the infliction of pecuniary penalties, under such headings as Army, Game, Highway, Licensing, Motor Cars, Marchant Shipping, Post Office, Public Health, Revenue and Vagrancy. These offences have been created and are being ordered to the control of 
In addition to summary criminal jurisdiction, justices have been endowed by many statutes with a summary civil jurisdiction of increasing scope and importance

(3) General Legislation.—A court of summary jurusduction is defined by the Interpretation Act 1889, as "Any justice or justices of the peace or other magistrate by whatever name called, to whom jurusduction is given by or who is authorised to act under the Summary Jurusduction Acts and whether acting under the S. J. Acts or any of them, or under any other Act or by virtue of his commission or under the Common Law." This does not apply to justices sitting as the licensing authority nor to the preliminary hearing by justices of inductable offences

In the Interpretation and the The Acts of the Interpretation and the Interpretation and the Interpretation and Interpretation a

(4) Constitution of the Courts.—A court consisting of not more than one pustice has a jurusdiction limited to received an information or complaint, issuing a summons or warrant (S1, Act 1848 s 1), adjourning the hearing to the next practicable sitting of a Petty Sessional Court, and where authorised by the statute creating the offence, trying the case and imposing a punishment of not more than 14 days imprisonment or a fine of not more than 2c/(S1, Act 1879 s 2c)

A Petty Sessional Court is defined by the Interpretation Act 1889, as "A court of summary jurisdiction consisting of two or more justices when sitting in a Petty Sessional Court, and shall include the Lord Mayor of the City of London and any Alderman of that city, and any metropolatan or borough police magistrate or other stipendiary magistrate, stuting in a court-house or place at which he is authorised by law to do alone any act authorised to be done by more than one Justice of the Peace" It is by this court that summary jurisdiction must ordinarily be exercised (S.J. Act 1879, s. 20 [p. and 1c.])

The position in London (excluding the city) is peculiar. Under the Metropolitan Police Courts Act 1830, a number of stipendary magistrates (commonly known as police magistrates) are appointed and sit at 14 police courts. The jurisdiction of the justices for the country of London was not expressly taken away, and in theory they possess a concurrent jurisdiction, but masmuch as by S. 42 of the Act of 1839 court fees in respect of proceedings elsewhere than in the police courts were prohibited, a practical obstacle was interposed which has prevented the jurisdiction of the process of the police courts were prohibited, as practical obstacle was interposed which has prevented the jurisdiction of the police courts were prohibited, as practical obstacle was interposed which has prevented the jurisdiction of the process of the police courts were prohibited, as practical obstacle was interposed which has prevented the jurisdiction of the property of the

Offences under the Conspiracy and Protection of Property Act 1875 are to be prosecuted before, and jurisdiction under the Law of Distress Amendment Act 1908 is to be exercised by, a stipendiary magistrate where there is one.

(5) Subject Matter of Criminal Jurisdiction.—(a) Summary Cases: It has been already stated that inclusive summary jurisdiction has been conferred in numerous criminal cases both by or under special statutory authority; this statement requires qualification.

(i.) When the offence is punishable by imprisonment for more than three months the person charged may claim to be tried by jury; to this there are at least two exceptions: a male person who knowingly lives wholly or in part on the earnings of prostitution or who in a public place persistently solicits or importunes for immoral purposes. Punishment: 6 months hard labour, without right to trial by jury (Crim Law Amend Act 1912 S 7 [2]) (11.) A like claim to the trial by jury may be asserted under the Explosives Act 1875 S. 92, and the Conspiracy and Protection

of Property Act 1875 S 9

(111 ) Some offences are triable either summarily or by indictment. eg, assault, some forms of public indecency, cruelty to children and the offences mentioned above under C.L.A. Act. 1012

(b) Indictable Cases Triable Summarily. Where an adult is charged with one of the offences specified in the second schedule to the Criminal Justice Act 1925 and the court thinks it is expedient and the accused consents, the court may try the case summarily, unless the case affects the property or affairs of His Majesty or of a public body, or unless the Public Prosecutor is prosecuting, in which cases the consent of the prosecutor is also necessary (C I Act 1925 S 24)

This statute greatly increases the number of indictable offences triable summarily, and confers wider, though more elastic, powers of punishment than any previous statute. The power to fine, which is particularly appropriate in some cases of dishonesty is not possessed by courts of Ouarter Sessions or Assize when

dealing with felonies

(6) Criminal Procedure .- (a) Procuring the Attendance of the Accused. Where the offence is originally indictable, the accused is brought before the court either on arrest without warrant or upon warrant or summons under the Indictable Offences Act 1848, and the charge cannot proceed in his absence

In summary cases, unless there has been an arrest by a constable under statutory powers, information is laid before a justice as to the offence, whereupon either a summons or a warrant may be issued. For a summons the information may be oral and unsworn, for a warrant it must be in writing and upon oath The information must be laid within six months from the commission of the offence unless a different time is limited by some particular statute (S.J Act 1848 S 11) or unless the offence is a continuing one. A warrant is not ordinarily granted in the first instance, except for a serious offence; but if the summons is disobeyed, a warrant may be issued upon proof of service The practice on this matter varies in different courts and according to circumstances Personal appearance is not in general The summons is served by a constable upon the accused either personally or by leaving it at his last or most usual place of abode, and should take place a reasonable time previous to the hearing.

(h) The Hearing: The hearing must take place in open court. and parties may appear by counsel or solicitor. If the accused does not appear and the court determines to proceed, the case must be proved in the ordinary way as if he had appeared. If the informant does not appear the case is dismissed, unless the court thinks proper to adjourn the hearing and to remand the accused either in custody (which would be very unusual) or on recognizance with or without surety. If the accused appears, he is asked to plead; if he pleads guilty, the court proceeds to

A police officer of whatever rank has no right ex officio, and should not be permitted to act as advocate or to take any part in the proceedings at all: that is, unless he is the actual informant: even in the latter event, whatever his actual right under the S.I. Act 1848, his activities should be confined, so far as possible, to those of a witness. The attendance of a witness may be enforced either by a Crown office subpoena or by a summons or warrant of a justice.

If there is a variance between the evidence and the information, and the party charged is prejudiced thereby, an adjournment on terms should be granted. At the close of the evidence for the prosecution, if the court is of opinion that there is a case to answer, the defendant may open his case and call his witnesses, subject to this: that if the defendant be the only witness on his side as to fact, he must be called immediately after the close of the evidence for the prosecution.

(c) The Judgment: The judgment follows the opinion of the majority of justices present at the hearing, and the chairman has no second or casting-vote. In the case of an equality of votes,

unless a justice withdraws his vote, the case should be adjourned for a rehearing before another court, when, if the same result ensues, the case should be dismissed. If the court decides to dismiss the information either upon the non-appearance of the informant or as being of opinion that the charge is not proved, it makes an order to that effect and may award costs to the defendant, but costs do not follow the event so frequently as in civil cases. If the charge is without foundation and the defendant is in no way to blame, there seems no reason why he should bear any part of the costs of the defence, whether the prosecution is by the police or by a private person, but a variety of considerations, generally unstated, influence the courts in this matter, and it cannot be pretended that there is any general or settled practice. If the defendant has pleaded guilty or the court is of opinion that the charge is proved, the court may either:

(1) Postpone judgment (either for consideration or to avoid inflicting sentence of imprisonment) and remand the defendant either in custody up to 8 days, in an appropriate case, or for that or a longer period, on recognizance, with or without sureties, or

(ii ) Convict the defendant, and commit him to the Assizes or Quarter Sessions in order that a sentence of detention in a

Borstal institution may be passed, or

(iii ) Convict and sentence the defendant. The maximum term of imprisonment and the maximum fine which can be inflicted are in general fixed by the statute or bye law creating the offence an order for costs can be included in the conviction. Whatever the provisions of the statute, or bye law, the imprisonment may be either with or without hard labour, and the court may reduce the term as it thinks fit or substitute for imprisonment (where no power to fine existed) a fine not exceeding £25 and not involving, on default, a longer term of imprisonment than that prescribed by the Act or bye law: and where a fine is prescribed, the court may, if it is imposed as in respect of a first offence, reduce the prescribed amount, or

(iv.) Without proceeding to conviction, where the court is of opinion that having regard to a variety of circumstances (see Probation of Offenders Act 1907 S. 1) make an order dismissing the information or charge, or discharge the defendant conditionally on his entering into a recognizance, with or without sureties, to be of good behaviour and to appear for conviction and sen-

tence at any time within not more than 3 years.

(d) Execution and Enforcement of Payment of Fines and Costs: Fines and costs, ascertained by conviction, are enforced by warrant of distress and, in default of distress, imprisonment on a scale set out in S 5 of the S.J. Act 1879. The court may issue a warrant of commitment in the first instance if the defendant has sufficient means to pay or if he does not ask for time to pay or has no fixed estate within the jurisdiction or for other special reasons. (See further C.J Act 1914 S. 25.) Where no fine has been inflicted but costs have been ordered to be paid either by the defendant or, upon dismissal, by the informant, recovery is by distress under SJ. Act 1848 S. 18 and C.J. Act 1914 S. 25. There are exempt from distress: the wearing apparel of the defendant and his family, and, to the extent of £5, the tools and implements of his trade. Provision is made in C.J. and S.J. Acts and rules for payment by instalments.

(e) Appeal: (i.) To Quarter Sessions: There is a general right of appeal against a conviction (including an order under S. z of the Probation of Offenders Act 1907) where the person aggrieved did not plead guilty (C.J. Act 1914 S. 37 [1]: C.J. [Amendment] Act 1926 S. 1), and against sentence after a plea of guilty (C.J. Act 1928 S. 25). There is no right of appeal against a dismissal, unless specially given by some statute. The procedure is regulated by the S.J. Act 1879 to which reference should be made to master the technicalities which are numerous.

(ii.) To the High Court by a Case Stated on a Point of Law: Such an application may be made by either party under the S.J. Acts 1857 and 1879. A recognizance, similar to that required on appeal to Quarter Sessions, is necessary. Generally speaking, the parties agree upon the form of the case; falling agreement the court settles the case. The court may refuse to state a case but only on the ground of frivolity; the court of King's Bench may rescand this refusal or order a case to be

(iii ) The court of King's Bench has further powers, on certain limited grounds, to restrain the exercise of or control a refusal to exercise jurisdiction by writ of prohibition and mandamus.

(7) Civil Procedure .- (a) As before stated, justices have been authorised by many statutes to make orders for the payment of money or otherwise, and some of the statutes contain special provisions as to the procedure to be observed. Mention is made of those most in use. Bastardy is specially dealt with under the Bastardy Acts 1872 and 1923 and the Affiliation Orders

Disputes between employers and workmen or apprentices are provided for by the Employers and Workmen Act 1875

A special code, applicable to certain differences between husbands and wives, is contained in the S J. (Married Women) Act 1805 as amended by the Married Women (Maintenance) Act 1920 and the S I. (Separation and Maintenance) Act 1925 and S. 5 of the Licensing Act 1902.

A limited jurisdiction in ejectment is conferred on justices by the Small Tenements Recovery Act 1838, at present qualified

by a variety of Rent Restriction Acts

In the absence of provision to the contrary in the Act conferring jurisdiction, the procedure is governed by such parts of the S I. Acts and rules as deal with orders and the recovery of civil debts. A summons is issued on complaint and not on information; and no warrant can be issued to compel attendance, On the hearing the civil laws of evidence apply To enforce an order for the payment of a civil debt or costs, in default of distress, a judgment summons, of which personal or substituted service is necessary, must be obtained If on the hearing of this summons it is proved that the defendant has or had, since the date of the order, means to pay, he may be committed for any term not exceeding 6 weeks. (S J. Act 1879 S. 35) Default in complying with an order other than for payment of money may be visited by an order to pay a sum (to be enforced as a civil debt) up to LI a day during default, not exceeding £20 in the aggregate, or for imprisonment, until compliance, for a period not exceeding two months.

(b) Appeal: There is no general right of appeal to Ouarter Sessions, in Bastardy, however, either party may so appeal, and various other statutes conferring civil jurisdiction include this right For instance the Pawnbrokers Act 1872 (on refusal of a certificate) and the Money-Lenders Act 1927 In matrimonial cases a special form of appeal hes to the High Court, Probate, Divorce and Admiralty Division.

The S.T. Acts 1857 and 1879 as to appeal by stated case apply to civil determinations in like manner as they do to criminal determinations, and the powers of the High Court as to write of certiorars, mandamus and prohibition can also be invoked.

(8) General Observations.-The public advantage of the courts is not confined to the work done in open court. The stipendiary magistrates, in London especially, act as friendly advisers of the poor, who flock to the courts for counsel and assistance. It must be confessed, however, that occasionally the need is felt for some further provision for the defence of the needy and ignorant persons in these courts. Societies for the protection of women and children play their part, the magistrate does what he can and even has been known to instruct a solicitor for the defence at the expense of the poor box. Yet still there is a gap to he filled. (H. W. W. WIL.)

BIBLIOGRAPHY.—G. C. Oke, Magisterial Synopsis (14th ed 1893) and Magisterial Formulist (10th ed. 1522); A. C. F. Boulton, Law and Practice of a Case Stated by a court of summary jurisdiction (1902); T. S. Pritchard, The Jurisdiction, Practice and Procedure of the Quarter 1.5. FIGURIA, The initial-tim, Fractice has Processor of the Quarter Session (and at 1904); T. F. Archbold, The Fractice of the Court of Quarter Sessions (6th ad 1906); C. J. Douglas, Summary Jurisdiction Proceeding (10th dc. 1916); W. F. Paley, Summary Convictions (9th dc. 1916); W. K. Wigner, The Justice's Mote-Book (11th dc. 1927). See also current of. of Stone's Suspice's Monual.

#### THE UNITED STATES

with the institution of summary jurisdiction as developed in Stuart England and adapted it to the exigencies of their new life Reasons such as their distrusts of bureaucratic tyranny, the lack of trained lawyers, the limited need for criminal legislation, made for a reduction in the extent of summary jurisdiction. That a vigorous and extensive jurisdiction over minor offences was exercised is, however, clear. (See Frankfurter and Corcoran. Petty Federal Offenses and the Constitutional Guaranty of Trial by July, 39 Harvard L. Rev 917, 1926 ) Some of the colonies gave general summary unisdiction of all offences where the maximum numshment was a moderate fine and a moderate term of imprisonment. Special legislation conferred summary jurisdiction for petty offences such as swearing, gambling, illegal selling of liquor, profiteering, etc. The extent of this jurisdiction as being "a veritable social control in the daily lives of the people" is demonstrated by the fact that prior to the American Revolution the number of offences punished in the first instance by a single magistrate in Massachusetts amounted to 170, a figure equally illustrative of the extent to which summary jurisdiction prevailed in the other colonies.

Prior to the Revolution much antagonism was aroused by the Crown's denial of the right to trial by jury in a number of cases where traditionally such trial was had. This grievance of the colonists loomed large in the Declaration of Independence of 1776 and was responsible for the inclusion of provisions in the United States and State constitutions guaranteeing the right to trial by jury The relationship of these constitutional provisions to the recognized summary jurisdiction of the magistrates has proved a controversial issue in American law. It is quite clear, however, that their effect was not to introduce jury trial in all cases but that, whatever restrictions they placed upon the statutory extensions of summary jurisdiction, they left the existing ambit of that jurisdiction, in the main, untouched The history of that jurisdiction has controlled the courts in determining the scope of the constitutional provisions for trial by jury. Thus, the constitutional provision has been interpreted by various courts as not to deny the power of the legislature to confer summary jurisdiction upon magistrates in a variety of petty offences such as assault and battery, disorderly conduct, petty larceny, violations of game, food inspection, liquor, vagrancy, Sabbath-breaking and highway laws The test of what offences can be entrusted to the summary jurisdiction of single magistrates has been framed by the New Jersey court of errors and appeals in Katz v. Eldridge, 97 N.J.L. 123, 151. (1922), as follows. "The offence must be a petty and trivial violation of regulations established under the police power of the State in order that the offender may be summarily tried, convicted, and punished without indictment by a grand jury and without trial by a petit jury It must, of course, be assumed that the punishment for such a petty and trivial offence will also be comparatively petty and trivial, otherwise it would violate another provision of the State constitution which prohibits cruel and unusual punishments."

The constitutional problem arising from the guarantee of jury trials is present to a less degree in the grant of summary jurisdiction in civil cases. In some States the constitutional provision is expressly limited to criminal cases. In those where it includes civil causes its interpretation has followed the historical manner given to the provision applicable to criminal jurisdiction. To increase summary jurisdiction without infringing upon the constitutional right to jury trial, statutes commonly provide that unless such trial is expressly demanded by the defendant at a certain stage of the proceedings the magistrate is empowered to proceed as if the case fell within his summary jurisdiction

The extent to which magistrates exercise summary jurisdiction varies with the statutes of each State. In criminal matters it is exercised only in the broad class of petty offences. The furthest extent to which this classification has been enlarged concerned the breach of a State liquor law where the penalty prescribed amounted to a fine of \$500 and six months' imprisonment. No Summary jurisdiction in the United States, as in England, is summary jurisdiction has as yet been conferred upon the judicial the creation of statutes. The American colonists were familiar officials of the Federal Government. Federal crimes are limited

in character and of such a grave nature as would traditionally call for the benefit of a jury trial. The prohibition amendment to the United States constitution and the legislation thereunder punishing the manufacture, sale and transportation of intexicating houor did, however, thrust upon federal courts a large amount of trivial criminal business and brought to the forefront the desirability of establishing some system for federal summary jurisdiction.

In civil matters magistrates exercise a large summary jurisdiction The abatement of nusances, the collection of taxes, the enforcement of liens actions upon official bonds, quo warranto proceedings, the enforcement of awards, bastardy proceedings, are examples of classes of cases commonly entrusted to single magistrates In ordinary civil actions upon contracts, promissory notes, torts and the like, summary jurisdiction is conferred provided that the claim does not exceed a certain pecuniary limit Actions involving title to real property are generally excluded from grants of summary jurisdiction

The procedure in summary jurisdiction matters is more informal than otherwise. Matters of form are largely dispensed with and great liberality with respect to the proceedings is exercised Actions are commenced by summons which contains a short statement of the cause of action No formal pleadings are necessary and in many cases the pleadings are oral, the magistrate's entry showing their substance Defenses are also pleaded orally Many states, however, require the plaintiff to set out his cause of action in a bill of particulars and require the defendant to file a formal answer

The admission of evidence is governed by general common law principles though less exactness in their application is required Judgments may be sued upon or executed in the same fashion as other judgments of superior courts. Dockets are required to be kept, upon which a record of the proceedings must be entered. Review of the proceedings is generally accorded by statute by appeal or writ of error within certain limitations as to the amount involved The review is limited to those issues which were presented to the single magistrate and to the jurisdiction of that magistrate

Provisional remedies of ariest and attachment are also generally conceded to magistrates invested with summary jurisdiction. (J M LA.)

SUMMER SCHOOLS. These may be described briefly as educational courses conducted during the summer.

### GREAT BRITAIN

The long residential course of several months characteristic of the Danish folk high schools met with only a limited success in Great Britain, but from the beginning of the 20th century there was a growing demand for summer schools and week-end courses which adults could attend with little interruption of employment. Not only did such courses increase steadily in number, but they also enlarged their scope to cover a wide range of studies. When Bishop Nikolai Grundtvig and his followers created their folk high schools in Denmark in the middle of the 19th century they stressed the social aspect-"a feeling of comradeship"-and this became a notable feature of successful summer schools in Great Britain. From mid-July to mid-September such schools, organized in colleges and hostels, attract hundreds of students who come to study under expert guidance some branch of knowledge which interests them. The schools are usually arranged in places which can offer also the attraction of beautiful scenery or cultural amenities. Vacation courses were not unknown in Great Britain in the 19th century, the old science and art department (merged in the board of education in 1800) organized courses for teachers of science, and an annual summer school was arranged in connection with university extension classes. But the first strong impetus came from the modern adult education movement launched by Albert Mansbridge and others in 1903. The courses subsequently organized by the Workers' Educational association and the extramural departments of universities created a new demand for summer schools, and they became an important outcrop of the adult education movement. The tutorial classes provided a supply of keen students and, beginning with the Oxford Summer school of 1910, similar schools continued to develop elsewhere Thus in 1012 the Manchester joint committee of the university extramural department and the WEA organized its first summer school for students from tutorial classes, it is held annually at Bangor, North Wales Foreign students come increasingly to British summer schools, and as far back as 1904 the University of London estabhished a vacation course in "English for Foreign Students" Held annually, it had by the 1950s, an eniolment of more than 200 students from 30 countries, some coming from as far as Thailand, Ceylon and Indonesia

Many summer schools are organized by associations, societies. government, departments, industrial organizations and political parties The board (later the ministry) of education has for many years provided summer schools and courses for teachers Before World War II it was arranging about 50 yearly and after the war the number rose to 120, attended by nearly 6,000 teachers These courses deal with the main subjects of the school curriculum and with such educational problems as vocational guidance, domestic subjects, art and crafts, nursery, infant and junior school methods, the teaching of handicapped children, technical subjects, adult education, youth service, continuation schools, school meals, physical education and the training of teachers

Local authorities also provide courses for teachers in their service, and a few organize summer schools of a nonlocal character Several teachers' associations organize vacation courses, and among those arranged by the National Union of Teachers is one held annually in France. Various educational societies promote courses to stimulate interest in aspects of education that are their particular concern. The two wais interrupted the organization of summer schools, but the work of the Army Bureau of Curtent Affairs during World War II did much to encourage a wider interest in group discussion. This new interest was carried forward into civilian life by the Bureau of Current Affairs which operated for five years after the war with the help of the Carnegie United Kingdom trust. By lectures, talks and discussions the British Broadcasting corporation also greatly widened public interest in the service that summer schools and courses can render with the result that many large-scale organizations provide them for members of their staff. Thus in the early 1950s the national coal board's summer school was attended by about 450 students drawn from almost every branch of the coal-mining industry; they were housed in five Oxford colleges and spent a full week hearing lectures by experts and participating in group discussions.

(W. O. L. S)

# THE UNITED STATES

In the United States after the 1870s, and more especially after about 1905, universities and colleges offered instruction during the summer months. The earliest programs of summer study retained many of the qualities of the customary summer vacation. In 1869 Dean Shaler arranged a field trip in the mountains of Colorado for students of geology at Harvard university, Cambridge, Mass Louis Agassiz of Harvard offered field work in a zoological laboratory established on Penikese Island in Buzzards Bay, Mass., in 1873 In 1880 C O. Whitman founded the Marine Biological labora-

tory at Woods Hole, Mass., as a centre for researchers in hiology.

An early form of summer study which greatly influenced the rrowth of schools was the Chautaugua summer assembly (see LYCEUMS AND CHAUTAUQUAS) which began with a ten-day session in 1874, enlisting the co-operation of many notable scholars and educators. One of these, William Rainey Harper, who conducted courses in Hebrew and in Old Testament literature, became president of The University of Chicago in 1801. Moved by the success of his Chautauqua experience he provided for a university calendar of four quarters, of which the summer one was an integral part of the university year Shortly thereafter other universities provided for summer sessions, many of them offering courses which could be counted toward the baccalaureate degree. among these were (1893) University of Nebraska, Lincoln; (1894) University of Michigan, Ann Arbor; (1896) University of Illinois, Urbana; (1897) Clark university, Worchester, Mass, Cornell university, Ithaca, NY, and Ohio university, Athens, (1899) University of California, Berkeley; (1900) Columbia university, New York,

One of the factors contributing to the growth of summer schools was the demand for trained teachers in a rapidly expanding system of public schools. During the first quarter of the 19th century teachers depended for help upon the county "normals," one-day conventions which were held at many points throughout the country By 1850 more elaborate institutes, often of two weeks duiation, were common, and were provided for by law in several states.

The first six-weeks summer course in education for public school teachers was offered at Martha's Vineyard, Mass , in 1878 This school emphasized teaching methods and in 1890 enrolled 700 students in its elementary, high school and academic departments. Because of the seasonal nature of public school teaching and the rapid increase in numbers of public school teachers, U S summer schools until the middle 1920s offered chiefly undergraduate courses in educational methods After the 1920s, standards of qualification for public school teachers reached so high a level that the emphasis of this aspect of summer schools, especially at the large universities, shifted toward postbaccalaureate courses.

A development in summer schools after World War II was the introduction of highly specialized conferences, workshops and seminars for selected groups of professional and industrial people. For example, in the summer of 1953 two universities offered special courses for electrical engineers on the subject of transistors. Other courses announced by various institutions included "Digital Computers and their Applications," "Mathematical Problems of Communication Theory," and "The Basic Process of Rorschach Technique" Courses of this sort vary in length from one day to several weeks. They make the results of research at educational institutions available to industrial technicians, teachers, and other professional persons. Their students are mature persons who usually do not wish to acquire additional academic credit or de-

Summer sessions of varying lengths are often provided within a single institution. At universities employing a calendar of four quarters, many courses offered in the summer quarter are so organized that students may enrol and receive credit for either the first or the last five or six weeks of the quarter. Other institutions schedule sessions of different lengths, as in 1952 Northwestern university, Evanston, Ill, scheduled 6-week, 9-week, 11-week, 8-week, 3-week, and 2-week sessions, all lunning con-(H W. Ss.) currently.

SUMMER TIME: See DAYLIGHT SAVING.

SUMMIT, a village of Cook county, Illinois, U.S., on the Illinois and Michigan canal, II mi. S.W. of the Chicago "loop." It is served by the Gulf, Mobile and Ohio railway.

The population was 8,957 in 1950; in 1940 it was 7,043; in 1930

The population was 0,937 in 2,937, in 2,937, in 1,937, in 1,937, in 1,937, in 2,937, i tain; served by the Lackawanna and the Rahway Valley railways. Population (1950) 17,929; in 1940 it was 16,165, federal census. It is a residential suburb, with private schools and some manufacturing. Summit was chartered as a city in 1899.

During the American Revolution it was known as Turkey Hill; a signal tower on the crest warned Washington's army of the

movements of the British.

SUMMIT HILL, an anthracite mining borough of Carbon county, Pennsylvania, U.S., served by the Lehigh and New England railroad. Pop , 4,924 in 1950; 5,406 in 1940; in 1930 it was 5,567. It has a famous burning mine, which first caught fire in 1832.

The Mauch Chunk Switch-Back railway, now abandoned, was built in 1827 by the Lehigh Coal and Navigation company for transporting coal after anthracite was discovered by Philip Ginter in 1791, and was said to have been the oldest railroad in the United States

SUMMONS: see PRACTICE AND PROCEDURE.

SUMNER, CHARLES (1811-1874), American statesman, was born in Boston, Mass, on Jan 6, 1811. He graduated in 1830 at Harvard college, and in 1834 at the Harvard law school At the age of 23 he was admitted to the bar The three years (1837-40) spent in Europe were years of fruitful study and experience

In his 30th year Sumner returned to Boston, to settle down to the practice of law But gradually he devoted less of his time to practice and more to lecturing in the Harvard law school

Sumner co-operated effectively with Horace Mann for the improvement of the system of public education in Massachusetts Prison reform and peace were other causes to which he gave support. He took an active part in the organizing of the Free Soil Party, in revolt at the Whigs' nomination of a slave-holding Southerner for the presidency; and in 1848 was defeated as a candidate for the National House of Representatives. In 1851 control of the Massachusetts legislature was secured by the Democrats in coalition with the Free Soilers, but the Democrats refused to vote for Sumner, the Free Soilers' choice for US senator, and urged the selection of some less radical candidate. A deadlock of more than three months ensued, finally resulting in the election (April 24) of Sumner by a majority of a single vote

In the closing hours of his first session, in spite of strenuous efforts to prevent it. Sumner delivered (Aug. 26, 1852) a speech, "Freedom national; Slavery sectional," which marked a new era in American history The conventions of both the great parties had just affirmed the finality of every provision of the compromise of 1850 In 1856, at the very time when "border ruffians" were drawing their lines closer about the town of Lawrence, Kan, Sumner in the Senate (May 19-20) laid bare the "Crime against Kansas" He denounced the Kansas-Nebraska bill as in every respect a swindle, and held its authors, Stephen A Douglas and Andrew P Butler, up to the scorn of the world. Two days later Preston S. Brooks (1819-57), a Congressman from South Carolina, confronted Sumner in the Senate chamber, denounced his speech as a libel upon his State and upon Butler, his relative, and struck Sumner till he fell unconscious to the floor. This assault cost Sumner three years of heroic struggle to regain his healthyears during which Massachusetts re-elected him, in the behef that in the Senate chamber his vacant chair was the most eloquent pleader for free speech and resistance to slavery

After the withdrawal of the Southern senators, Sumner was made chairman of the committee on foreign relations (March 8, 1861), a position for which he was pre-eminently fitted by his years of intimate acquaintance with European politics and statesmen. While the war was in progress his letters from Cobden and Bright, from Gladstone and the duke of Argyll, at Lincoln's request were read by Sumner to the Cabinet, and formed a chief source of light as to political thought in England In the turmoil over the "Trent Affair," it was Sumner's word that convinced Lincoln that Mason and Slidell must be given up, and that reconciled the public to that inevitable step

Throughout the war Sumner had constituted himself the special champion of the negro, being the most vigorous advocate of emancipation, of enlisting the blacks in the Union army and of the establishment of the Freedmen's bureau The credit or the blame for imposing equal suffrage rights for negroes upon the Southern States as a condition of reconstruction must rest with him.

In the impeachment proceedings against Johnson, Sumner was one of the President's most implacable assailants. Sumner's opposition to Grant's pet scheme for the annexation of San Domingo (1870), brought upon him the President's bitter resentment. Sumner had always prized highly his popularity in England, but he unhesitatingly sacrificed it in taking his stand as to the adjustment of claims against England for breaches of neutrality

Under pressure from the President, on the ground that Sumner was no longer on speaking terms with the secretary of State, he was deposed on March 10, 1871, from the chairmanship of the committee on foreign relations Whether the chief cause of this humiliation was Grant's vindictiveness at Sumner's opposition to his San Domingo project or a genuine fear that the impossible demands which he insisted should be made upon England, would wreck the prospect of an adjustment with that country, cannot be determined Sumner's last years were further saddened by the misconstruction put upon one of his most magnanimous acts. In 1872 he introduced in the Senate a resolution providing that the names of battles with fellow-citizens should not be placed on the regimental colours of the United States. The Massachusetts legislature denounced this battle-flag resolution as "an insult to the loyal soldiery of the nation" and as "meeting the unqualified condemnation of the people of the Commonwealth" For more than a year all efforts-headed by the poet Whittier-to rescind that censure were without avail, but early in 1874 it was annulled On March 10 against the advice of his physician, Sumner went to the Senate-it was the day on which his colleague was to present the rescinding resolution. That night he was stricken with an acute attack of angina pectors, and on the following day he died

"The slave of principles, I call no party master," was the proud avowal with which Sumner began his service in the Senate. His was the first clear programme proposed in Congress for the reform of the civil service. It was his dauntless courage in denouncing compromise, in demanding the repeal of the Fugitive Slave Act, and in insisting upon emancipation, that made him a great propelling force in the struggle that put an end to slavery great propeiling iorce in the struggie that put an eine to stavery See Summer's Works (Boston, 1870-83), and Edward L. Petere's Memoir and Letters of Charles Summer (Boston, 1877-93). Britographies have been written by Anna L. Dawes (New York, 1891); Moorfield Storey (Boston, 1900), and George H. Haynes (Phila-delphia, 1909). See also Charles Summer, His Camplete Works with an introduction by G. F. Hoar (Boston, 1910); W. G. Slotwell, Life of Charles Sumner (1910), A. N. Gunke, Charles Sumner Centenary

SUMNER, EDWIN VOSE (1797-1863), American soldier, was born at Boston (Mass ), and entered the U.S. Army in 1819. He took part in the Black Hawk war and served many years on the frontier. For distinguished action in the Mexican war, he received the brevet rank of colonel From 1851-53 he served as military governor of New Mexico At the outbreak of the Civil War (1861) Sumner had just been promoted to the rank of brigadier-general, and was sent to relieve Sidney Johnston in command of the department of the Pacific. The following year, he was recalled to command the 1st Corps of the Army of the Potomac At the battle of Fredericksburg he commanded the right grand division under Burnside. Upon Hooker's appointment to chief command of the eastern army, Sumner was assigned to command the department of Missouri, and died suddenly, on March 21, 1863, while on his way thither SUMNER, WILLIAM GRAHAM (1840-1910), Ameri-

can economist, was born, of English parentage, in Paterson (N J.), on Oct. 30, 1840. He was brought up in Hartford (Conn.), graduated at Yale college in 1863, studied French and Hebrew in Geneva in 1863-64 and divinity and history at Gottingen in 1864-66, and in 1866-69 was a tutor at Yale.

He was ordained a priest of the Protestant Episcopal Church in 1869, was assistant rector of Calvary Church, New York city, and in 1870-72 was rector of the Church of the Redeemer, Morristown (N.J.). From 1872 to 1909, when he became professor emeritus, he was professor of political and social science at Yale. In 1909 he was president of the American Sociological Society.

He died at Englewood (N.J.), on April 12, 1910.
SUMPTUARY LAWS, those laws intended to limit or regulate the private expenditure of the citizens of a community. They have existed both in ancient and in modern States. In Greece, it was amongst the Dorian races, whose temper was austere and rigid, that they most prevailed. All the inhabitants of Laconia were forbidden to attend drinking entertainments, nor could a Lacedaemonian possess a house or furniture which was the work of more elaborate implements than the axe and saw.

At Rome the system of sumptuary edicts and enactments was largely developed, whilst the objects of such legislation were concurrently sought to be attained through the exercise of the censorial power. The code of the Twelve Tables (q.v.) has provisions limiting the expenditure on funerals The most important sumptuary laws of the Roman commonwealth were the following:-

except on occasions of public religious ceremonies. This law, which had been partly dictated by the financial necessities of the conflict with Hannibal, was repealed 20 years later, against the advice of Cato (2) The Orchian law, 187 Bc, limited the number of guests at entertainments (3) The Fannian law, 161 BC., limited the sums to be spent on entertainments, it provided amongst other things that no fowl should be served but a single hen, and that not fattened (4) The Didian law, 143 BC, ex tended to the whole of Italy the provisions of the Fannian law, and made the guests as well as the givers of entertainments at which the law was violated liable to the penalties After a considerable interval, Sulla anew directed legislation against the luxury of the table and also limited the cost of funerals and of sepulchral monuments. Julius Caesar, in the capacity of praefectus moribus, after the African war re-enacted some of the sumptuary laws which had fallen into neglect Suetonius tells us that Caesar had officers stationed in the market-places to seize such provisions as were forbidden by law, and sent lictors and soldiers to feasts to remove all illegal eatables (Jul 43) Augustus fixed anew the expense to be incurred in entertainments Tiberius also sought to check inordinate expense on banquets.

In modern times the first important sumptuary legislation was: in Italy that of Frederick II; in Aragon that of James I in 1234; in France that of Philip IV, in England that of Edward II. and Edward III In 1294 Philip IV of France made provisions as to the dress and the table expenditures of the several orders of men in his kingdom Charles V. forbade the use of long-pointed shoes, a fashion against which popes and councils had protested in vain. Under later kings the use of gold and silver embroidery, silk stuffs and fine linen wares was restricted. In England we hear much from the writers of the 14th century of the extravagance of dress at that period In the reign of Edward II. a proclamation had been issued against the "outrageous and excessive multitude of meats and dishes which the great men of the kingdom had used, and still used, in their castles." In the year 1336 Edward III attempted also to legislate against luxurious living, and in 1363, at the same time when costumes were regulated, it was enacted that the servants of gentlemen, merchants and artificers should have only one meal of flesh or fish in the day, and that their other food should consist of milk, butter and cheese An act of 1444 had regulated the clothing, when it formed part of the wages, of servants employed in husbandry; a bailiff or overseer was to have an allowance of 5s a year for his clothing, a hind or principal servant 4s, and an ordinary servant 3s. 4d -sums equivalent respectively to 50s, 40s, and 33s 4d of modern money. Another statute was passed in the year 1462 (3 Edw. IV c 5) for the regulation of the diess of persons of all ranks. Similar acts to those above mentioned were passed in Scotland also. In 1433 (temp. James I.), by an act of a parhament which sat at Perth, the manner of living of all orders in Scotland was prescribed, and in particular the use of pies and baked meats, which had been only lately introduced into the country, was forbidden to all under the rank of baron. In 1457 (temp James II) an act was passed against "sumptuous cleithing." The Scottish sumptuary law of 1621 was the last of the kind in Great Britain

kind in Great Britam
BBRIGORATY—Gellius, Nocies atisiae, il. 24, and Macrobius,
Satura in 17, Hanry of Humingdon, Historia Anglorum ("Rollis
Satura in 17, Hanry of Humingdon, Historia Anglorum ("Rollis
Century (1889), W. J. Ashley, Introduction to English Economic
History and Theory (1893); W. Cunningham, Growth of English
Austry and Commerce is Modern Times (1991) and Growthe of English Industry and Commerce during the Muddle Ages (1991); Baldwin
Samphany Lugglathon and Fermand Regulation in England (1995)

SUMTER, THOMAS (1734-1832), American soldier, was born in Hanover county, Va., on July 14, 1736. He served in the French and Indian War, and was present at Braddock's defeat in 1755. Later he removed to South Carolina. After the fall of Charleston in 1780, when his State was ravaged by the British, he escaped to North Carolina, where he took the field as brig.-general (i) The Oppian law, 215 s.c., provided that no woman should at the head of a body of light horse and soon became one of the possess more than \( \frac{1}{2} \) oz. of gold, or wear a dress of different most active and able leaders of the other. His vegilance and colours, or ride in a carriage in the city or within a mile of it bravery earned for him the sobriquet of "Gamecock." After

(Lancaster county), he was surprised and defeated by the British general, Tarleton, at Fishing Creek (Chester county) Raising a new force, he defeated Mayor Wemys at Fishdam (Union county) and repulsed Tarleton's attack at Blackstock (Umon county) in Nov 1780 At the time of his death at South Mount, SC. on June 1, 1832, he was the last surviving general officer of the War of Independence

See Edward McCrady, The History of South Carolina in the Revolution (1901-02); H A M Smith, "General Thomas Sumter" in Magazine of History (vol. 8, 1908, and vol. 9, 1909).

SUMTER, a city of South Carolina, USA, the county seat of Sumter county; 45 mi. E.S E. of Columbia, on U.S. highways 15-15A and 76. It is served by truck, bus lines, and the Atlantic Coast Line and the Seaboard Air Line railways Pop. 20.185 in 1050 Woodworking is its main industry. Sumter was founded in 1800, named for Gen. Thomas Sumter, and chartered in 1887. It was the first city to adopt (1912) the commission-manager form of government. The Swan Lake Iris gardens are there.

SUMY, a town of the Ukrainian S.S R., in 50° 56' N , 34° 47' E, on the Isel river, a tributary of the Psiol, and on the railway It is a grain and beet-collecting centre and has an elevator Its industries include the making of agricultural machinery, sugar refining, woollen, cloth and leather manufacture, and saw-milling, Pop (1939) 53,883. SUN. The sun is apparently the largest and brightest, and

actually almost the smallest and faintest, of naked-eye stars The illusion, of course, arises from its comparative nearness-the next nearest star is, in fact, nearly 300,000 times as far away.

### TELESCOPIC INVESTIGATION

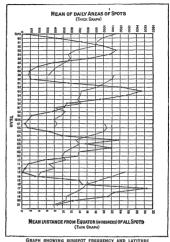
General Characteristics .- The sun presents to the telescopic view a dazzling white circular disc, with a sharp edge, whose diameter subtends an angle of about half a degree Slight but systematic variations of the angular diameter reveal the fact that the distance from the earth to the sun is not constant, and that the earth's orbit is an ellipse with the sun at one of the foci. Several methods have been employed to measure the various distances of the sun from the earth; it will suffice to describe one of them Early in the 17th century Johann Kepler, by the method of trial and error, discovered rules from which an accurate plan of the solar system could be drawn, although the scale could not be given It then became necessary only to measure at some instant the distance between any two of the bodies represented in the plan in order to fix the scale for the whole. A minor planet named Eros at certain times in its career comes within 14 million miles of the earth, and if its direction be then measured simultaneously from two places at a known distance apart on the earth the distance of the planet can be calculated from the angle between the directions A scale is thus obtained from which the distance of the sun from the earth at any time follows immediately. The mean value throughout the year (from which the actual distance never departs much) is found to be about 93,000,-000 miles. This is generally expressed by saying that the solar parallax is 8".79 (i.e., 8.79 seconds of arc), the solar parallax being the angle the earth's equatorial radius subtends at the distance of the sun.

The sun's linear diameter follows at once from this measurement and the observed angular diameter. It is approximately 865,400 miles-far transcending the powers of imagination, but small as stellar diameters go; the sun is, in fact, a dwarf star. Its mass is calculated from the force with which, according to Newton's law of gravitation, it attracts the earth, whose mass is separately determined (see EARTH). The result-2×1088 gms., i.e., 2×10<sup>27</sup> tons, or 333,400 times the mass of the earth—is about the average for stellar masses. Mass and diameter are sufficient data for the estimation of the mean density of the sun, viz .- 1.41 times that of water. This figure, of course, affords no information about the density in any particular region or the rate of variation of density from the surface inwards,

Close examination of the night sky over a prolonged period

successes over the British at Catawba and at Hanging Rock on the whole, to be getting farther apart, whereas, in the opposite direction, they appear to be gathering together This is interpreted as an indication that the sun, with its attendant satellites, is moving towards a point in the former region

Surface Features -These general characteristics must now be supplemented by more mtimate knowledge. When the surface of the sun is carefully examined it is found to present a grained



The scale on the left indicates the spotted area with a unit of one-millionth of the Sun's visible hemisphere During a complete cycle—i.e., from one minimum to the next—the solar latitude at which the spots break out changes in the manner indicated by the thin lines. As the cycle progresses there is a fairly steady approach to the equator, which, however, is never

structure; the appearance has been likened to that of rice grains and even willow leaves. The brightness of the disk in other respects also is not uniform; the region near the circumference. or lsmb, is appreciably less bright than the centre of the disk-a fact which appears most obviously in photographs. More striking violations of uniformity are caused by sunspots, which are frequently visible, sometimes even to the unaided eye. A sunspot generally consists of a central, apparently black, umbra, surrounded by a less dark penumbra. It should be said at once that each of these regions is in reality exceedingly bright, and appears dark only by contrast with the still brighter solar disk

Spots often are clustered together in groups, but perhaps even more significant is their characteristic of associating in pairs. They move steadily across the face of the sun in such a manner as to leave no doubt that the motion is due to a rotation of the sun about an axis. The sun, therefore, like the earth, is approximately a sphere, and its bright visible surface is accordingly known as the photosphere. A remarkable feature of the sun's rotation is that it does not take place at the same rate in all latitudes; ie., the sun does not rotate as a rigid body; the nearer to the equator the faster is the rotation. Sunspots very rarely shows that around the constellation Hercules the stars appear, appear outside two zones of the photosphere, bounded by circles of latitude about 5° and 40° N and S respectively Near the equator, the mean rotation period is 24 65 days, at solar latitude 20°, it is 25 19 days, at 35°, 26 63 days, and at 60° from the

Doppler effect (p 562) 30 93 days.

Individual sunspots appear spasmodically, remain visible for periods varying from one day to several months, and then disappear. This apparently capticous behaviour, however, contributes to a striking regularity which is revealed only when large numbers of spots and a great length of time are considered. Samuel Heinrich Schwabe, in 1843, tound that if the number of spots appearing per year (or the total area covered by them) were plotted against time, as in the dagram, a markedly periodic relation was shown, he number resching a maximum approximate requirity characterized the location of the spots. At a time of minimum those of a new cycle began to appear in the higher latitudes, both north and south, of their appointed bels, and as the cycle progressed the place of outbreak gradually moved towards the equator. The thin lines in the figure illustrate this

Sunspots are often accompanied by exceptionally bright areas on the photosphere, known as *faculae* They are most easily seen near the limb, where the brightness of the photospheric back-

ground is diminished.

On the comparatively rare occasions on which the sun is observed in eclipse, red flames are seen apparently rising from various points on the circumference of the dark moon. They belong in realty to the sun, and are known as promeneate: They are not seen through the telescope alone in full daylight, because the intense photosphere light, diffused by our atmosphere as by a screen of ground glass, acts as a veil through which promunences and stars alike are invisible as individual objects although their radiation contributes to the sum total of the light of day. Prominences assume various shapes and sizes, sometimes reaching heights of hundreds of thousands of mules, On such occasions they can easily be seen by the naked eve during eclipses

The most striking solar echpse phenomenon, however, is the corona, a pearly white halo enveloping the sun and extending in more or less definite rays or streamers to a distance of several of its radii. The brilliance of the corona diminishes fairly rapidly with distance from the sun's limb, and although its total brightness is not far short of that of full moon, it is still less able than the prominences to maintain the individuality of its appearance in full daylight. No two aspects of the corona seen at different eclipses are identical, but here again the apparent arbitrariness is subject to conformity with a rather vague but unquestionable relation with the sunspot period. At sunspot maximum the corona appears to extend from the sun's limb to roughly the same distance all around. At sunspot minimum, on the other hand, the poles of the sun are marked by comparatively small tufts of light, while from the equatorial regions long streamers shoot out to great distances. There is also a not fully determined relation between the corona and prominences of certain types.

### SPECTROSCOPIC INVESTIGATION

General Considerations.-The spectroscope is an instrument by means of which a beam of light is analyzed into its constituent colours, or wave lengths. The analyzed radiation of a substance is called its spectrum, and the instrument is constructed to show each colour radiated as a thin vertical line; hence the term spectra line is often used to denote a particular colour. When, in the laboratory, a substance is vaporized and made luminous, the light it emits, when analyzed by the spectroscope, appears as a collection of isolated lines and is characteristic of the substance. On the other hand, a glowing solid, liquid or gas, under great pressure or of great depth, such as is found in the stars, radiates light of all wave lengths (within rather ill-defined limits), appearing in the spectroscope as a continuous band of colour ranging from red to violet in the order of the colours of the rainbow. This is known as a continuous spectrum Again, when a beam of light which, if analyzed, would form a continuous spectrum, is allowed to pass through a less brightly glowing vapour which, acting alone, would give a line spectrum, and is then received by the spectroscope, the spectrum formed consists of a continuous background on which dark lines appear exactly in the postions of the bright lines which the interposed vapour would give by itself. This is called an absorption spectrum The glowing vapour absorbs, from the light passing through it, precasely those colours which it can itself emit. Absorption lines are not absolutely dark They contain the light emitted by the glowing vapour.

The Solar Spectrum.—The spectrum of the sun is an absorption poetrum. This gives us immediately a piece of knowledge which the telescope was powerless to reveal, namely, that the sun has an atmosphere of glowing vapours surrounding the brilliant photosphere. Further, it enables us to ascertain the elements which make up this strongshere by simply companing the postions of wave lengths, of the absorption lines with those of the emission lines produced by known substances in the laboratory. In this manner the presence in the solar atmosphere of 66 elements when when the earth (including a few doubtful identifications) has been established. For many of the remaining elements, solar conditions are unfavourable for the production of observable

lines; most of the rest are very rare

The existence of the solar atmosphere is revealed in another way during times of total eclipse. When the moon has just covered the last remnant of photosphere, the crescent of the atmosphere which still remains exposed for a few seconds gives a bright line spectrum, for the glowing vapours there have no bright photosphere behind them. On account of its evanescence, this spectrum is known as the flash, and it is, of course, essentially identical with the Fraunhofer, or absorption, spectrum in the positions of its lines Careful observation at such times enables the heights reached by the various substances to be determined It is found that the majority are confined to the lowest atmospheric layer, not more than 500 miles high, known as the reversing layer. Hydrogen, helium and calcium charged with positive electricity (sonised calcium), however, reach much greater heights, extending up to 8,000 or 9,000 miles, and form a relatively thick upper stratum of the atmosphere, which is known as the chromosphere on account of the red colour imparted to it by the glowing hydrogen Prominences are eruptions of hydrogen.

The portion of the solar atmosphere just outside the sun's limb might be expected to give a bright line spectrum in full daylight. It does not do so, however, because of the diffused photospheric light in the earth's atmosphere which masks the bright radiations. Pierre Jules César Janssen and Joseph Norman Lockyer, in 1868, independently succeeded in partially overcoming this difficulty II the dispersion of the spectroscope (£a., its power of separating the colours) is increased, the intensity of the continuous spectrum at any one point is diminished, while the lines in a bright line ness. Janssen and Lockyer found it possible so to weaken the diffused daylight that the bright lines of the chomosphere and prominences became visible

When the spectroscope is directed towards the corona, it is found that a great deal of the coronal light yields the ordinary Fraunhofer spectrum and is therefore reflected sunlight. But there is also light which must originate in the coron itself, for it gives a spectrum of which part is continuous and part is composed of bright lines which have not yet been matched terrestrially. The name coronism was one given to a hypothetical element which was once held to raduate the lines; but Bengt Eddlen has shown that almost all the coronal lines can be identified with radiations which would be emitted by isolated and very highly ionized atoms of fron, nickel and calcum.

Spectra and Physical Conditions—This change of spectrum with change of physical conditions is one of the most important phenomena of spectroscopy. We shall at this stage consider three of its aspects without inquiring into their theoretical foundations. They are, respectively, the effect on a line spectrum of temperature, a magnetic field, and motion of the source of light.

When a luminous compound body is gradually raised in temperature, changes of spectrum of two kinds take place successively. First, the spectrum of the compound gives place to the lines of the constituent elements as the compound becomes dissocated by heat; secondly, the earliest elementary lines to appear slowly lade out, while new lines\_come into view and are gradually strengthened Spectrum lines may therefore be roughly classified into "high temperature" lines and "low temperature" lines These observations have an important application when the spectra of the photosphere and a sunspot are compared. The spectrum of the spot contains evidence of compounds of which only the separated elements contribute to the photospheric spectrum, and, furthermore, the spot spectrum shows a strengthening of "low compared with the spectrum of the photosphere. The obvious conclusion is that the vapours over a sunspot have a lower temperature than the rest of the solar atmosphere.

A source of light placed in a magnetic field (i.e., a region such us the neighborhood of the poles of a magnet, m which a freely suspended compass needle is constrained to be in a definite direction) has each of its spectrum lines split into a number of component lines, lying side by side Unless the field is a very strong one, the components are too close together to be seen as distinct individuals and the lines merely appear to be broadlened. By means of special appliances, however, the existence of the separate components can be detected. In 1908 George Ellery Hale, using such appliances, found that the lines in the spectrum of a sunaport such appliances found the such lines in the spectrum of a sunaport of the support of the sup

to the sun's statuce.

Further observations showed that all sunspots are magnets, some presenting a north, and others a south pole to the surrounding space. In each pair of spots, the leader and the follower in the journey round the sun's axis had opposite polarities: Indeed, many provides to the property of the polarity in the sun's provides to the provides of the polarity in the sunthern solar hemisphere as compared with the northern; thus, if the leader of a pair were a N-pole in the northern thus, if the leader of a pair were a N-pole in the northern shapes, at vowe the northern the provides and the polarity in the sunthern solar hemisphere, and vue versa and, with few exceptions, this order would characterize all spots from one minimum to the next of a sunspot space, and vice versa, and, with few exceptions, this order would be reversed, so that the approximate period of a complete set of sunspot shenomena turned out to be, not it but az years.

More refined investigations of the same kind have shown that the sun as a whole is a magnet, just as the earth is. Its field, however, is much weaker than that of a spot, being only so gausses at its strongest observable region (the base of the reversing layer) as compared with about 4,000 gausses in large spots. (The maximum value of the earth's field is roughly 0.5 gauss)

The third of the effects mentioned above—that of motion of the source of light, or Doppler effect, as it is called—has had may and varied applications. When the distance between an observer and a source of light is decreasing the wave length of every line emuted is lessened by an amount proportional to the wave length itself and to the rate of approach. When the distance is increasing the wave length is augmented in a similar manner. This shows itself by a displacement of the spectrum lines compared with their normal positions, and the amount and direction of the displacement indicate the velocity of approach or recession.

This effect has been used to measure the speed of the sun's motion among the stars. The displacement of spectrum lines, when properly analyzed, shows that the solar system is moving at a speed of about 12 miles per second among the stars.

Another application of the Doppler effect to the sun is the verification of the speed of rotation by observing the rates of approach of the east limb and recession of the west limb. The values obtained agree very well with those indicated by the spots, and the observations can be extended beyond the belts to which the spots are confined. The same spectra can be used for a further purpose; namely, to determine what lines in the solar spectrum are produced by absorption in the earth's atmosphere. Our atmosphere, though not-luminous, is able, in great thickness, to absorb cortain lines (nown as tellular lines) proper to its constituents, which are mixed with the true solar lines in the ordinary Fraunbofer spectrum. Such lines, however, occupy identical positions

by heat; secondly, the earliest elementary lines to appear slowly in the spectra of the two limbs and are therefore readily distinfade out, while new lines\_come into view and are gradually guished from the displaced solar lines.

One of the most difficult and important applications of the Doppler effect is to the detection of atmospheric currents in the sun itself Solar storms not infrequently occur, of incomparably greater fury than the hurricanes and tornadoes of the earth, and the violent motions of the solar gases are revealed by distortions and displacements of the spectrum lines. Eruptive prominences are often the results of such storms But there are more systematic movements also which have been brought to light in the same way, and of these perhaps the most interesting are the movements occurring near sunspots The researches of John Evershed and Charles Edward St. John have shown that in the lower atmospheric levels gases move upwards and outwards from a spot, while in the higher levels the movements are inwards and downwards, as if a spot were a sort of whirlpool into which the high level gases are drawn. Indeed, there is definite evidence of high level circulatory movements round the axes of spots, which point strongly to the same conclusion

#### SPECTROHELIOGRAPHIC INVESTIGATION

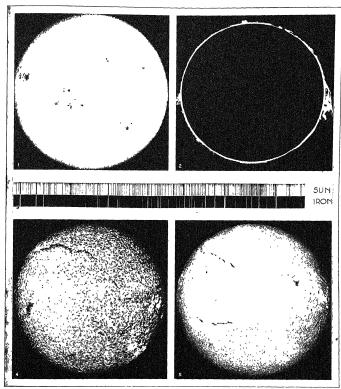
It has been saud that the absorption lines in the solar spectrum contain light emitted by the glowing atmospheric gases; it is the photospheric light that is absorbed. The spectrobeliograph is an instrument which gathers the light in a particular spectrum line and builds up a picture of the solar atmosphere in the light of that line, showing thereby how the substance producing the line is distributed in the solar atmosphere. The construction of the instrument is explained in the article SPECTROMENIOGRAPH. Some of the results which it produces are shown in Plate I, figs. 4 and 5

It is clear that the evidence of the spectroscope and spectroheliograph points the way to a fairly complete knowledge of solar meteorology, from which it appears that the structure of the solar atmosphere is anything but uniform. Atoms congregate in clouds, or flocculi, particularly in the regions of sunspots, where they form the faculae observed through the telescope Different substances are differently distributed, and the distribution of each substance is in a state of continual flux. The restless turmoil of the solar atmosphere stands in striking contrast to the comparative quietude and regularity of our own air Yet even in the sun the motions are not wholly chaotic. On the large scale there is a consistency which points to a fundamental equilibrium. There is a fairly well defined limit to the ascent of each substance above the photosphere, we never find sodium so high as hydrogen, for example. Spectroheliograms are markedly characteristic in appearance for each substance; the coarse mottled structure of the calcium clouds is immediately distinguishable from the finergrained layers of hydrogen, inconstant as each of them may be in detail. Once more there is a foundation of law and order to the superficial irresponsibility.

## BOLOMETRIC INVESTIGATION

The Sur's Total Radiation—One of the most important characteristics of the sun is its practice of radiating energy. Of the 3-79 × 10<sup>-38</sup> ergs which it discharges every second in the form of light, best, and other ethereal vibrations, its attendant planets and their satellites receive about one part in 120 million, so that he significance of the process is cosmic rather than human. This enormous quantity of energy is sent forth regularly and ceaselestly, and goes no one knows whither or to what end. In seeking there knowledge of this fundamental process the first step to be taken is the measurement of the precise rate of radiation, for which purpose use has been made of various instruments bearing the generic name, bolometer.

Owing to natural limitations we can measure only the radiation received by a small area of the earth's surface, but, knowing the dimensions of the solar system, we can readily deduce the total amount. The general method is to convert the sun's radiation into heat, which can be accurately measured—making an allowance, which must be estimated from separate investigation, for absorption but he earth's strusobhere. The result is usually example.

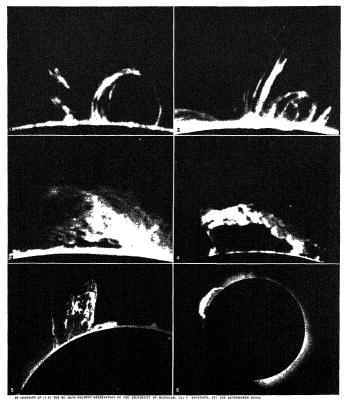


PHOTOGRAPHIC STUDIES OF THE SUN

- The photosphere of the sun, showing an unusually large number of spots, facules, and darkening at the limb (Rutherfurd)
  Photograph taken in calcium light, the image of the photosphere having been artificially covered. Shows Chromosphere and Prominences (Everhebe)
- 3 Comparison of solar spectrum with laboratory spectrum of Iron (violet
- region). Presence of Iron in the atmosphere of the sun is indicated by coincidence in positions of lines (importal College).

  4 Spectrobeliogram (photograph of sun made by monochromatic light) showing distribution of high level calcium in the solar atmosphere (Deslander).
- 5 Spectroheliogram showing distribution of hydrogen is the solar atmosphere (Deslandres)

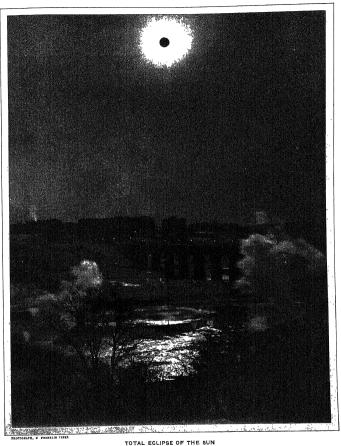
PLATE II SUN



BY COURTLEY OF (14) THE MC MATH HULBERT OBSERVATORY OF THE UNIVERSITY OF MICHIGAN, (5) J EVERSHED, (5) THE ASTRONOMER ROYAL

# STUDIES OF SOLAR PROMINENCES

- Prominens of Sec. 23, 1299; an example of the sumport-type claim.
   Satlin, A. I detectable mattern were conversed (\*\*). Rowerd to survivate of the sum). The photograph thower a loop formation that measured approximately 90,000 m/j. in height and 105,000 m/j in both at the start of the report The overall dimensions increased about 25% during the period of observation.
- 20% during we person to users with a fine and a markable suspective prominence of Seat. 7, 12959, recorded in a markable suspective progressed, the general pattern became intricate, developing a background of faint (plantic losses and many small soodensations might high velocities toward the chromosphere. The longest treamer extended more than 150,000 ml above the edge of the sun.
- 3 Quasi-cruptive prominence of Aug. 24, 1939, photographed in the light of ionized caloium. The prominence was about 105,000 mi. high and extended about 155,000 mi. along the edge of the sun.
- 4. The same prominence as in (3), photographed the next day
- 5 Prominences of the sun observed May 26, 1916, at Srinagar, Kashmir, India
  - 6 Inner corona and prominence photographed during a total solar collipse, May 29, 1919, observed at Sobral, Brazil The red flame rose from a height of 130,000 mi to more than 500,000 mi above the surface of the sun in less than seven hours



The sun in total colipse at 9 a m. January 24, 1925, showing the long streamers of the Corona. From a photograph made from High Bridge Park, New York City, overlooking the Harlem River. Although the sun itself is hidden by



SUN

presed as the solar constant, which is defined as the amount of energy which would fall perpendicularly per square centimetre per minute on a surface placed just outside the earth's atmosphere. The value of this constant, according to Charles Greeley Abbot, is about 1 94 calones (81,000,000 ergs), but it is subject to slight variations which are related to the sunspot periodicity and possibly to other factors also. The rate of radiation appears to increase with the prevalence of sunspots, but further observations are recaused to determine the relation precisely

The question of the source and maintenance of this ceaseless efflux of energy will be dealt with in a later section of this article For the present we will limit ourselves to the consideration of the immediate use which can be made of the measurements in the light of ascertained physical principles It is known that surfaces in a certain condition-known as that of a berfect radiator or black body-when they radiate energy, do so at a rate strictly proportional to the fourth power of their absolute temperature The assumption that the sun radiates like a black body, though oversimplified, should give a fairly good approximation to the temperature Now the sun cannot be uniform in temperature throughout, so that it is necessary to consider what region has the temperature so determined Since the greatest part of the radiation is in the form of visible light, this region must be the photosphere, and the photosphere is a relatively thin superficial layer at the base of the atmosphere. Thus the temperature measured from the total radiation is that of the outside of the sun It is called the effective temperature, and has a value of 5.750 absolute centigrade degrees

The Sun's Analyzed Radiation -The bolometer also provides the data for another method of estimating the sun's effective temperature. The 1adiation from a black body is distributed among the various wave lengths in its continuous spectrum in a manner definitely related to the temperature of the body. Thus, if the bolometer be passed along the solar spectrum, and the amount of energy at each point in the continuous background thereby measured, the distribution of energy throughout the spectrum may be determined and the absolute temperature deduced. (Allowance must again be made for absorption by the earth's atmosphere, which is not uniform for all wave lengths ) There are two partially independent methods of analyzing the observations to obtain the temperature, which yield the respective values, 6,150° C. and 5,800°-6,300° C. If the sun behaved exactly as a perfect radiator, these determinations would agree with one another and with the result obtained from the undissected radiation. The slight departures from agreement show that the sun is not quite in this condition, but is sufficiently near to it to enable us to say with confidence that the temperature near its surface is about 6,000° C.

#### CONSTITUTION OF THE SUN

Modern View of the Sun's Constitution .- The chief facts concerning the sun which have so far been brought to light are now before us, and the question arises: What idea of the sun do they lead us to form? Following the independent investigations of Arthur Stanley Eddington and James Hopwood Jeans, we think of a vast concourse of broken fragments of atoms in violent movement, held together by gravitational attraction. An atom, it should be remarked, is now pictured as a sort of miniature solar system, in which a number of electrons, or units of negative electricity, revolve round a positive nucleus. The net amount of positive electricity in the nucleus is, in the normal atom, exactly equal to the sum of the negative charges constituting the revolving electrons, and one element is distinguished from another by the amount of this charge. Thus, the hydrogen atom consists of a nucleus with one unit of positive charge and a single satellite electron: the helium nucleus has two units of positive charge and two satellite electrons; and so on, up to uranium, the heaviest known element, which has 92 units of charge in the nucleus and 92 revolving electrons. By certain methods some of the electrons can be detached, one by one, from their orbits and set free. The remainder of the atom is then said to be ionized Atoms can thus be singly, doubly, and, in general, multiply ionized, according to the number of electrons which are so detached. In such states, however, they for fully 1,000,000,000 years.

are unstable and recapture electrons to make up their deficiency at the earliest opportunity

Positive nucles and electrons, then, are the material units of which the sun is believed to be composed Present knowledge of nuclear physics makes it very improbable that stable atoms of other kinds—which would necessarily be heavier than those known on earth—should be present in the sun 'The direct evidence of the spectroscope, of course, reveals the composition of the sun's atmosphere only. Since the sun is radading energy, contions of stability require that it shall get hotter towards the centre, so that the effective temperature of 6,000° C represents approximately the minimum solar temperature. Now from laboratory experiments and deductions therefrom, we know that high temperature is one of the agentischrough which atoms are ounzed the interfor of the sun must therefore be pictured as a swarming control of electrons and iomned another the control of electrons and of inset characteristics. He control is approached. Near the centre, in fact, the nuclea are almost, if not only its first satellite electrons.

In the ceaseless and inconceivably rapid motions electrons are captured by nuclei and set free again millions of times per second Both the cause and effect of this process is radiation. Every time an electron is captured the energy of its former motion is liberated as a unit beam, or quantum, of radiation; every time a quantum falls on an atom tuned to receive it a satellite electron absorbs its energy and flies into momentary freedom. Ionized atoms. electrons, and radiation thus take part in a process of continual interchange, rapid beyond conception and without pause or diminution of intensity. But there is an important difference in the behaviour of the atoms and electrons on one hand and the radiation on the other. The headlong careering of the former is kept within a limited range by the gravitational equilibrium of the whole mass, while electrostatic forces preserve a constant proportion between the number of nuclei and the number of electrons in each region Radiation, however, is not so controlled It works its way from the centre, where it is most intense, out to the surface and thence to space at the observed rate of 3 79×1033 ergs per second. The sun loses radiation at this enormous rate, and has been doing so for countless millions of years, while the electrons and atomic nuclei remain chained within its boundaries. How is it possible for the process of interchange to be maintained?

It has been realized for some years that the energy required to keep it going must anse from reactions involving the nuclei of atoms, which result in a diminution of their aggregate mass, and the liberation of the great amount of energy which, by the principles of relativity, corresponds to thus Great numbers of nuclear reactions have been produced in the laboratory by various means since about 1930; and among these a group has been found which suffices to account quantitatively, as well as qualitatively, for the sun's energy production.

The researches of Hans A. Bethe have revealed a complex cycle, involving reactions between nuclei of hydrogen, carbon and nitrogen, with the (net) result that hydrogen disappears, helium is formed, much energy is hberated, and the heavier nuclei are regenerated to act as catalysts again (and again). Every reaction nucleved in this process has been produced in the laboratory, the would combine into an automatic operation only at temperatures of the order of 2,000,000° C. This process probably maintains the radiation of the siars of the main 'sequence' (ree STELLA CONSTRUTION AND EVOLUTION').

The picture of the sun which we have so far drawn will fat almost any star, and indeed will be found with greater elaboration of detail in the article Star. We proceed to particularize for our own luminary. The calculations of G. Blanch, A. N. Lowan, R. E. Marshak and H. A. Bethe (which satisfy the physical requirements known in 1944). lead-to a central temperature of 26,000,000° C, a central density 110 times that of water, and a hydrogen abundance of 35% by weight. Other solutions, with kelium present and somewhat different internal temperatures, are possible. The transformation of 1% of the sun's mass from hydrogen into helium would supply energy enough to keep it shining each.

Application to Detailed Features -Such, in outline, is the idea which is now held of the sun's constitution. The concepts out of which it is formed are atomic nuclei, electrons and radiation If it were complete, the existence of sunspots, prominences and the corona, the sun's rotation, equatorial acceleration and magnetic field, and the phenomena of the atmosphere would follow as mevitable consequences They do not do so because we have either not yet specified sufficient fundamental concepts or failed to realize the full potentialities of those we have specified. Yet some progress has been made, especially in the consideration of the atmosphere, where, thanks largely to Megh Nad Saha, Ralph Howard Fowler, Edward Arthur Milne and Henry Norris Russell, ideas consistent with those applied to the interior have shown how the more prominent of the observed phenomena arise The atom of each element requires a certain amount of energy to detach each of its elections successively, and the conditions favouring detachment, or ionization, are high temperature and low pressure. Thus the specof its elections successively, and the conditions invouring unanament of ionization, are high temperature and low pressure. Thus the spectrum lines of sodium are produced only up to a certain height because, in the lower pressures above that height, all the atoms of sodium are ionized, in which state they produce different spectrum lines lying outside the range of wave length which the transparency of our atmosphere allows us to observe The precise connection between the ee of ionization and the physical conditions has been formulated, and this enables the temperature and pressure in the sun's atmosphere to be estimated from the observed heights reached by the various elements. It appears that the pressure in the sun's atmosphere is very low—less than one thousandth of that of the earth's atmosphere—while the temperature is not far below that of the photosphere. Whom wants the temperature is not in below that of the photosphere. When the temperature is not in below that of the photosphere when the theory of the throughpets are processed of the throughpets are processed of construction (see Censotwarman) papers in processes of construction (see Censotwarman) of the chromosphere is in processed of construction (see Censotwarman) of supports about the lines of the general solar theory, the work of Hale has greatly clarified our ideas of the nature of those objects. Hale pictures

Although there is at present no sign of an explanation of sunspots along the lines of the general solar theory, the work of Hale has greatly clarified our sciens of the nature of these objects. Ella pictures are considered to the solar present of the control of the solar particles produces a magnetic field. Photospheric matter is projected upwards along the axis of the vortex, becoming cool by sodden expansion and so appearing dather than the rest of the photosphere. This forms the umbra of a spot, and the outspreading and circulation of the material in the atmosphere constitutes the permuthra summing that during sesh 11-year cycle there exist, immediately beneath the photospheric two vortex rings, one in each hemsphere, each lying along a circle of latitude. When, at a certum point, a ring rises up to the photospheric and the strespected by it the two sections of the rotations and therefore opposite magnetic polarities. Periodic movements of the rings in latitude, occurring as part of a definite system of circulating currents of solar matter slightly below the photospheric elevel, account for the observed altitudinal magnation of the spots. This a very plausable hypothesis. It remains to be shown how such mag-have developed in a sun having the constitution described above.

in the construction of the state of the constitution the screen and constitution to be a state of the state o

SUNBIRD, the name of a group of small birds of about 104 species forming the passerine family Nectarinidae They live in the old world, chiefly the tropics; Africa is richest in species, then southern Asia and near-by islands, and one species reaches Australia. They are forest, brush and even garden haunting birds. The males of many species have brilliant colours; iridescent blues, purples and greens with patches of yellow, red and black are common. However, some species are dull coloured, as the females usually are. Sunbirds are characteristically flower birds, flitting about actively, perching among the blossoms and probing into the flowers for their food of small insects and nectar. For this they have long, slender, curved bills and extensible, more or less tubular tongues. The usual type of nest is an oval, pensile structure attached to a twig. The entrance is at the side near the top, over which a perchlike roof projects. The eggs are usually spotted and two in number. (A. L. Ro.)

SUN BITTERN, a bird, Eurypyga helias, of Central and South America placed in a family by itself, Eurypygidae. It is distantly related to such birds as the kagua of New Caledonia, rails

and cranes, and is grouped with them in the order Gruiformes. It is a slender bird about 17 in. long, somewhat raillike but with



full wings, a long, ample tail and a plumage variegated with browns, yellows, black and white It lives on the ground in wet forests and feeds on insects. Its display, involving spread wings and tail, is striking.

A L Rp.)

SUNBURY, a city of Pennsylvania, U.S., the county seat of Northumberland county; 40 mi (in an air line) N of Harrsburg, at the confluence of the west and the north branches of the Susquehanna iiver; served by the Pennsylvania, the Lackawanna and the Reading railways The population was 15,570 in 1950, and in 1940 it was 15,462. Sumbury is on the site of the old Indian village Shambolia. It is the site of historic Fort Augusta, pre-Revolutionary fort erected in 1756, where the power of the French was broken in the French and Indian War, a vital development in determining that the language and culture of the United States should be Englash rather than French.

Sunbury was surveyed in 1772 and was incorporated as a

borough in 1792
SUNBURY-ON-THAMES, an urban district in the Spelthorne parliamentary division of Middleses, Eng. 17 mi S.W. of
S. Paul's cathedral, London, by road. Pop. (1951) 23,356. Area
9 sq mi. It is a favourite riverside resort and residential district
which now includes Shepperton, Littleton, Charlton and parts of
Ashford common 'There are large buildings, pumping works and
filtration beds for the water supply of London, the installations
belong to the Metropolitan Water board 'The reservoirs at Littleton are very extensive. To the northeast is Kempton park, the
northeast of the state of the state of the state of the state of the parts
The park is famous for its race meetings, the principal fature being
the jubilee Handicap, established in 1887. There are locks on the
river at Sunbury and Shepperton, and at each place regultas are
held during the summer

SUN CHUANG-FANG (1885- ? ), one of the group of men who rose to prominence and obtained a brief tenue of power in China during the years of strife which succeeded the death of Yuan Shih-kai, Born in Lingcheng in the province of Shantung, he received military training at the Peryang college and in Japan In 1921 he obtained command of a division under Wu Pei-fu, and two years later he was appointed military governor of Chekiang. During 1924 and 1925 he extended his authority over Kiangsu and after defeating his northern rivals, announced the consolidation of five provinces, Kiangsu, Chekiang, Anhwei, Kiangsi and Fukien, into an independent state under himself as governor general. He was the ablest and the most enlightened of the tuchuns, travelling continually through his territory to see for himself that the people were fairly treated. He was on friendly terms with the foreign authorities of Shanghai, openly expressed shame at the backward state of Chinese cities and pleaded for foreign co-operation. In May 1927 he was swept aside in the advance of the Nationalist army from Canton to the Yangtze and fled to Peking. In 1928 he fought bravely but unsuccessfully at Hsuchowfu against Chiang Kai-shek's march on Peking. In 1933 he became a Buddhist monk Later it was widely reported that he had been assassinated by a woman whose father he had executed.

SUN COPYING or Photocopying, the name given that branch of photographic contact printing which is carried out without the aid of a camera-made negative.

(See Blue Print.)

SUN CURE; see Heliotherapy; Sunlight Treatment.

SUNDA ISLANDS, the collective name of the islands from the Malay peninsula to the Moluccas, including the Great Sunda Islands—i.e, Sumatra, Java, Borneo, Celebes, Banka and Billiton, and the Lesser Sunda Islands, Bali, Lombok, Sumbawa, Flores, Sumba and Timor, etc.

Sunda strait is the channel separating Sumatra from Java and uniting the Indian ocean with the Java sea. Its narrowest part, between the southeastern extremity of Sumatra and the

town of Anjer in Java, is 14 mi wide In the middle is the lowlying well-wooded island of Dwars-in-den-Weg ("right in the way"), otherwise Middle Island or Sungian, which divides the strait into two channels each about 4 mi wide. In 1883 Sunda strait was the scene of the eruption of Krakatoa (q.v.). The

Sunda group was occupied by Japan in 1942,

SUNDARBANS or SUNDERBUNDS, a tract of country in Bengal, India, forming the seaward fringe of the Gangetic delta It extends for about 170 m along the sea face of the Bay of Bengal, from the estuary of the Hooghly on the west to that of the Meghna on the east, and runs mland for a distance of 60 to 80 miles It is intersected from north to south by large tidal rivers or estuaries, which are connected by numerous interlacing channels. The whole tract is a network of estuaries, rivers and creeks, which enclose a large number of flat, marshy islands Many are covered with forest and a dense undergrowth standing m soft mud, half m and half out of the water The area under forest is about 3,000 sq miles The characteristic tree is the sundri (Herstiera littoralis), from which the name of the tract has probably been derived Along the sea face the forest is composed of mangrove, which in some places are separated from the sea by a line of sand dunes. Cultivation is confined to the north, where over 2,000 sq m. have been settled, but the population is very sparse South of the area of cultivation, the Sundarbans are practically ununhabited The chief wild animals are tigers, of which many are man-eaters, leopards, deer and wild pig; crocodile infest the estuaries

SUNDAY, the Lord's day in the Christian world, the first day of the week, and the day set apart for divine worship in Christendom, in memory of the Resurrection Early apostolic writings bear witness to the sanctity of the day dedicated to the duties laid down in the fourth commandment, the equivalent in the Christian religion of the Jewish Sabbath (Saturday). Eventually the Roman emperor Constantine enjoined Sunday rest from labour, except agricultural, by constitutions, the first of which was decreed in AD. 321, and most of which are contained in the

code of Justinian.

English Laws .- In the 7th century AD. the laws of Wihtred, king of Kent, provided that if a servant, contrary to his lord's command, did servile work between sunset on Saturday evening and sunset on Sunday evening, he should pay a fine to his lord: they forbade a servant to make a journey of his own on horseback on Sunday under penalty of a fine or the lash, and a freeman to work during the forbidden time, under certain penalties including the payment of half the fine to the informer, who also was entitled to the profits of the Sabbath-breaker's labour. On the other hand, Ina, king of Wessex, in the same century ordained that if a slave worked on Sunday by his lord's command he should become free, and the lord be liable to a fine of 20 shillings.

By a series of statutes, many of which are still the law of the country, it is illegal to work or to take part in certain forms of pastime on a Sunday, which in English law is reckoned from midnight to midnight The first such prohibition in a statute is in 28 Edw. III. c. 14 (repealed) by which in 1354 the sale of wool at the staple was forbidden on a Sunday. Although the church had sufficient temporal power to visit Sabbath-breakers with its displeasure, Sunday observance was not ordained by statute until the reign of Edward VI. by the Act of Uniformity of 1551. By I. Eliz. c. 2 (1558) everyone had to go to church on a Sunday or be liable not only to the censures of the church but to a fine of twelvepence. The penalty was not formally repealed until 1846 (9 and 10 Vict. c. 59). It is still the law of England that members of the Church of England are required to attend divine service on Sunday, and though in practice this law has not been enforced for generations, obedience to the law has been upheld by the High Court in the analogous case of Ascension Day as against a - later Act relating to compulsory education attendance (Marshall and Bell v. Graham, 1907, 2 K.B. 112).

By the Sunday Observance Act 1677 tradesmen, artificers, la-bourers "or other person whatsoever" are forbidden to carry on their ordinary businesses under penalty of a fine of 5s or two

some of the inconveniences in modern life caused by the 1677 Act, which however did permit the sale of milk before 9 AM. and after 4 PM., and of victuals in cook shops and fried fish shops (Bullen v Ward, 1905, 14 L J K B, 916) Other statutes followed but are all repealed Still law are the Acts of 1762 (2 Geo. III c 15 s. 7), allowing fish carriages to travel on Sunday in London and Westminster; 1827 (8 Geo. IV. c 75), repealing s. 2 of the Act of 1677 as far as regards Thames boatmen. The Bread Acts of 1822 (3 Geo IV. c. 106) allow bakers in London, and of 1836 (6 and 7 Will. IV c. 37) allow bakers out of London, to carry on their trade up to 1.30 P M Since an Act of 1871 (34 and 35 Vict. c. 87) no prosecution for penalties under the Act of 1677 can be instituted except with the consent in writing of the chief officer of a police district or the consent of two justices or a stipendiary magistrate. (Thorpe v Priestnall, 1897, 1, QB 19.)

Since 1871.—The result of the Act of 1871 has been in substance to make the Lord's Day Acts a dead letter as to Sunday trading. In London Sunday markets are usual in all the poorer districts, and shopkeepers and hawkers are allowed freely to ply their trades for the sale of eatables, temperance drinks and tobacco The Factory and Workshop Act (1901) forbids the employment of women, young persons or children on Sunday in

a factory or workshop (s 34).

The Shops Acts 1912-22, which regulate certain conditions of employment for shop assistants and ensure them a half-day holiday, tacitly imply that the x677 Act is still in general operation with regard to shops. The intention to exclude Sunday from the operation of the 1912 Act may be assumed from the power given by s. I to exclude shops of any specified class from the operation of a closing order which would be in conflict with the Sunday Observance Act.

Fishing is permissible on a Sunday, except that one may only fish for salmon with rod and line (Salmon Fishery Act 1861). By the Game Act 1831, it is a crime to take or kill game on a Sunday, but the prohibition does not apply to rabbits. The law with regard to Sunday entertainments and performances is based upon the Sunday Observance Act 1781 (21 Geo. III. c. 49) by which heavy pecuniary penalties were imposed upon anyone who promoted any public entertainment or debate to which people were admitted only by payment A bill to permit certain public entertainments on a Sunday was introduced in April, 1931.

Sunday is a dies non for the sitting of the courts or meetings of public bodies, though parliament has at times sat on a Sunday in national emergencies, and Saturday sittings of the House of Commons have been extended into the small hours of the Sabbath. Process may not be served nor persons arrested except in cases of treason, felony, or breach of the peace (1677 Act), but

a justice may issue an arrest or search warrant.

Contracts on a Sunday.—Though at common law a contract made on a Sunday is valid, the technical restrictions imposed by statute on Sunday labour, especially those contained in the Sunday Observance Act 1677, render most contracts made and completed on that day void or voidable (Smith v. Sparrow, 1827, 4 Bing. 84). But any contract in respect of labour, business, or work not done in the course of a man's ordinary calling is binding. A cheque drawn on a Sunday is binding on the drawer; in an action on a bill of exchange drawn on a Sunday the drawer was given judgment against the acceptor (Begbie v. Levy, 1830, I C. and J. 180). The position in regard to these matters has been clearly laid down by the Bills of Exchange Act.

Computation of Time.-Where any limit or period of time fixed in the High Court exceeds seven days the Sundays included in it (except in divorce proceedings) are counted in computing the time, provided that if the last day fall on a Sunday, the period must be computed so as to cover the next following working day. But where the period fixed is less than six days Sunday is not counted, so that five days from a Saturday would commence on the following Monday and end on the Friday,

In Scotland and the British dominions the laws as to Sunday have followed more or less the same course, except that native customs have been interfered with as little as possible and parhours in the stocks in default. Acts have been passed to obviate ticular Acts have been passed to meet special needs. (W. La).

United States.-In the United States Sunday legislation, beginning with an enactment of the Virginia colony in 1617, was quite general in colonial times, and Sunday laws of varying types have been passed by all the states Their general trend is to prohibit the carrying on of any business on Sunday that is neither necessary nor charitable in nature. In some states general provisions to this effect are in force, others prohibit the conduct of particular trades and occupations. Many states forbid Sunday sports, prohibiting games and theatrical performances from being conducted for profit. Violation of the Sunday laws entails three It subjects the violator to the criminal penalty prescribed by statute. It makes unenforceable contracts, including promissory notes, executed or to be performed on Sunday. In a few states, it subjects the violator to a civil disability, thus preventing a traveller on Sunday from recovering for a negligent injury done to him inasmuch as his own illegal act was a cause of the injury. The criminal enforcement of Sunday laws throughout the United States is notoriously lax. (I. M La)

SUNDAY SCHOOLS. Late in the 18th century the educational problems arising from the industrial revolution led to a new religious effort in the form of the Sunday school movement. Robert Rarkes established his first Sunday school in Gloucester, England, in 1780 The idea, however, did not originate with Raikes. Among earlier pioneers in this field were Joseph Alleme, the Puritan Father, who founded Sunday schools in England in the 17th century, and John Wesley, who held Sunday classes in Savannah, Georgia, in 1737. Yet, by reason of his achievements in organization, Raikes is justly regarded as the founder of the English Sunday school. In its early days the Sunday school was of especial educational value because of its combination of secular and religious instruction; sometimes sessions were held on Saturday, as well as Sunday. But with improved economic conditions and the establishment of day schools the Sunday schools became more restricted to religious instruction.

Early in the 19th century the Sunday school movement became firmly established in the United States, and expanded apidly oflowing the organization in 18-24 of the American Sunday School Union and again after the introduction in 1872 of the international uniform Sunday school lesson system From Great Britain and the United States, Sunday schools have spread widely in other parts of the world, although according to figures released by the World's Sunday School association in 1936, the U.S.A. contained more than half the world Sunday school membership of 38,000,000 The Methodist Episcopal church led all U.S. denominations with a Sunday school membership of 35,000,000

SUNDERLAND, CHARLES SPENCER, 320 EARL OF (c. 1674-1722), English statesman, was the second son fit and earl, but on the death of his elder brother Henry he became heir and in 1703 succeeded to the perage. He married in 1700 Anne Churchill, daughter of the famous duke of Mariborough.

Sunderland met George I in 1706 and when the elector became king he was made lord-lieutenant of Ireland. In August 1715, he joined the cabinet as lord keeper of the privy seal, and in March 1718, he became prime minister, but his connection, though slight, with the South Sea bubble led to his political ruin. In April 1721, he resigned his offices. He died April 193, 1722.

SUNDERLAND, ROBERT SPENCER, 200 EAU. or (1662-720). English politician, was the only son of Henry Spencer (1602-648), 1st earl of Sunderland In Feb. 1670, he nettered political life as secretary of state for the northern department. He voted for the exclusion of James, duke of Vork, from the throne, and made overtures to William, prince of Oratee, and consequently in 168t he lost both his secretaryship and his seat on the prity council. Early in 7683, however, through the influence of the duchess of Portsmouth, Sunderland returned his position of secretary, to which was soon added that of lord president of 1fth coincil. Blug although he had in 7687 openly empraced the Roman Catholic faith, he hesitated to approve the Regie acts of the King 2 devotes, and in Oct. 1688 he was dismissed. He took refuge in Holland, but, in 7691 he was permitted by refurit to Expland, and he declared himself a Protestpan and be-

gan to attend the sittings of parliament, He died Sept 28, 1702. SUNDERLAND, seaport, municipal, county and parliamentary borough, Durham, England, at the mouth of the river Wear, on the LNE. railway, 261 mi N from London. Pop. (1951) 181,515. The borough includes the township of Bishopwearmouth, which lies on the south bank of the river, and that of Monkwearmouth, situated on the north bank The borough has been considerably extended, its area being 10 8 sq mi and including the former urban district of Southwick The great castiron bridge which crossed the river with a single span of 236 ft at a height of 120 ft above water was replaced by a modern structure in 1929. The old bridge was opened in 1796 and widened under Robert Stephenson in 1858 The only ancient building is the church of St. Peter, Monkwearmouth, in which part belongs to the Saxon building attached to the monastery founded by Benedict Biscop in 674. The church of St. Michael, Bishopwearmouth, is on an ancient site, but was rebuilt in the 10th century. There are six parks (136 ac.) in the borough, a museum and art gallery

The prosperity of Sunderland rests on the coalifields of the neighbourhood, the enstence of which gave rise to an export trade in the reign of Henry VII For 5 ml. above its mouth the Wear resembles on a reduced scale the Typne in its lower course. The town has exported as much as 5,000,000 tons of coal and coke yearly, but the dependence upon the coal trade only aggravated the effects of the depression of the 1930s. The harbour of 125 ac is formed by two stone piers. The parliamentary borough returns two members

History.-The history of Sunderland is complicated by the name Wearmouth (Wiramuth, Wermuth) being applied impartially to the Monk's town on the north bank of the Wear, the Bishop's town on the south and the neighbouring port now known as Sunderland. In both Monk's and Bishop's Wearmouth the settlement was connected with the church. Benedict Biscop in 674 founded the Benedictine monastery of St. Peter on the north bank of the river. The abbey, where Bede was educated, was Walcher (1071-80) settled Aldwin and his companions there.

Bishop William of St. Calais (1081-96) transferred monks there from Durham, and Wearmouth became a cell of the larger house There seems no doubt that the borough, identical with that to which Bishop Hugh of le Puiset granted his charter, was in reality Sunderland, the name Wearmouth being used to cover Bishop's and Monk's Wearmouth and the modern Sunderland. The shipping trade of Bishop's Wearmouth showed a steady increase. In 1382 there was probably a dock here and from the 16th century, Bishop's Wearmouth seems to have been completely identified with Sunderland: in 1567 Wearmouth was one of the three ports in Durham where precautions were to be taken against pirates, while no mention is made of Sunderland. Monk's Wearmouth remained purely agricultural until 1775, when a shipbuilding yard was established and prospered to such an extent that by 1795 five similar yards were at work. Prosperity continued until the depression of the 1930s caused severe unemployment-41% of the insured population in 1934.

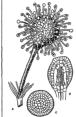
Sunderland was at farm in 783 and rendered 100 shillings and the town of Sunderland rendered 38 shillings tallage in 1179 turning the vacancy of the see, in 1138 Thomas Menvill held the borough, Edward IV in 1464, sede vacante, granted a lease of the borough, Edward IV in 1464, sede vacante, granted a lease of the borough, Edward IV in 1464, sede vacante, granted a lease of the borough from time immemorial, under the name of the New Borough of Wearmouth

SUNDEW, the popular name for plants of the genus Drossra, of which there are more than 90 species with world-wide distribution. There are four species in North America and three in Europe. The most extraordinary development of this genus is attained in Australia and South Africa, where, in addition to the low, soft, herbaceous plants found elsewhere, occur tall plants attaining a height of three feet with wirry stems which climb by the aid of certain of their addhesive leaf blades.

All species are carnivorous. They catch their prey by means of tentacles which spring in a regular pattern from the upper surface of the leaf blade. As many as 400 have been counted on a leaf of D. rotundifolia o 9 cm in diameter The tentacles ovate, compressed body-whence the popular name pumpkin seed stand distinctly separated They vary in size, shorter in the middle of the blade and much longer (o 6 cm ) along and near the margins In some species with linear leaves there is little or no difference in size Each tentacle consists of a stalk, broader at the base and tapering to the top, which supports an oval or nounded gland of rather complex structure The middle of this gland is occupied by a cylindrical mass of water vessels enclosed within a bell-shaped layer of flat cells. The cells which form the

edge of the bell extend to the outer surface of the gland Covering this bell are two courses of cells normally filled with red or purplish sap Each gland secretes and supports a droplet of mucilage, which, in multiple, renders the leaf very dewy in appearance, hence the common name The red point of colour shining through the clear mucilage presents an appearance of rare beauty, which appears to attract insects. Connecting the gland with the vascular tissues of the leaf is a strand of vascular tissue extending through the stalk and base to the veins of the blade.

The tentacles are capable of motion. Darwin was the first to make extensive experimental studies on the matter. When a small insect alights on the leaf, its escape is prevented by the mucilage, which smears and smothers sections of a GLAND FROM THE it during its struggles to escape



FROM LLOYD, "THE CARNIVOROUS PLANTS"

SUNDEW (DROSERA ROTUNDIFOLIA) A. LEAF, SHOWING GLANDS, B AND C. LONGITUDINAL AND TRANSVERSE TENTACLE

The presence of an insect affords a stimulus to neighbouring tentacles, which bend toward the prey and attach themselves to it by their mucilage, bringing a large contact surface to bear A digestive ferment is then secreted which attacks the nitrogenous content of the prey. The products of this digestion are then absorbed by the same glands. The movements of the tentacles are complex, but the net result is to bring the body of the prey toward the middle zone of the leaf blade, which itself can bend to surround the prey. There are also many minute sessile glands scattered over both leaf surfaces whose function is problematical The leaf blade may be nearly orbicular, or linear and rush-like (it is then nonmotile), with various intermediate forms. Some are peltate and circular, bowl-shaped or lunate, others variously ovate to large strap-shaped.

Reproduction takes place not only by seeds, but also by leaf buds which spring normally from the bases of the tentacles, more abundantly on leaves which have been detached. In one or two species, buds, in the form of gemmae, spring from the apex of the stem after the foliage leaves have been produced Some species produce "droppers," special branches with negative geotropism, which penetrate the substrate Their ends then enlarge into tubers, Closely related to Drosera are the genera Drosobhyllum and Byblis, both carnivorous, and Roridula (q.v.), once thought to be so. See C Darwin, Insectivorous Plants (1875); F E. Lloyd, The Carnivorous Plants (1942). (F. E. L.)

SUN-DIAL: see DIAL.

SUNDSVALL, a seaport of Sweden in the district (län) of Västernorrland, on a wide bay of the Baltic, at the north of the Selanger river, 360 mi. N. of Stockholm, the terminus of a branch from Ange on the Northern railway. Pop. (1943), 19,167. It was rebuilt in brick and stone after a fire in 1888.

SUNFISH, a name sometimes given to the Centrarchidae, a family of perch-like fishes inhabiting the fresh waters of North America, and especially to the common sunfish or pumpkin seed (Eupomotis gibbosus), abundant, especially in ponds, from Maine to Minnesota and southward near the Atlantic coast to Florida. This favourite of juvenile anglers has a strikingly coloured.

-which is sometimes 8 in, long, though usually smaller, greenish and bluish olive above, spotted with orange on the sides, and orange below. The female deposits her eggs in a nest scooped in the muddy bottom of shallow water by the male, who guards it until the young are hatched The name sunfish is applied also to the Molidae marine fishes of the order Plectognathi curious fishes appear tailless, the body ending abruptly behind the dorsal and anal fins, they have a small mouth, with a single sharp-edged tooth-plate in each 1aw. Mola include two species, large. stout, deep-bodied fishes with a rough skin, they are oceanic inhabiting warm seas, and may often be seen resting at the surface, they reach a length of 8 ft and a weight of perhaps two tons The oblong sunfish (Ranzama truncata) is longer and more compressed, smooth, with tessellated scutes; it reaches 2 feet.

SUNFLOWER. The common sunflower, Helianthus annuus, a member of the family Compositae, is a native of the Great Plains region of the USA It is an annual herb with a rough hairy stem 3 to 15 ft. high, broad coarsely toothed rough leaves 3 to 12 in long, and heads of flowers 3 to 6 in. wide in wild specimens and often I ft or more in cultivated. Double forms are in cultivation, one (globosus fistulosus) having very large globular heads. The plant is valuable from an economic as well as from an ornamental point of view The leaves are used as fodder, the flowers yield a vellow dve and the seeds contain oil and are used for food. It is cultivated in the U.S.R., England and other parts of Europe, in Egypt and in India for the seeds. the vellow sweet oil obtained by compression being considered about equal to olive or almond oil for table use. Sunflower oilcake is used for stock and poultry feeding, and is ordinarily exported from the USSR, to Denmark, Sweden and elsewhere The genus Helianthus contains about 60 species, chiefly natives of North America, a few being found in Peru and Chile. They are tall, hardy annual or perennial herbs, several of which are of easy cultivation in gardens with moderately good soil H decapetalus is a perennial about 5 ft. high with solitary heads about 2 in across in slender twiggy branchlets; H. multiflorus is a beautiful species with several handsome double varieties, H orygalis is a graceful perennial 6 to 10 ft high, with drooping willow-like leaves and numerous comparatively small yellow flowerheads. H atrorubens is a smaller plant, 2 to 5 ft. high, the flower heads of which have a dark red or purple disk and yellow rays. There are many fine forms of this, some of which grow 6 to 9 ft high and have much larger and finer flowers than the type. Other fine species are H giganteus, 10 to 12 ft.; and H. mollis, 3 to 5 ft H, tuberosus is the Jerusalem artichoke.

SUNG DYNASTIES: see China: History; Chinese PAINTING; CHINESE SCULPTURE.

SUNIUM, a cape at the S extremity of Attica, with a temple of Poseidon as landmark for ships, the modern Cape Colonna. The rocky promontory was fortified by wall and towers, in 413 BC., against the Spartans in Decelea; but was soon after seized by fugitive slaves from the Laurium mines. In the 4th century it was still a fortress. The temple, probably built in the time of Pericles, in the place of an earlier one, similar but of tufa or 'poros" stone, is shown by an inscription to be dedicated to Poseidon, not, as formerly supposed, to Athena, whose temple, of peculiar plan, with colonnade on two sides only, lies about a quarter of a mile away to the N E. Of Poseidon's temple there are still standing nine columns of the S. side, two of the peristyle on the N., one of the antae and an inner column of the brongos, of local white marble, which has suffered from the weather,

SUNLIGHT TREATMENT. (See also Heliotherapy: VITAMINS.) In countries where, relatively, there is much persistent cloud, in extreme northern or southern lands where night is long in winter, on the sunless slopes of mountains or in sunless valleys, in factory towns where smoke defiles the atmosphere with its soot particles, in slums where the houses are crowded together and men, women and children are herded in dark damp rooms with vitiated air, it is found that resistance to infective disease is low, rheumatism and tuberculosis are rife, expectation of life is below normal, infant mortality is high. To these conditions, no doubt, many causes contribute; but it is generally believed a deficiency of sunlight is a powerful factor. The tendency at the present day regarding the attributes of the sun's rays is to lay much stiess upon the invisible ultra-violet rays of the solar spectrum as well as upon the invisible infra-ed and the visible rays.

Treatment by Direct Sunlight,-This is difficult or impossible under such conditions as have been mentioned above; some methods of supplying it are by the provision of open spaces and playing fields in the neighbourhood of crowded areas, establishment of open-air schools, cult of outdoor sports, etc. But even if sunlight be available, the atmospheric conditions may permit of little penetration by the ultra-violet rays Hence, methods have been adopted to supply these from abundant supplies such as the electric arc and the mercury-vapour quartz lamp, and to minimize screening effects by the use in buildings of such material as glass made of quartz which admits a maximum of ultra-violet and other beneficial rays, by the use of lighter and more porous clothing, or even by exposure of much of the body Thus in one way or another, whether as a curative or preventive measure against disease, there is a great movement towards supplying, naturally or artificially, that sunlight which is deficient. As a preventive measure the use of sunlight is modern, but the curative side has been recognized for centuries, having been used by the Chinese, Egyptians and the South American Indians and is represented by the numelous health spas and resorts throughout the world.

Mode of Action of Direct Sunlight .- The rays of sunlight, when analyzed by the prism, range between the infra-red (heat) rays of relatively long wave-length and slow frequency to the ultra-violet (chemical) rays of shorter wave-length and greater frequency. Within this range the penetrating power of the infrared and of ultra-violet rays into human tissues is definitely less than that of the visible rays. Hence heat from the visible rays of sunlight passes through the skin and, largely, is taken up by the blood and distributed by way of the circulation throughout the body; infra-red heat rays warm the superficial layers of the skin and from them heat is carried to other parts. Ultra-violet light produces its effects in the skin itself and its action is manifested by the inflammation, peeling and tanning that exposure to the sun occasions in most persons. The pigment of coloured races prevents the penetration of ultra-violet rays deeper than the pigment layer and thus is a protection in tropical countries

Warmth.—The increased warmth, when moderate, stimulates metabolism, induces a sense of well-being, increased appetite and mentals activity; when greater, as in the height of summer or m the tropics, leads to sweating, desire for cool drinks and cool breezes and disfinitiantion for food, particularly sugars and fast, since moderate of which supplies a large proportion of animal heat; and when excessive it leads to the pathological condition of sunstrole or heatstroke (see SUNSTROKE AND HEATSTROKE).

Ultra-violet Rays .- But the ultra-violet rays are now known to have special qualities. For long it has been known that the skin has the property of regulating heat loss and so contributing towards maintenance of a stable body temperature in warmblooded animals. Recently it has been shown experimentally that even a short exposure to ultra-violet radiation modifies the bactericidal power of the blood and its leucocytic content. Moreover, the discovery that vitamin D (see VITAMINS) can be produced in ergosterol-an impurity ant to be present in all cholesterols but found originally in ergot of rye  $(q v_{\cdot})$ —has indicated a variety of action of which the full importance is, probably, still unknown. In investigations on rickets (q.v) it was found that cod-liver oil is beneficial; later, that ultra-violet irradiation is beneficial, even in the absence of cod-liver oil, and ultimately that ultra-violet rays act on the non-saponifiable part of a natural fat, i.e., the sterol, and produces vitamin D. From this it appears that the ultraviolet rays of summer sunlight act upon the ergosterol impurity in the cholesterols present in all animal cells and build up a store of vitamin D for our use during the winter when the ultra-violet radiation of sunlight is deficient

The fact that ergosterol when exposed to ultra-violet radiation produces vitamin D has been turned to practical and commercial account. Under the rays ergosterol changes from a white crystal-

Ine sold to a pale yellowish oily find which possesses the highest voltame D potency known Thus artificially produced, there are be supplied to footsuffs ( $e_F$ , milk, butter, marganne) in their preparation an element deficient when produced in winter burnormally present in sufficient quantity when produced in summer Under natural conditions we ast foods containing ergosterol and this is acted upon in our bodies by the ultra-violet radiation reaching our skin,  $\sigma(e_F$ , in the consumption of New Zealand butter) we incorporate during the relatively sunless period in England vitamin D formed in the New Zealand sump period

Experiments and Theories .- The subject is a very complicated one but there is no doubt that the mortality from many diseases normally reaches its highest point in England in the winter months of January, February and March. Confidence in the therapeutic value of sunlight is strengthened by the beneficial results accruing in the monkey-house of the Zoological gardens, London. where electric lamps of fused quartz have been installed to allow of the passage of ultra-violet rays to the animals It must be noted, however, that this artificial sunlight must be used with great caution and for short periods as otherwise it has proved harmful, Indeed there is reason to believe that while a moderate exposure to ultra-violet radiation builds up vitamin D, an excessive exposure destroys it The output of ultra-violet radiation from an electric system, though dependent upon the current and voltage between the poles of the arc, varies widely according to the type of electrode used. A positive carbon electrode with an iron core, disposed below the negative plain carbon electrode, instead of above, is a powerful source of ultra-violet radiation

Lastly, menton must be made of Dr. Rollner of Leysm, Switzerland, and of Sr Henry Gauvan of the Treloar hospital for cripples at Alton, Hants, England, pioneers in the modern sunlight treatment of disease and of a remarkable journalists success in the Swinght and Health Supplement to The Times newspaper issued in London on May 22, 1928, to which the writer of this article is much indebted.

SUNN or INDIA HEMP (also termed Bombay hemp, Jubblepore hemp and Benares hemp). The plant (Crotalaria juncea) is an annual of the Leguminosae family and is propagated by seed. It is in no wise related to "true" hemp (Cannabis satisfied). Other native names include "San," "Sann" and "Saan" India is the only country in which there is any extensive production of Sunn fibre. The crop is used widely there for green manuring as well as for fibre. When grown as a summer crop the seed is planted in May or June; as a winter crop it is seeded in October The seed is broadcasted at 70-80 lb an acre. On suitable soils the plants grow 5-10 ft. high and mature in from 120 to 150 days. The bright yellow flowers are self-sterile and are crosspollmated by insects. Harvesting is done between the full blossom stage and the mature seed stage. The plants are usually pulled but sometimes cut with a hand sickle. The fibre occurs in the outer tissues of the mature stalks (pericycle and phloem) and cannot be satisfactorily separated from the other plant tissues until the stalks are partially decomposed by water retting (rotting). Because good retting is very difficult to obtain, much Sunn fibre is poorly cleaned and improperly prepared for spinning. Yields of fibre vary greatly, but average crops produce from 500 to 600 lb, an acre. The area harvested for fibre in India during the period of 1920 to 1940 was estimated as 500,000-700,000 ac. annually, an indicated average yearly production of around 165,-000 tons of fibre. Nearly all of that exported went to the United Kingdom and the United States. Sunn fibre is used for making practically every kind of cordage-ranging from coarse ropes to fine twines. One of its best known uses in the United States is for making oakum for calking and packing

See A. H. Wright, Personal correspondence with private and public agencies (1942); Alfred Wigglesworth, India's Commercial Fibres, Royal Soc. of Arts, London (1930). (A. H. Wr.)

SUNNIS (SUNNITES): see ISLAM.

SUNSHINE, the sun's light; the direct rays neither scattered nor reflected; hence the warmth and light given by the sun's rays Sunshine includes not only the visible portion of radiation from the sun, but also invisible ultra-violet and infra-rerays Radiation from the sun is the ultimate source of all except a practically negligible portion of the supply of energy that is essential for the maintenance of nearly all plant and animal life on the earth and the operation of nearly all ratural phenomena on the surface of the earth. In patietizin, the amount and distribution in time and space of the solar radiation which is intercepted by the earth are the prime generating causes of the physical activities the surface of the contract o

The rate at which sunshine is received on a hornoutal surface depends upon (i) the solar constant, or the emanation from the sun, (2) distince from the sun, (3) the inclination of the incident rays to the hornoutal, as determined by lattice, time of year and time of day, and (4) depletion to which the tadiation has been subjected during passage through the atmosphere As sunshine passes through the atmosphere, it is in general divided into three parts, (1) one part, almost unchanged in wave length, is turned aside from the direct beam and scattered in practically all directions, (2) another part is shorhoed, i.e., changed almost entirely into heat energy; (3) the remainder is propagated unchanged in wave length.

Measurement of Sunshine.—Several types of devices are used to record sunshine, few give highly accurate indications of sunshine according to the true definition. Instruments which purportedly measure the direct rays of the sun fail with faint sunshine, while others are affected by diffuse, or indirect sunshine

The Campbell-Stokes sunahine recorder consists essentially of a segment of a spherical netal bowl, having a glass sphere placed concentrically within it and centred so that the sun's rays are focussed on a card lining the bowl. Diffuse light does not record; direct sunahine burns a spot or a line on the card. Differentiation between a record of a few seconds and a mitute of intense sunlight is difficult because the two traces are similar. Also, when the sun is barely visible through snoke or thin clouds, its rays are too weak to record. The Campbell-Stokes is used chiefly by the Brutsh and a few other European countries.

Modified forms of sunshine recorders use blue-print paper mounted on a cylinder The Jordon type contains two semicylinders with narrow sitis in their narrow sides and, like the Campbell-Stokes recorder, maintains its own time-record

The Marvin sunshine recorder is an air-thermometer in which an electrical circuit is closed through the expansion of mercury



FIG. 1 -- CAMPBELL-STOKES SUN-SHINE RECORDER

by the main action of the sun. The duration of sunshine genesally is recorded on a triple register which also indicates the direction and velocity of the wind and the amount of precipitation. The adjustment of this instrument is so critical that frequent errors arise from imperfect setting. Not only are corrections necessary to allow for failure of contact with low sun, but also in many instances diffuse light from the sky is sufficient to expand the mercury when the sun's disk, is not visible.

At best, all of the types of instruments so far mentioned merely indicate when the sun does or does not shine and none sives quantitative results.

The Eppley 180° syrletioneter, which accurately responds to nearly all the radation which reaches the surface of the earth on a horizontal surface, gives quantitative results. This instrument consists of two concentric rugs of equal area, one black-ened and the other white-coated. The hor junctions of a multiple thermopile of gold-vallatium and platuman-hodum alloys are attached to the lower side of the black ring, and the cold junctions are fastened to the lower side of the white ring. The differential in temperature between the two rings when radiation falls upon, them creates an electromotive force that is nearly proportional to the amount of radiation received. The rings are

rays Radiation from the sun is the ultimate source of all except
a practically negligible portion of the supply of energy that is which is sealed to prevent deterioration of the receiving surfaces essential for the maintenance of nearly all plant and animal life and also to prevent mosture from condensity them. The election the earth and the operation of nearly all natural phenomena tomotive force generated by the receiver is recorded on a



THE EPPLEY LABORATORY, INC
FIG 2 —EPPLEY 180° SUNSHINE
RECORDER

potentiometer and reduced to values in gram-calones per minute per square centimetre

Receiving surfaces of instruments for measuring direct sunsine are mounted at the lower end of a disphragmed tube Thermoples offer ease of recording for total solar energy, photoelectric cells are useful for measuring limited components of radiation. More accurate determinations of the visible portion of sunshine are made by means of photometers, or instruments by which the brightness of sun-

light is matched against a known artificial light-source. Quality of Sunshine.—The major portion of sunshine which penetrates through the atmosphere ranges in wave-length from o  $s\mu$  (so coop mm) to  $s\mu$ . Qu. Ordinarily, sunshine is broked down into three major components: (1) the visible, or that part between  $c_{A\mu}$  and  $c_{B\mu}$  (one octave of wave length), (2) the between  $c_{A\mu}$  and  $c_{B\mu}$  (one octave of wave length), (3) the and (3) the infra-red with wave length shorter than  $c_{A\mu}$  and (3) the infra-red with wave lengths (longer than  $c_{B\mu}$ ).

Owing to a continual shift in the position of the maximum of the solar energy curve, no one factor can be used accurately to convert values in gram-calones to values in foot-candles. However, the value of 6,500 foot-candles per gram-calorie suffices for most practical purposes.

Visible Radiation—Visible radiation is commonly termed light; however, the word light too has a breader meaning and includes the ultra-violet, or that invisible portion immediately adjoining the shortest wave length of visible radiation. The visible portion comprises nearly one-half of the total radiation received at the surface of the earth. While most persons can discriminate between colours in the solar spectrum, the majority of males can detect red light of longer wave lengths than can females, while the latter as a rule can detect blue light of wave lengths shorter than can males. The yellow liquid within the iris acts as a filter which cuts off much of the ultra-violet light in 1945 it was accidentally discovered that when the eyebalis drained of its liquid, the subject can see ultra-violet light never before visually detected by man.

Sunlight is essential for the manufacture of carbohydrates from carbon dioxide and water; the first visible products of photosynthesis are starches, sugars and oils.

Ultra-violet Radation—While ultra-violet light comprises only a very small proportion of the total radiation, this component is extremely important. It produces vitamm D through the activation of ercosterol. It also is an important germicidal agent.

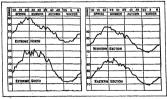


FIG. 3.-AVERAGE WEEKLY SUNSHINE IN DIFFERENT PARTS OF THE BRITISH ISLES

Table I - Monthly and Annual Percentages of Sunshine at Points in the United States and in the vicinity of the Mediterranean Sea

Stations	Jan	Feb	Mar	Apr.	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Albany, N. Y. Albaquerque, N. M. Albany, N. Y. Albaquerque, N. M. Altanta, Ga. Bisnarck, N. D. Columbus, O. Del Rio, Per. Denver, Golo. El Paso, Ore. Habaca, N. Y. Lancoin, Neb. Manna, Fin. Manna, Fin. New York, N. Y. Oklahoma City, Okla Portland, La New York, N. Y. Sergment, Okla Portland, Gre. Sergmento, Calif. Satt Lake City, U. U. Yuna, Aru. Yuna, Aru. Yuna, Aru.	Jan  42 72 49 51 48 37 51 68 73 44 31 57 65 43 49 54 58 75 43 49 45 68 81	Feb 51 70 53 58 56 44 56 67 76 60 60 72 47 51 60 60 77 59 33 57 49 53 84	53 74 59 55 57 48 61 64 81 72 43 60 74 57 61 63 82 59 41 68 57 56 89	Apr.  54 76 65 57 57 56 62 63 86 83 74 60 63 64 87 77 49 76 66 56 57	58 79 68 58 59 63 57 61 87 88 53 63 67 65 66 64 65 92 59 52 83 69 61 97	June 61 85 69 61 62 68 66 69 87 94 59 70 62 68 64 66 74 94 961 56 90 78 63 97	July  63 77 61 73 63 71 71 68 78 97 71 58 67 79 83 65 71 96 97 94 92	Aug 62 77 60 69 63 68 80 67 77 96 59 70 69 69 59 69 69 59 70 69 69 69 69 77 70 69 69 69 69 77 70 69 69 69 69 69 69 69 69 69 69 69 69 69	Sept  58 78 66 62 61 66 64 78 92 56 66 65 66 67 74 88 91 54 90 66 93	Oct 53 80 68 59 57 59 60 70 82 87 44 64 63 65 66 67 88 57 88 69 61 93	Nov 39 77 61 50 48 45 49 67 77 74 29 57 64 55 60 83 83 48 28 66 59 59 59	Dec 38 72 48 48 46 34 46 66 72 49 3 54 66 43 45 58 76 51 24 45 46 45 82	Annual  53 76 59 58 57 55 60 67 80 45 63 67 59 59 59 67 84 57 84 57 74 64 57 90
Athens, Greece Carro, Egypt Lasbon, Portugal Madrid, Spain Nice, France Rome, Italy	49 61 47 52 55 38	50 62 49 59 53 45	52 62 55 58 50 42	55 67 61 64 52 44	53 76 63 65 60 50	66 85 69 74 60 62	81 85 77 85 70 76	81 86 82 83 75 73	73 77 70 69 63 59	61 71 56 59 50 47	43 70 47 47 50 44	37 62 44 46 45 37	60 73 62 65 57 53

Unfortunately, the contaminated atmosphere over large cities robs radiation of practically all the shorter wave lengths, which explains why there is such a high incidence of rickets in tenement areas. On the other hand, vitamin D is harmful when the to excess, whether through natural sunshine or through the use of chemicals

Ultra-violet and the near ultra-violet rays comprise the socalled actinic rays which are very potent in effecting chemical changes on photographic films. Many photographic emulsions available in 1704 are sensitive to practically all wave lengths in sunshine and also to wave lengths at both ends of the solar spectrum.

Instructed radiation has its chief merit in its heat-producing quality. Close to one-half of total solar radiation received at the surface of the earth is infra-red. The spectrobolometer is the most important instrument for measuring small components of smilight. Solar rays of different wave lengths are refracted on entering and emerging from a prism, the shorter wave lengths being refracted more than the infra-red rays. It was through the use of the spectroscope and matched absorption-bands that knowledge of the composition of the sum was determined.

Exposure.—The ideal exposure of a sunshine receiver with a free horizon is not always possible, particularly in hilly or mountainous country. The shading is especially large in valleys between mountain ranges running in a N.-S. direction. Southern sloves are the most favourable for arriculture.

Sunshine is not the only determining meteorological factor to be considered when selecting a pleasant climate; temperature, wind and humidity also are important. The sun shines more than 90% of daylight hours in northeastern Sahara desert; yet few consider this an ideal climate.

The British Isles.—Sunshine is, however, one of the most important meteorological elements in the compact British Isles, which accounts for a wider distribution of sunshine recorders there than in any other area of equal size.

there than in any other area of equal size.

The average weekly distribution of sunshine in different sections of Great Britain based on 25 years of record is shown in fig. 3. Throughout the Isles the maximum sunshine occurs in early summer with a minimum amount in early winter. Longer summer days in south Britain account for the larger number of hours of sunshine in that section. Conversely, shorter winter days in north Britain result in the smaller number of hours of sunshine in that section.

TABLE II — Monthly Means of Daily Totals of Solar and Sky Radiation (Total Sunshine) on a Horisontal Surface, Gram-calories Per Souare Centimetre: Stations Are in Order of Increasing Latitude.

Square Centimetre; Stations Are in Order of Increasing Landiae.													
	Jan.	Feb	Mar	Apr.	May	June	July	Aug.	Sept	Oct.	Nov	Dec.	Annual
New Orleans, La.	215	262	336	419	45I	463	422	415	378	362	280	196	350
La Jolla, Calif	258	316	427	520	547	542	556	508	433	357	393	236	417
Riverside, Calif.	256	286	392	470	540	572	580	524	466	359	283	310	412
Nashville, Tenn.	150	198	298	414	401	550		438	358	277	187	112	33I
Fresno, Calif	172	249	415	547	648	606	494 681	616	508	382	261	163	445
Davis, Calif	180	272	415	565	66r	756	741	663	527	389	243	154	465
Washington, D. C.	163	227	321	408	486	513	406	446	370	294	203	140	340
Columbia, Mo.	142	228	318	370	456	474	585	522	362	338	181	125	342
Boulder, Colo.	210	220	391	430	457	537	529	459	436	335	228	200	369
New York, N. Y.	131	192	296	385	463	480	478	402	340	271	162	120	311
State College, Pa.	137	100	297	402	456	510	500	470	358	233	149	114	316
Lincoln, Neb	180	251	347	418	494	553	576	482	404	302	200	166	366
	163	236	331	426	495	534	512	472	374	273	185	141	345
Put in Bay, O.	1-34	198	299	389	435	581	552	484	357	256	140	112	328
E. Wareham, Mass.	дór	, 240	304	418	489	5×5	492	453	347	251	171	154	333
Blue Hill, Mass.	160	237	327	1396	487	510	502	474	360	275	172	135	336 286
Boston Mass	118	198	272	367	447	427	453	408	301	206	124	106	286
Twin Falls, Ida.	164	224	347	466	577	622	605	531	462	326	177	124	385
E. Lansing, Mich.	112	178	264	349	343	494	474	415	302	217	110	88	279
Madison; Wis.	150	217	315	404 .	469	523	537	452	343	245	151	118	327
Fairbanks, Alaska.	13	64	195 -	360	454	502	452	303	176	84	28	6	220

Continental United States—The number of stations which maintain Marvin sunshine recorders in the United States is 184, 27 stations of the weather bureau and co-operating institutions record more accurate

the weather bureau and co-operating institutions record more accurate solar data by means of Epipley pyrhehometers

Sunshine data are tabulated in the number of hours that the sun shines and also in percentages of possible sunshine. The former is important for agricultural pursuits while the latter has the advantage that it eliminates the necessity of considering latitude when the data are correlated

Over two-thirds of the United States receive more than 60% of possuble sunshine annually, and these areas compare favourably with localities commonly referred to as having sunny chmates In southwest-



WEATHER BUREAU SOLAR PADIATION SUPERVISORY STATION .... FIG 4 -- PERCENTAGES OF THE POSSIBLE AMOUNTS OF SUNSHINE IN THE UNITED STATES IN JUNE, BASED ON MANY YEARS OF OBSERVATION

crn United States from south-central Texas to within a few miles of the Pacific coast the average is more than 70% of the possible, with a maximum of 80% in southern Arizona. Yuma in southwestern Arizona. ractinum of 50% in southern Arzona. Train in southwester I in cona, average 50% for the year with averages almost as high throughout the Colorado and Mohave deserts The San Joaquin valley in west-central Cahifornia has more than 90% of possible sunshine in midsummer The average sunshine in the northwestern United States, areas adjoining the Great Lakes and over the Rocky mountains and



BY COURTESY OF U.S. WEATHER BUREAU, SOLAR BARRATION SUPERVISORY STATION SURE MILL OWSERWATORY, MILITON, MASS, FIG. 5.—PERCENTAGES OF THE POSSIBLE AMOUNTS OF SUNSHINE IN THE UNITED STATES IN DECEMBER, BASED ON MANY YEARS OF OBSERVA-

the Appalachian range is appreciably less than the average for the entire

the Applaichian range is appreciatory tes uses the applaichian range is appreciatory to the World—John Bartholomew's Physical Allas, vol. 3, Allas of Meteorology, includes maps showing the annual distribution of smalline over other parts of the world. Central Spainer of the application of smalline over other parts of the world. Central Spainer of the application of the small smalline than the reminder of Europe. Portions of the Salar desert have more sunshine than iny other part of the world, the eastern section averaging more than 95% in summer and 95% in white. The average sunshine along the equator in Alfaca is slightly more than 55% of the possible Allaska, the Aleuthan Islands and the Hudson bay region have comparatively little sunshine, especially in winter.

In general, the number of hours of bright sunshine increases from the poles, where it is less than one-third of the possible, to the zone between latitudes 30° N and 35° N where it ranges from 50% to between latitudes 30° N and 35° N where it langes from 50/6 or Coastal areas, as a rule, and with Australia a notable exception, have more sunshine than inland areas Sunshine ordinarily is less over hilly and mountainous country

The charts on figs 4 and 5 show the percentage of possible sunshine for the entire United States during June and December, respectively Table I gives the monthly and annual percentages of sunshine in the United States and in the vicinity of the Mediteiranean sea. Table II gives the monthly averages of solar and sky radiation in the United States and Alaska (I F H )

SUNSTONE, a variety of the mineral feldspar (q v ) exhibiting a brilliant spangled appearance in certain directions, caused by minute scales of iron oxide arranged parallel to a cleavage. It is somewhat similar to aventurine The best-known locality is in Tvedestrand, Norway It is also found near Lake Baikal, Siberia, and at several localities in the U S, especially at Middletown, Pa., and Statesville, N C

SUNSTROKE AND HEATSTROKE are terms applied to the ill effects produced upon the central nervous system and thereby upon other organs of the body by exposure to the sun or to any environment which raises the body temperature to haimful degree They are most frequently seen in the tropics but also in temperate climates during prolonged hot weather No race or oc-

cupation shows any peculiar susceptibility Heatstroke depends principally upon failure of the normal cooling mechanism of the body, te, evaporation of sweat from skin and body water from the lungs. Any situation such as great environmental humidity, ill-suited clothing or disease that impairs circulation and respiration predisposes to heatstroke. Acute and chronic alcoholism, high blood pressure, arteriosclerosis and chronic kidney disease are common predisposing causes. Overwork, anxiety, loss of sleep and prolonged hot weather are factors that increase body heat production and also exhaust the cooling mechanism

Cessation of sweating is always present at the onset of heatstroke, which may be abrupt or follow mild discomfort such as giddiness, slight would have been accounted to the control and the point as a summary of a control and the contr but always there are changes in the biain and numerous organs

If treatment is applied promptly and properly, many survive; but there is a degree of fever and a duration which causes lasting brain injury even though cooling was done After cooling, victims but there is a degree of fever and a duration which causes lasting brain fijury even though cooling was done. After cooling, victims may be unconscous for several days and fail rather than a couse in spate of good medical care. Severe cases that recover frequently have head-aches and other vague discomforts, especially on re-exposure to heat.

aches and other vague discomitoris, specially on re-exposure to heat, when the discomitoris and the state of the victim state of the state of the state of the state of the victim of the state of the s

World War II desert warfare troops were best protected from heatstroke by drinking abundant water to which small amounts of salt had been added, thus maintaining large volumes of sweat for cooling. had been added, thus maintaining large volumes of sweat for coung, in jungle warfare, in which great humidity was combined with heat, sweating was less effective, and when clothing was necessary because of other conditions such as injects, the work load of the soldier was neces-

ones consistent state in sector, the work had of the Solinlet Was Becks-saily reduced to prevent heatstroke

Treatment—Quick energetic cooling is best, because inversible brain damage may occur otherwise Hospitals preparing for heatstroke epidemics have tub baths of cold (preferably ice) water ready. Brisk rubbing of the skin and massage of soft tissues disspates the body heat rubung of the star and massage of soft closues classpates the booty next into the cold water. When the retail temperature is between 102° and 100° F, energetic cooling should stop. If ice water baths are unavailable, brisk familing of the wetted skin is useful. Also, to lay the naked patient on the cool ground meanwhile is better than a warm bed. Skillul medical care is needed for occasional profounged unconsciousness or heart.

patient on the too groups assessment of the contract of the co

SUN YAT-SEN (1866-1925), Chinese republican leader, known in China by the more familiar title of Sun Wen, may truly be described as the father of the Chinese republic. His father, a poor farmer living at Hsiang Shan near Macao, was a convert to Christianity (under the London Missionary society) and his son continued to describe himself as a Christian till his death, before which he gave instructions that he should be buried with Christian rites

As a boy Sun was educated at Honolulu under the care of an elder brother In 1801 he entered the newly formed medical school in Hong Kong and graduated in 1894. It was there that his lifelong friendship with Sir James Cantlie began From boyhood his mind had been revolutionary Through a Chinese fellow student, Sun came into association with a secret revolutionary society and was conspicuous in a revolutionary plot after China's defeat by Japan in 1895, he escaped, though the other conspirators were executed Then during a long period he worked outside China to bring about a revolution. In 1898 he adopted the three fundamental principles of Nationalism, Democracy and Socialism, afterward glorified by the Kuomintang (the republican party he founded) as the Three Principles of the People Sun attempted to use the reaction after the Boxer outbreak of 1900 as a means of establishing a democratic government and ending the Manchu regime, but this attempt, like others, proved abortive. In 1905 the Chinese Revolutionary league was formed in Europe and Japan, and through this Sun raised large sums of money from overseas Chinese to spread his ideas through secret agencies in China A price of £100,000 was placed upon his head, and in 1896 he was kidnapped while in London and held at the Chinese legation for several days His release came about through a note to Sir James Cantlie which was smuggled out of the legation

Only Sun's personal influence and the efficient organization of the Kuomintang was able to turn the anti-Manchu tide into a prorepublican movement. Sun was in England when the revolution began on Oct. 10, 1911 He returned to China and on Jan. 5, 1912, he took the oath of office as provisional president of the new republic, at the request of the national convention in Nanking On Feb. 12 an imperial edict announced the abdication of the emperor and the substitution of republican for monarchical government The former vicerov Yuan Shih-kai was entrusted with the task of carrying through the changes involved, and Sun, realizing the impossibility of uniting the country under his own presidency, 1esigned his presidency in favour of Yuan. He accepted the post of director general of transport and trade, but was always more of the propagandist and inspirer than the practical administrator.

It soon became plain that Yuan had no thought of establishing a republic. This led, in 1913, to the second revolution, which Yuan easily crushed, and Sun fled to Japan. In 1917, after Yuan's failure to make himself emperor and after his death. Sun put himself at the head of a movement for an independent republic of south China The strength of his support had always been drawn from Kwangtung province, but he soon found it impossible to co-operate with the military leaders in Canton. He therefore resigned from his position as president of the republic of south China. The military regime was maintained largely by Kwangsi troops until 1921 when Gen Chen Chiung-ming drove them out and called in Sun

The following year he determined on an advance in force against the north, while Chen desired to consolidate the work begun in the province of Kwangtung. This led to an open breach, and Sun was once more driven from his native province, finding refuge in Shanghai. In Feb 1923 he called to his aid troops from Kwangsi and Yunnan and thus defeated his one-time colleague and subsequent rival, General Chen. From that time until his death he was acknowledged as the chief executive of the province, but his effective sway did not extend far beyond Canton. He used and permitted violent methods, more particularly in the attack upon the Merchants Volunteer corps and the looting and burning of a considerable part of the city of Canton in March 1924. In this way he lost much of the support which had been given to him and to the Kuomintang by the Chinese overseas. But his Socialist views ensured him the support of the mass of the workers, and he re-

peatedly secured riscs in wages for the Canton workers He was also still idolized by the student class and in his own party, where his was a name to conjure with

In 1923 Sun, having failed of other support against the north, turned to Moscow, which sent him an extraordinarily capable agent, Michael Borodin, and the equally capable General Galens to reorganize the nationalist troops. Borodin not only gave to the somewhat incoherent Kuomintang an efficient organization but succeeded in getting it to admit to its membership the Communist party, which by 1927, when Gen Chiang Kai-shek broke with it and expelled Borodin from China, had gained almost complete domination of the nationalist movement. Early in 1925 Sun went to Peking with some hope of peace and a new regime, to be formed with northern leaders then in power with whom he was friendly, but he died of cancer on March 12 He was buried in a mausoleum at Nanking in 1929 Sun was twice married. His first wife. mother of Sun Fo, who later attained eminence in the Kuomintang as a sort of elder statesman, he divorced in 1015 to marry Chingling Soong, sister-in-law of Chiang Kai-shek Mme. Sun was from Oct. 1949 a vice-chairman of the Central People's (Communist) Government council

BIBLIOGRAPHY -Sir James Cantlie and C S Jones, Sun Yat-sen and BBELOGRAPHY—SIT James Canthle and C. S. Jones, Sun Val-ten and the Audahemy of China (London, 1912), Sin Val-ten, Memoirs of a Chinese Revolutionary (London, 1927), P. M. A Linebarger, Political Doctriges of Sin Val-ten (1937), N. Gangulee (ed.), The Teachings of Sun Yal-ten (London, 1944)
SUPERANDUATION. The custom of providing pensions

for aged employees who, after mentorious service, are no longer able to discharge their duties efficiently became increasingly common after the middle of the 19th century The problem of mitigating the hardships of old age has been attacked from many angles and a great variety of solutions has been tried In England superannuation schemes for discharged seamen and soldiers date back to the middle ages, these were followed by systems applicable to civil servants and other public officials, and the custom of making some kind of provision for old age gradually spread to the employers of labour on a large scale and even to businesses with relatively small staffs. The question has also received attention on national lines, this aspect of the subject is treated under Pensions and Social Security, the present article being limited to the exammation of superannuation schemes in which the title to benefits has its roots in service given to a particular employer during the pensioner's working life

At the outset the granting of a pension is often merely an eleemosynary act dictated by the employer's wish to reward meritorious service or to safeguard an old servant from penury in his declining years. Later, the occasional grant in these circumstances having become a custom, superannuation allowances come to be looked upon as a right by the staff and regarded by the employer as an important element in the maintenance of an efficient personnel. In such a case a definite scheme prescribing the ages between which retirement shall normally occur (generally between 60 and 65), laying down scales and conditions of benefit (including the grant of pensions on retirement before the normal age on breakdown in health) and defining the class of persons to be included is soon recognized to be essential. The need for sound financial principles was not realized so soon. In the early days of pensions schemes, the expenditure on pensions, being almost negligible in the early years, was often charged to current revenue, and until this burden became heavy as the numbers on the pension roll grew, causing expenditure to increase rapidly, the need for making provision for accruing liabilities was not appreciated. Generally speaking, prudential considerations dictate that appropriate sums should be set aside and accumulated at compound interest throughout a person's service, while the liability for superannuation is accruing, in order that when he retires the sum in hand shall be sufficient to provide for his superannuation allowances By this method, as full provision is made before the pension commences, the burden of superannuation is met pari passu with payments of salary during service.

The accumulation of the appropriate reserves can be effected either in a privately managed superannuation fund or by an assurance company on behalf of the managers of the scheme. Under the former arrangement it is usual to institute a trust fund definitely the equivalent of his own contributions increased proportionately alienated from the ordinary business transactions of the employer In Great Britain such funds enjoyed certain privileges after 1021 in regard to income tax upon their interest income, provided that the main benefit took the form of a pension and not a lump sum Relief from tax was allowed also in respect of contributions whether paid by the employer or employee to a superannuation scheme Similar concessions were granted in the United States

Provident Funds .- The simplest form of superannuation scheme is a fund supported by periodical contributions (of fixed amount or varying with salary) generally paid in equal shares by the employer and the staff On retirement the employee is entitled to withdraw the contributions paid by himself and on his behalf by his employer, with their accumulations of interest

Superannuation Pensions Schemes,-The superannuation schemes which definitely provide for pensions are, however, gencrally considered to be more appropriate to the requirements of both the employer and the staff than the simple system described above The pension may be of fixed amount or may vary with length of service; in the latter case the amount of pension may be uniform for each year of service or may be related to the salary or wage earned by the employee during the whole or last few years of service Systems under which the pension depends both on the duration of service and also on salary are particularly appropriate to the differing circumstances of a salaried staff consisting of many grades. There are, however, many schemes in which fixed pensions or pensions which grow by uniform increments for each year of service have been adopted, eg, where a scheme is limited to man-

In systems based on salary it is common practice to express the pension as a specified proportion (e.g., one-sixtieth) of pensionable salary for each year of service, subject to a maximum (e.g., fortysixtieths). There are numerous methods of defining pensionable salary, one being the terminal salary (16., that earned in the last year before retirement) but, in order to avoid fortuitous inequalities of treatment, the average of the last few years of service is more usual Another plan often adopted is to take the average salary throughout service. Where the employee contributes a fixed percentage of his salary throughout his service, and the employer makes annual payments equal to the aggregate contributions made by his staff, it has been argued that from the standpoint of equity the resulting pension should be related to the contributions which have been paid by, or on behalf of, the beneficiary and that accordingly the average salary method should be adopted. But a practical objection to this is that the pension based on average salary is likely to be insufficient to enable a senior officer to maintain a reasonable standard of comfort after retirement unless the scale is fixed so high as to be overgenerous to the lower-paid ranks. In this connection it has to be remembered that while all new entrants, with trifling exceptions, start in junior grades entitled to low salaries, their progress varies widely. Judged on the principle that an employee, retiring after long service, ought to be able to maintain approximately the style of living to which he has been accustomed, anomalies appear inevitable under the average salary system, and for this reason the terminal salary system has become increasingly popular. With regard to the contention that the average salary system is fairer to the lower-paid grades, it may be said that, as one of the main objects of an employer is to secure efficiency, his contributions may fairly be allocated in the best way to achieve this purpose, and it is generally agreed that since even under the terminal salary method the employee, whatever his rank, receives at least full value for his own contributions and some part of the employer's subvention, the unequal distribution of the latter is not a valid criticism of the fairness of the scheme viewed as a whole. In periods of inflation, however, and general raising of salary levels, the terminal salary method results in higher pensions than were provided for in the financial basis of the scheme and large deficiencies may arise. The method therefore is suitable mainly in cases where the employer is prepared to guarantee the solvency of the fund.

out of the employer's grant, but if exact equivalence is desired the scheme has to be framed on other lines In such a case each contribution secures a definite amount of deferred pension, varying with the amount of the contribution, the age of the employee and the age at which the pension is to commence. On retirement instalments of pension purchased throughout service are aggregated. The system, generally known as the "money purchase" plan, is easy to work and is often adopted, especially in the United States and where it is found convenient to remaine the liabilities for pension with an assurance company in heu of instituting a private superannuation fund

Other Benefits and Developments.-The original object of a pension scheme was limited to the provision of an income in retirement whether because of age or ill health. Other forms of benefit were discouraged except that it was customary in contributory schemes to return the employees' own contributions in those cases where employees died in service or resigned or were dismissed before having qualified for pension

Some schemes however were subsequently amended by providing, in compensation for a reduction in the pension scale (e.g., from one-sixtieth to one-eightieth of pensionable salary for each year of service), a lump sum payment on death or retirement, the payment on death being intended to make some provision for a widow although the amount was usually too small to cover more than her maintenance for a short period. This plan was adopted in many schemes established after World War I.

Later, a further plan was introduced under which a pensioner in good health at his retirement could, at his option, relinquish part of his pension in return for an annuity to his widow after his death, This plan was of limited value for the purpose as it was not available for employees who had to retire because of ill health or who died in service

These haphazard extensions resulted in anomalies and hardship cases, and to remedy the situation thus created a more comprehensive scheme was developed whereby widows' pensions became an integral part of the arrangements. The lump sum which previously had been paid on retirement or death was reduced in the case of married men and replaced by a widow's pension equal to a proportion (eg., one-third) of the man's own pension The full scale of lump sums is paid to bachelors and to women, and the terms of the widows' scheme are so arranged that, for married men as a whole, the reductions in the lump sums are actuarially equivalent to the widows' pensions Plans on these lines were introduced after World War II in some of the public and quasi-public services in Great Britain.

In the period between World Wars I and II the growing recognition of social problems led to considerable activity in the establishment of pension funds. At the same time, the serious unemployment situation gave rise to a tendency to reduce the retirement age and to retire employees at the minimum age permissible under the rules to make way for the younger unemployed and so to relieve the labour market,

A further great expansion in the establishment of schemes took place after World War II, but the situation otherwise was radically different. Shortage of labour, increased longevity and improved standards of fitness at older ages led to a reversal of the retirement policy, and older employees were encouraged to continue in service as long as they were capable of carrying out their duties. To this end, the maximum number of years allowed to reckon for pension purposes was raised in some cases; e.g., from 40 to 45.

Further, in order to facilitate change of employment without the loss of accrued pension rights, a system was introduced in the public and semipublic services in Great Britain under which, by mutual agreement, a "transfer value" is paid out of the pension fund from which the employee is withdrawing into the fund of which he becomes a member, and he is then given credit in the latter scheme for an appropriate number of years of past service.

Financial Principles .-- As indicated above, the need for sound financial arrangements was often overlooked when the earliest schemes were started; in the following section the underlying prin-The average salary system approximates to giving each employee ciples of contributory schemes are briefly examined. In order that a fund may be in a position to meet its obligations it is essential that the capital in hand, together with the real value of contributions payable in the future, is not less than the present value of future benefits If this equivalence is maintained, the accumulated fund will continue to increase over many years until the expenditure on benefits becomes stabilized Where, for example, the number of new entrants each year is constant over a long period the position will eventually be reached when the current expenditure will exactly balance the combined income from contributions and interest When this occurs the active and retired staff will have reached a stationary condition and very substantial reserves are necessary since in many cases the current expenditure on benefits grows to more than twice as much as the contribution income, and the interest on a fund, which may amount to more than three times the current salary bill of the firm, is required to secure equilibrium The fund should be sufficient without relying on the contributions of future entrants, and its solvency should not be jeopardized if it is decided to close the fund to new entrants In the past the reasons why large funds should be built up were not always appreciated, and it sometimes happened where a sound fund had been accumulated that an uninformed decision was taken to increase benefits without regard to the enhanced habilities, often with disastrous results This experience was not confined to one country in particular. Many instances in which a scheme, having been started on unsound lines, had to be reconstructed later can be found In this connection reference can usefully be made to the report of the New York City Pensions commission (1916) and to the history of superannuation schemes in the British railways disclosed in 1910 by a departmental committee.

Before a scheme is launched the actuary has to estimate the contribution required to provide the benefits, basing his calculations on the various elements affecting the problem, the most important of these are the rate of interest which will be earned on well-secured investments, the rates of mortality likely to be experienced by the active staff and pensioners respectively, the proportion of staff that will resign voluntarily or that will be retired on health grounds before reaching the normal pension age, and the rate of progression of salaries (on the average) from age to age during service. Such an estimate must necessarily be tentative since experience as to all or many of these elements may change in the future; it is necessary. therefore, that the financial structure of the scheme should be reviewed periodically by an actuary and, if the valuation discloses a deficiency or a disposable surplus, appropriate action should be taken to restore equilibrium.

Back Service .-- At the initiation of a scheme the determination of the terms on which existing officers should be included presents some difficulty. Some credit for back service is generally deemed essential, otherwise the pension available in many cases would be too meagre for subsistence. In practice the problem has been dealt with in various ways, for example, it is not unusual to provide for all back service to count at one-half the standard rate, the whole of the cost of the concession being borne by the employer. Even so the liability cast upon the fund at the outset is substantial and ordinarily its redemption is carried out over a period of years.

Life Office Schemes.—Assurance companies offer many facilities to employers desirous of setting up superannuation schemes, and often an arrangement for the liabilities to be reinsured with a company is preferred in lieu of instituting a drivate superannuation fund. There is a wide choice of contract, and though generally speaking it is not possible to secure quite so much elasticity (e.g., in regard to disability) as under a self-contained scheme the method is popular because it is simple to work and because it protects the employer from the effects of fluctuations of experience. Again, it is peculiarly adapted to occupations where migration from one employer to another is customary, and for this reason is common in the United States where, generally speaking, immobility is thought to be a clog on efficiency. Common forms of policy prowide in return for periodical contributions, deferred annuities of a fixed sum payable on attainment of a specified age (with or without returns of premiums in the event of earlier death), or endowment assurances securing a lump sum (with or without bonuses) at a specified age or earlier death.

In those cases where the contribution is based on salary the amount of the annuity or the sum assured is fixed in relation to the salary current when the policy is taken out, supplementary contracts being effected when increases of salary occur. A variation of the deferred annuity system provides an annuity of fixed amount for each year's service, the increment of pension being secured by the contribution (increasing year by year) paid in the related year of service Another plan, which had its origin in the United States, is to make provision for pensions by a group assurance covering several provident benefits for the staff of a particular undertaking These group policies at the outset afforded protecand superannuation

and superamutation

Bibliotoanty—Department Committee appointed by the Board of

Trade, Report on Superamutation and Similar Funds of Rathway Compenses, Cand Says (H.M. SO, Jondon, 1910), Commission on Fensons,

penses, Cand Says (H.M. SO, Jondon, 1910), Commission on Fensons,

penses, Cand Says (H.M. SO, Jondon, 1910), Commission on Jerose

of the Departmental Committee on the Superamutation of Persons

framework (Property of the Superamutation of Persons

of H.M. SO, London, 1910); Jont Committee Report, Sand Congress

and Sesson, Pensons in the United States (1937), G. R. Hosking

and R. C. B. Lane, Superamutation Schemes (London, 1948) and

STUPPEDEDGATION by negrifice S. W. F.; D. A. bby, is

SUPEREROGATION, the performance of more than is asked for, the action of doing more than duty requires (late Lat supererogatio, payment beyond what is due or asked). In the theology of the Roman church, "works of supererogation" are those which are performed beyond what is required by God, thus forming a reserve store of works of ment which can be drawn upon for the dispensation of those whose works fall short of the standard

See Catholic Encyclopaedia, article "Supererogation."
SUPERHETERODYNE RECEPTION, a means of radio reception in which the received current is combined with the current from a local oscillator (a.v.) and changed into a current of intermediate frequency. This is then amplified and detected to reproduce the original signal wave

SUPERINTENDENT, a term which, apart from its general use for an official in charge, has a distinct religious connotation, being applied, eg, to the head of a Sunday school and to the chief minister in a Methodist circuit In its most important historical sense it refers to certain ecclesiastical officers of reformed churches of the Lutheran model

In the confusion of the Reformation the name of superintendent was given to a class of men who discharged many of the functions of the older bishops, while bearing a character which in several respects was new. Only in Denmark was the name of "bishops" reserved for the new officers after the Lutheran model had been adopted and the older bishops had been deposed and imprisoned It survived there, though no claim is made that it is the sign of formal apostolical succession. In Scotland the First Book of Discapisne provided not only for ministers, teachers, elders and deacons, but also for superintendents and readers. The superintendents (who were appointed because of the scarcity of Protestant pastors) took charge of districts corresponding in some degree with the episcopal dioceses, and made annual reports to the general assembly of the ecclesiastical and religious state of their provinces, in the churches of which they also preached.

Duties of Superintendents .- The distinctive character borne by the new officers was determined by the cardinal principles which Luther had laid down in his work regarding the religious functions of the state. He conceived of the secular government as an ordinance of God, and as being set to direct and control the external fortunes of the church,

He hoped that righteous magistrates would at all times form a sound court of appeal in times of ecclesiastical disorder, and that they would guard the interests of truth and justice more securely than had been done under papal jurisdiction. The superintendents. who now had to undertake large administrative responsibilities in the church, were therefore to be appointed by the civil power and to be answerable to it. They were to stand as intermediaries bein their districts on the other.

In his earlier writings Luther had laid his main emphasis on

was declared free not only to preach but also to administer the sacraments and to rebuke evil livers. The differences in office and function between the members implied no difference in rank. for the members of Christ's church were all members of His body, and Luther believed that they would all be ruled into true order and charity by the Head But he was shaken by the Peasants' War and his faith in the virtues of the average man never recovered

The result was seen in his later writings, where he expresses his conviction that men need to be directed and restrained from without, and he looks to the state to undertake this duty. In the last resort the civil magistrates must take control of the church His vindication for thus subordinating the ecclesiastical to the civil lav in his assumption that the rulers of a Christian land would themselves be Christian, and it was the Christian duty of the church to render obedience to those who had been ordained of God to bear rule. He was as firm a believer in a visible Catholic church as were any of those of whom he speaks as "the adherents of the old religion." Luther, always conservative in feeling, clung to an alliance with the state and denied that the repudiation by the reformers of papal authority had severed them from the visible church.

The character of the office and duties of the superintendent were not everywhere the same. Luther shrank from imposing any stereotyped forms and asked that the special circumstances of each separate district should be consulted. He hoped that as few changes as possible would be made, and trusted that the reformed doctrines would spread peacefully throughout the country After the Diet of Speyer (1526) the civil authorities were invited to reorganize the Church in their respective dominions as they thought best. In the free towns superintendents were answerable to the city fathers for their good order. There were difficulties in the territories of the German princes, and in the case of Saxony Luther proposed to the elector that his first step should be to send out a commission of visitation which should report on the moral and spiritual condition of his principality, district by district. His proposal was carried out, and Luther himself became one of the visitors (1527-1528). He found the people in a state of such religious indifference and ignorance, and the clergy living often in such grossness, that his faith in their fitness to govern themselves ecclesiastically sank even lower than before, and he resisted all schemes for self-government such as had been proposed by Francis Lambert. The church organization which he devised for Saxony provided no place for democratic or representative elements; the grasp of the state must at all times be felt. The superintendent must speak at all times as a minister of the state, and the state must be represented in the synod to which he makes his first report, for upon the synod there must sit not only the pastors but also a delegate from every parish. If any appeal should be made from the decisions of the synod it must be heard in the court of the electoral prince, for he, as supreme civil ruler, possessed the jus episcopale, the right of oversight of the churches. Luther proposed that he should exercise this right by appointing a consistorial court composed in part of theologians and in part of canon lawyers, and it was thus that in 1542 the Wittenberg ecclesiastical consistory was formed. Other principalities adopted the model, so that the institution became common throughout the Lutheran churches.

In this scheme the superintendent (or superattendant) was charged with such part of the duty of the older bishops as had been purely administrative. He must concern himself with the discharge of their duties by the pastors of the churches, as well as with their character and demeanour. He must supervise their conduct of public worship, as well as give them licence to preach. He must take cognizance of their ministry to the indigent in their parishes, and of their management of the schools. He must further direct the studies of candidates for the pastoral office. He was answerable to the civil authorities to report all evil-living and false teaching.

The earliest occasion of the appointment of such a superin-

the spiritual priesthood of all believers. Every sincere Christian Saxony about 1527. He assigns the duties of the office, and summons the newly appointed officer to give diligent heed to the conduct and teaching of the pastors under him, faithfully to warn them of all errors, and, in case they prove obstinate, to report them to the electoral court. He must further give close attention to the due observance of the marriage laws, for in this matter the previously appointed visitors to the principality had reported grave laxity

Some of the smaller principalities appointed but a single superintendent for their territory, who, instead of being answerable to a consistory, sat as spiritual member on the territorial council, whilst in towns the superintendent was summoned to the town council whenever Church matters arose for discussion In larger states there were various classes of superintendents with their respective duties severally assigned

In modern times the functions of the superintendent have been somewhat confused in consequence of the introduction into Lutheran Church theory of inconsistent elements of Presbyterian and

therita content theory of the Reformation (xoo6), i. 400-416;
See T. M. Lindsay, History of the Reformation (xoo6), i. 400-416;
and the articles "Kirchenordnung" and "Supermendent" in Herzog-Hauck's Realencyklopadie fur protestantische Theologie und Kirche.

SUPERIOR, a city in the northwestern corner of Wisconsin, U.S., at the western end of Lake Superior, opposite Duluth, Minn. with which it is connected by bridges; a port of entry and the county seat of Douglas county. It is on federal highways 2, 35 and 53, and is served by the Chicago, Milwaukee, St. Paul and Pacific, the Chicago, St. Paul, Minneapolis and Ornaha, the Duluth, South Shore and Atlantic, the Great Northern, the Northern Pacific and the Soo Line railways, and many lake steamers Pop. (1950) 35,091; it was 35,136 in 1940 by federal census The city occupies a spacious site (42 sq mi.) on gently rising ground facing three bays (Superior, Allouez and St Louis). It has 29 mi of water front, and shares with Duluth (q v) one of the finest natural inland harbours of the world, ranking second only to New York among the ports of the United States in the amount of commercial tonnage handled There is ample water power, and the manufacturing industries are important

Superior has a cheap fuel supply and power is furnished by electricity generated on the St. Louis river

Superior is also an important grain market Flour is the principal product, and shipbuilding is important. Among steel ships, the type, now almost entirely extinct, known as the "whaleback originated there, and iron and wooden ships, launches and small pleasure craft are also made Other manufactures are railway cars, coal briquettes, sawmill and planing mill products, furniture, door catches, windmills, gas engines and heavy machinery.

Much iron and copper ore is shipped from the Duluth-Superior harbour, and large quantities of coal, brought by lake boats, are distributed from there throughout the United States and Canadian northwest.

Superior is the seat of a state teachers college (established in 1803).

Pierre Esprit Radisson and Medard Chouart des Groseilliers probably visited the site of Superior in 1661, and it is practically certain that other French coursurs de bois were there at different times before Daniel Greysolon, Sieur Dulhut (Duluth), established a trading post in the neighbourhood about 1678. About 1820 the Hudson's Bay company established a post there, but there was no permanent settlement until after the middle of the 19th century. Attention was directed to the site by a survey made by George R. Stuntz, a government surveyor, in 1852, and in 1853 a syndicate of capitalists, at the head of which was William Wilson Corcoran, the wealthy Washington banker, associated with whom were Senators Stephen A Douglas (for whom the county was named), R. M. T. Hunter and J. B. Bright, former Senator Robert J. Walker, Congressmen John C. Breckinridge and John L. Dawson, and others, largely southern politicians and members of congress, bought lands there and platted a town which was named Superior The proprietors secured in 1856 the construction of a military road to St Paul, Minn., 160 mi long. The town tendent would seem to be found in the decisions of Prince John of grew rapidly, and in 1856-57 had about 2,500 inhabitants. The panic of 1857 interrupted its growth, and the population dwindled so that in 1866 there were only a few hundred settlers on the town-site. The Civil War increased the depression, and the lands of those who had taken part against the Union were confiscated. In 1862 a series of stockades was built as a protection from the Indians. Within the area under the government of the town of Supenor, which was at first co-extensive with the county, West Superior was platted in 1883 and South Superior soon afterwise. A village government was established in September 1887, including the three settlements mentioned, and in April 1889 Superior was bettlements mentioned, and in April 1889 Superior was chartered as a city. The harbour was surveyed in 1833—1835 by Laeut Henry Wolsey Bayfield (1795—1882) of the British Navy. In 1860—1861 it was resurveyed by Captain Genge G. Meade, who was engaged in the work at the outbreak of the Civil War. A branch of the Northern Pacific 1ailway was built to Superior in 1881.

SUPERIOR, LAKE, the most north-westerly of the Great Lakes of North America, and one of the largest bodies of fresh water in the world, is bounded on the east and north by the Province of Ontario, on the west by the State of Minnesota, and on the south by Wisconsin and Michigan.

Physiography.-It has deep, extremely cold, clear water, and high and rocky shores along a large portion of its coast. Its general form is that of a wide crescent convex towards the north, but its shores are more irregular in outline than those of the other lakes Following the curves of its axis from west to east the lake is about 383 m. long, and its greatest breadth is 160 miles. Its maximum recorded depth is 1,302 ft., and its mean height above sea level 602 14 ft . 22.38 ft. above that of Lakes Michigan and Huion, to which it is joined at its eastern extremity through the St. Mary's river. The lake receives the waters of 200 rivers, and drains a territory of 40.080 sq mi, the total area of its basin, including the water surface of the lake, being 80,900 sq. miles. The largest river which empties into it is the St. Louis, at its western end. The principal rivers on the north shore are the Pigeon, which forms the international boundary line, the Kaministikwia, the Nipigon, which drains the lake of the same name and together with the lake is about 200 m. long, the Pic, the White and the Michipicoten, No large rivers empty into Lake Superior from the south. There are not many islands in the lake, the largest being Isle Royale, 44 m. long, Michipicoten island in the eastern part; St Ignace, in the northern part, off the mouth of the Nipigon river; Grand island between Pictured Rocks and Marquette; Manitou island east of Keweenaw Point, and the Apostle Group, to the north of Chequamegon bay.

The boundary between the United States and Canada follows a median line approximately to about mid-lake; thence it sweep north-westward, so as to include Isle Royale within the territory of the United States, and continues near the north shore, to the mouth of Pigeon river, which it follows westward, leaving the whole west end of the lake in US, territory.

Resources of Region.—The Lake Superior region is rich in minerals that have been extensively worked The lake is, as it were, surrounded by iron, which is the probable cause of very strong magnetic fields of influence. Native sulver as well as silver orês exist around Thunder buy, native copper was formely worked on lake Royale, and rich copper mines are worked on the south shore, while nickel abounds in regions of the country north of the lake.

Coasts and Currents—It has a picturesque coastline, the north shore particularly being indented by deep byas surrounded by high cliffs; the islands also rise abrupily to considerable heights, the north shore furnishing the boldest seenery of the Great Lakes. On the south coast, opposite the broadest part of the like, are precipitous walls of red sandstone, extending about 14 mi, shinois at the Fletured Rocke, so called from the effect of waye action on them. There are no appreciable titles and little current. A general sket of the water towards the 'outlet ext., especially on the southern shore. From the Apostle islands to the existing of the well-well was current to a great width, and (loweds the eistern end of the lake spreads out in the shape of a sam, a branch passing to the northward and westward reaching the

north coast Autumn storms raise dangerous seas. The level varies with the season, and also from year to year, the maximum variantion, covering a cycle of years, being about 4 ft. The discharge of the lake is computed to be 27,2000 cut. The re-scond at mast stage of water, and is controlled by dikes and sluice gates at the head of St. Mary's falls.

Navigation.—The season of navigation, controlled by the opening and closing of the Sault Ste Marie canals, swerges about eight months—from the middle of April to the middle of December. The lake never freezes over, though the temperature of the water does not, even in summer, rise far above freezing point. The bays freeze over and there is border ice, often gathered by wind mol large fields in the havs and extremities of the lake.

Into large fields in the bays and extremities of the lake.

Harbours—Lake Superiot is fairly well provided with natural harbours, and works of improvement have created additional harbours of religue at various points. Marquette and Presque Isle Point, Mich; Agate Bay and Grand Marais, Minn.; and Ashand, Wis., are on bays which have protective breakwaters across their mouths Duluth, Minn.; Superior and Port Wing, Wis; and Ontonagon and Grand Marais, Mich, are harbours with entrances formed by parallel jettles extending across obstructing bars. On the Canadian side Ft. William, in the mouth of the Kammistikwis, and Port Arthur, 4 mil distant, an artificial harbour, are the moly important shipping points, being the lake terminals of two great transcontinental railway systems, though the whole north shore is liberally supplied with natural harbours.

Commerce.—The traffic on Lake Superior grows constantly in volume. The data collected at United States and Canadian locks at Sault Ste Marie showed an increase of 100% in tonnage throughout the first quarter of the 30th century, resulting in 83,-000,000 tons annually and more than 50,000 passengers. In the second quarter there were similar increases, and the annual traffic in the 1950s represented a total of almost 200,000,000 tons and more than 60,000 passengers.

The principal freight shipped east consists of flour, wheat and other gains, through Duluth-Superior in the US and through Ft. William-Port Arthur from the Canadian prantes; copper ore from the mines on the south shore; from ore in mmense quantities from both shores, the principal ore-shipping ports being Ashland, Two Harbors, (Munn.), Marquette and Superior. Lumber, produced on the tributary rivers, is another important cargo. West-bound freight consists largely of soft coal for general

west-bound freight consists largely or soft coal for general distribution and for terminal railway points. Stone and petroleum represent most of the remainder of freight shipped west.

(See also GREAT LAKES.)

Conserve Galler Schales, on Savey of Northern and Northern made Northern made Northern Market Schales, on Savey of Northern and Northern Market Schales, on Save Schales, on Sav

SUPERNATURALISM, a term that may be used for the attitude of mind in which experience of the unfamiliar or uncanny appears to invest it with a distinct character, as if it belonged to a world of its own. On the psychological side it involves the somewhat complex mood known as awe, in which, as W. McDougall shows, various primary feelings such as fear, wonder and submissiveness commingle in no very fixed proportions. On the institutional side it provides raw material alike for magic and for religion. As Hartland puts it, commenting on Marett's use of the term, supernaturalism furnishes the original "theoplasm, god-stuff." Primitive notions of the type of mana (qv.) refer to this special class of experience in which the subject feels powerfully moved and the object seems powerfully moving, so that both inwardly and outwardly wonders happen, whether for better or for worse It is certain, on the other hand, that the savage does not spend all his time in wonderland, but distinguishes another world, another level of experience, which as the Polynesians phrase it, is noa, "commonplace"—the routine of every day. Our word "natural" has to-day very similar associations, though as a matter of fact, if Hubert and Mauss are right, the Greek physis, literally "growth," from which our conception of nature is derived, originally meant much the same as mana, namely, the occult force that makes things grow If it is felt that the word "nature" ought to be reserved for the whole order of the universe, as being rational and intelligible, the more pedantic term "super-normalism" may be substituted, though it cannot be denied that psychologically and historically men have been inclined to view the regular course of things, and certain interruptions of it, as sharply contrasted aspects of mind and being

II, as snapy contrasted spects of mind and open of Rigion (1914); E 5 Hatland, British Association Report, Address to Section II (1906); H Hubert et M Muss, "Equipse d'une thôme générale de la Mage" in L'Innée Sociologique, vol vu (1904); W McDougall, An Introduction to Social Psychology (oth et 1915). (R R M)

SUPERNORMAL CHILDREN, EDUCATION OF. T L Terman calls children "superior" if they have intelligence quotients of more than 110-ie, if they mature, mentally, more than 10% faster than the average He designates as "gifted" those with intelligence quotients of more than 135 The education of "superior" children does not present a major problem They do not diverge so widely from the average as to require any basically different educational approach

"Gifted" children are almost a distinctive type, and require, for their adequate development, a distinctive kind of education Not only are they from two to four or more years further advanced in mental capacity than other children of their age, but their superiority tends to be general Contrary to popular notions. gifted children are, on the average, large for their age and well developed; and they excel in many personality traits. It is in this group that there reside the greatest potentialities for distinguished achievement in life. For this reason it is important to adapt their schooling to their needs

The commonest, and least satisfactory, way of trying to adjust the school to the needs of gifted children, is to have them skip grades This does almost nothing toward developing their special abilities, though better than retaining them in lower classes

The next commonest practice consists of "ability grouping." Children are classified as X, Y, or Z according to their general ability as shown by intelligence tests, teachers' judgment, etc. The brightest, or X, group is, ideally, given an "enriched curriculum," going into each subject more intensively and extensively The large majority of the children in the X group, however, are merely "superior" rather than "gifted," and the ability grouping is, accordingly, adjusted to their needs It is not an adequate solution to the problem of the really gifted child.

A third method of caring for gifted children is through classes organized especially for them. Germany was the pioneer in this field, but in the United States by 1930 there were 135 such classes. They depart widely, in the best instances, from usual school practice. Routine drills and reviews give way to independent investigations and reports, the children using libraries, laboratories, shops, museums, and excursions. There is considerable freedom. Creative expression and originality are stressed.

The most common objection to such classes for gifted children is that they may tend to make children conceited. Proponents of special classes, however, claim that direct experience does not bear out this criticism, and argue that children competing with their peers are less prone to conceit than are those who are constantly associated with children of inferior ability.

A more practical objection lies in the fact that since less than one percent of school children are gifted, only the larger cities have a sufficient number, at the different grade levels, to make such classes feasible. In those cities, however, where special classes for gifted children have been organized, the consensus is that the gifted children get a real chance to develop their abilities; and as experience accumulates, such classes should be able to provide almost ideal conditions for them.

In smaller communities, the problem is more difficult. Hope lies in some of the newer general methods of education. So-called progressive schools, particularly, stress for all children just the types of education found most suitable for gifted ones-freedom.

responsibility, and much more emphasis on original investigation.

Where individual progress is added to these "progressive" methods, as for example, in Winnetka, Ill., a partial solution appears. Gifted children are allowed to progress somewhat more

rapidly, their individual programs are enriched with special assignments, electives, and responsibilities, and they are given considerable freedom, participation in group activities, and stimulus toward original investigation and creative work

This kind of procedure in smaller communities, and, in large cities special classes for gifted children, are, up to the present, the best solution that has been found to the as yet inadequately solved problem of the education of gifted children. (C. WAS )

SUPERNOVA: see Nova and Supernova. SUPER POWER. The term has come into wide use, particularly in the United States, in connection with the extensive development of the electric power industry. It has been defined as "the systematic grouping and interconnection of existing power systems to the end that greater economy will be effected." It means in its final form, generation at large, highly efficient plants, transmission in bulk at very high voltage, such as 220,000 volts and supply to existing power systems in large blocks

Technically, the basis of super power hes in the economy effected in interconnecting systems with peak loads coming at different times, thus reducing spare capacity and therefore investment, and bettering the load factor of the interconnected gen-

erating plants.

SUPERSTITION. Like many words having a derogatory sense, "superstition" is often loosely and vaguely used, and is therefore not easy to define To identify it, for example, with false belief or practice would be quite misleading. For in the first place, the field in which superstition is generally to be found, the magico-religious, is the very one in which the standard of truth and falsehood is most subjective and fluctuating, in the second, a custom or belief, religious or not, which is false may nevertheless be accepted at some times and places by men of enlightened intellect and conscience To call a person superstitious, however, regularly implies more or less definite mental or moral deficiency Thus, we should describe a man as superstitious who in a modern European or American community seriously believed that to break a mirror brought bad luck; but the original holders of that or a similar belief were perfectly reasonable in their views, according to their lights. Supposing that a shadow or reflection was in some sort a part of the soul, they naturally concluded that to break it, by breaking the substance upon which it was cast or reflected, was to injure the soul or life itself. They had merely been misled by a false inference. In like manner many savage customs and ideas, often described as superstitious by explorers or missionaries, turn out on investigation to be the product of quite sound reasoning, vitiated by the false premises on which it is based. To adhere irrationally to these premises after having their falsity clearly demonstrated might indeed be called superstition.

The word in question being of Latin origin, light may be thrown upon it by the usage of a Latin author Vergil, in a well-known passage (Aen. viii 187), characterizes superstitio as uana (empty, groundless) and also as ueterum ignara deorum (having no knowledge of ancient gods, ie, of well-tried and long-established religious ideas) If we turn to the Greek equivalent δεισιδαιμογία, literally "fear of superhuman powers," we find Theophrastos (Characteres, 28-[16]) ridiculing the δεισιδαίμων, not for holding polytheistic views nor for believing in omens, but for spending much time in the worship of obscure and foreign derties, and paying a ridiculous amount of attention to petty omens, such as a more sensible man would disregard.

We may now perhaps attempt to define superstition as the acceptance of beliefs or practices groundless in themselves and inconsistent with the degree of enlightenment reached by the community to which one belongs. It is clear that such a definition excludes, for instance, the mental attitude of one who, about the year A.D. 50, or in the middle ages, believed in astrology, which was accepted and defended by many, though not all, intelligent and well-educated persons of the time; it also excludes the action of a savage who adores what is to Europeans a ridiculous and nonexistent godling. But it includes, for example, those contemporaries of Plato who let themselves be deceived by the lower practitioners of Orphism, or by those moderns who appear seriously to believe in mascots. Even so, a certain element of varueness is unavoidable, since agreement is far from being reached as to what ideas, and consequently what practices, especially those having reference to things not obviously material, are false and unenlightened A long list might be drawn up of things which some would regard as false and outworn, others as plausible or even certainly true, it would range from theistic belief and religious observances of any sort to such matters as second sight and dowsing or water-finding There still remain, however, a great number of ideas and actions which the consensus of educated modern opinion would regard as superstitious in the sense above defined. These remaining superstitions fall into two categories, survivals and accretions

Survivals,-It is well known (see Anthropology: Folklore) that a great many customs characteristic of a less advanced stage in social and intellectual evolution survive into higher stages, either as meaningless and fossilized customs or because a new significance and use has been found for them. Thus many performances originally magical survive, more or less modified, as games for children or adults; a new use, the satisfaction of the play-instruct, has been found for them, but in their details they show, on investigation and comparison, traces of their original purpose Again, the very old Northern European custom, in origin probably a fertility-rite, of decorating the house with greens at Christmas, survives simply because it is a pretty and picturesque traditional usage. Some such customs have become matters of etiquette. The need being still felt for some kind of conventional gesture to express friendly feeling or desire for better acquaintance, the old, probably magical, gesture of "handshaking" is still in use, and from childhood, we are taught to use the right, or lucky, hand for the purpose. The reason now given is that it is polite to use the right hand rather than the left; here as in many other instances what is now polite was once magically good. Such things as these can hardly be called superstitions; certain customs being still found necessary in various spheres of modern life, and the old ones being in themselves inoffensive, it saves mental effort to retain them, although their original meaning was something quite foreign to our conceptions. But alongside of these some things survive which are useless or even obnoxious, on any theory of conduct, expressed or understood, save one involving some now exploded doctrine.

A good example is furnished by rest-days The whole experience of mankind proves that it is advantageous to have occasional periods in which no avoidable work is done, since in the end the worker actually achieves more than if he had not rested, in addition to tiring himself much less; and for this there are sound physiological and psychological reasons Moreover, it is the perfectly reasonable practice of members of the higher religions, such as Christianity and Islam, to set apart certain days (Sunday, Friday, etc ) for the intensified practice of their worship. But it is well known that, long before either an ethical religion appeared or the physiology of fatigue was studied, tabu-days, like the gennas of the Nagas, were observed by people in a savage or barbarous stage of culture, owing to the belief that, at regular or irregular intervals, the prevailing conditions were so magical that ordinary work would be unlucky or would prevent or hinder the beneficent effect to be expected from these conditions. Now the feeling that on certain days certain occupations, or all ordinary occupations, are particularly unlucky (or lucky) is quite common at far higher stages than these. Those who appear seriously to believe in the unluckiness of Friday for starting any work may rightly be called superstitious, for the ground of their conduct is ultimately the savage notion of the incompatibility of ordinary occupations with the spiritual atmosphere, so to call it, of a tabu-day, in this case a Church fast-day of comparatively modern origin. Not dissimilar considerations apply to the quite wide-spread avoidance of the number thirteen, ultimately based upon very ancient ideas of the peculiar character of this number.

Accretions Evidence of the survival, among a civilized poulation of a savage type of mentality is furnished abundantly by the occurrence of quite new superstitious practices in our own day, and in circles, not always uncultured, of Europeans and Americans. It is of course a commonplace that gamblers are superstitious, and many of their practices may fairly be deemed survivals, such as turning a chair around to "change the luck" (imitative or homocopathic magic) or wearing a mascot (fetishism?) But examples are not wanting of entirely new beliefs, based upon modern conditions and having no near parallel in savage or ancient custom. A popular English newspaper finds it necessary, owing to its large circulation, to employ a number of presses In order to check, and, where necessary, correct the work done by each of these, it has its title printed in a slightly different manner by each machine, the difference consisting of a varying number of small white dots in the large black lettering A few years ago a firm belief grew up among its less instructed readers that these dots conveyed racing "tips", thus, if there were three dots in the letter D, they signified that in the third race of that day a horse whose name began with D was the likely winner

Here we have a definitely superstitious belief, although connected with no magical or religious idea, old or new Clearly such a delusion would have been impossible but for two factors (1) Instead of rationally crediting the paper with the possession of a good deal of information on various subjects, gathered through reporters and by other such means, these readers manifestly supposed it to have a quasi-omniscience, embracing such unknowable things as the result of a race not yet run (2) Whereas it is in fact the custom of newspapers to state in plain language, in their sporting columns, which horse they think likeliest to win a given race, it seems to have been vaguely felt that it was more in keeping with the supposed oracular and infallible wisdom of the Press to adopt a symbolic style and set forth valuable information in a riddling form

The above example throws some light on the question whether superstition is declining in modern civilizations. The statement that it is rapidly disappearing is often and confidently made, but on examination of the instances given in support of such assertions, it will be found that what are really disappearing are certain old and traditional forms of behef or custom, which have rather gone out of fashion than been overcome by reason. For example, in Britain and America very little is left of the old rites connected with the last sheaf. This is only partly due to the spread of education among country people; probably not many farm labourers could say either what the old rites were or why they were irrational, it is rather the result of the rapid drift of population towards industrial centres, and the consequent influence on the country of town ideas Now the townsman, not being a producer of foodstuffs from the soil, is apt to laugh at the customs connected with them as rustic; compare the contemptuous tone of such words as rustre, rusticus, boor, άγροικος, etc The irrational custom has been irrationally displaced. Here, therefore, is no evidence of the growth of a more logical and critical mentality, less prone than the old to superstition; and it has already been shown that superstitious beliefs are actually in process of creation in the towns themselves. To take another example, while the traditional belief in witches seems practically confined to a few country districts and small towns, and the old methods of divination hardly survive at all, save as amusements, fortunetelling by various methods, mostly pseudo-scientific, including a crude and degraded form of astrology, is by no means extinct, as may be seen by examining the advertisements of popular magazines and also the police-court reports. At best it may be said that superstition appears to be yielding, although very slowly, to the gradual rise of the average intelligence which there is some reason to suppose exists, and that it may in time disappear with other irrationalities.

Other interconstruction of classical superstitions, see art. "Aborganics" in Pharmatheman, Enderschiehöldte, For others, see Aveninovinors Bibliography; Fouxious: Bibliography; Souxious: Bibliography; Souxious: Bibliography; See also Lehaman, Aborgane and Zauberel (1898); A. Wuttke, Der deutsche Volksaberglaube der Gegenwart (1900), Philip. F. Waterman, The Story of Superstition (1921).

SUPER-TAX: 566 INCOME TAX. IN PRACTICE. SUPERTONIC, in music, the second degree of the diatonic tonal scale, as D in the scale of C, that is, the note next above the tonic, whence its name,

(See HARMONY.)

SUPLO, FRANO (1870-1917). Yugoslav statesman, was born of poor Croat parents at Cavitat (Raguas Vecchus) in southern Dalmata In 1900 he became editor of Nove Lett, a Croat paper published at Pume, which became a rallying ground for opposition to the intolerable regime of Count Khuen Héder-vérv

In 1905, together with Anton Trumbić, Pero Čingrija and Smodlaka, he drew up the resolution of Piume, which became the bass of political co-operation between Serbs and Croats in the critical period before World War I When the Magyar condition parties came into power in Hungary in April 1906, and placed the Serbo-Croat coalition in office at Zagreb, Supilo became a deputy at Budanest

Within a year Magyarizing tendencies produced an acute confict between Budapes and Zagreb, and for a time Supilo was the soul of Croat resistance. He thus became a marked man and was specially aimed at in the notorious forgeries by which the Austro-Hungarian foreign office attempted to prove Serbia's revolutionary intrigues in Croatia and thereby to justify the innecation of Bosma in roos.

At the Fredjung tral, however, in Dec. 1909, Supile was trumphantly undicated. He was the first to discover the secret negotations with Italy which culminated in the treaty of London (April 26, 1915), and earnestly winned Sazonov of the disastrous complications to which it would give rise, but he was unable to prevent the promise of wide Slav territories on the eastern Adriatic to Italy in the event of victory. Supile came into conflict with the Pan-Serb and reactionary tendencies of Pais's, and even withdrew from the Yugoslav committee, which in the early stages of the war he regarded as unduly subservent to Belgrade.

But before his premature death (in London, Sept. 23, 1917) he heartily endorsed the declaration of Corfu, issued in July 1917, which laid down the lines upon which the Yugoslav state was to be constructed.

SUPPÉ, FRANZ VON (1820-1895), Austrian musical composer, whose real name was Francesco Ezechiele Ermenegildo Suppé-Demelli, was born at Spalato, in Dalmatia, in 1820, and died at Vienna in 1805

Originally he studied philosophy at the university of Padua, but on the death of his father devoted himself to muse, studying at the Viennas conservatoirs. He began his musical career as a conductor in one of the smaller Viennase theaters, and gradually worked his way up to be one of the most popular composers of ephemeral light opens of the day. Outside Vienna his works never wom much success of his 60 comic opens Patinitzs (Vienna, 1876; London, 1882) only enjoyed moderate favour

Suppé's overture to Dichter und Bauer, widely known as the Deat and Peasant overture, became his most successful orchestral work. He also wrote some church music, including a mass, Missa dalmatica (Spina, 1877) and a requiem, L'estremo Giudizio (Zara, 1860.)

# SUPPLEMENTARY ESTIMATES: see ESTIMATES.

SUPPIX; provision, more particularly the money granted by a legislature to carry on the work of government. In the United Kingdom granting of supply is the exclusive right of the house of commons, and is carried out by two committees of the house, one of supply and the other of ways and means (see Parliament). In the United States supply originates in the house of representatives (see Broner: United States of America)

SUPPLY, MINISTRY OF: see MUNITIONS, MINISTRY OF, SUPPLY AND DEMAND. Economics, or polltical economy, is sometimes defined as the science of supply and demand. Although this is an inadequate definition it cannot be said to be allogether mileading. A very important part of economics, and the part which probably has the best title to the name of science, has to do with the operations of supply and demand and with the way in which variations of supply and centand are related to the movements of prices and to changes in the production and distribution of wealth. The "law of supply and demand" was not invented or discovered by the economists, however, nor of they

lean very heavily upon it as a general explanatory formula. Long before there was any systematic analyses of economic processes men had observed that prices vary with supply and demand, and from the earliest days, trades have had to take account of that circumstance. The economist's task has been to scrutinize those characteristics of human behaviour and of the physical environment which determine the various forms or patterns in which supply and demand appear and to inquire into the complicated interactions of the demand for and the supply of different committees and services.

Elementary Principles.—Consider the familiar theorem that the price of a commodity must be such as to make supply and demand equal. If supply is taken to mean the amount solid and demand the amount bought the theorem is mere tautology, for supply and demand become different names for the amount transferred from sellers to buyers at any pince whatever. But if it be understood that demand means the amount which buyers would be willing to take at a specified price, that supply means similarly the amount which sellers would be willing to take at a specified price, that supply means similarly the amount which sellers would be willing to take at a specified price, that supply means similarly the amount which sellers would be willing to part with at a specified price, the supply are similarly the amount which sellers would be willing to part with a specified or lowered, the theorem has meaning and significance, for there will be one price, and only one price, at which supply and demand will be equal.

In another elementary theorem, namely that an increase of demand for a commodity will ruse its price, that an increase of supply will lower it, and that a decrease of supply or of demand will have an opposite effect, other meanings are attached to changes of supply and demand. Here an increase of demand or supply means an increase of the amounts which will be taken at given prices, not an increase which is dependent upon a redution of price. The general state of supply and demand, in the sense specified in the preceding paragraph, can be represented by lists or "schedules" of "supply prices" and "demand prices" In this other sense, however, supply and demand are regarded as independent variables, and a change of supply or demand means an alteration of the schedule of supply prices or demand prices, such as might come on the one hand from a change of consumers preferences or an enlarging of the market or, on the other hand, from a change of costs of production.

It is proper to assume that at any given time the immediate general condition of supply might be represented by a schedule in which the progressively higher prices which are required to evoke a progressively larger supply are set forth. But if the commodity is one which can be produced more economically if produced in large quantities, the ultimate effect of an increase of demand, in the sense of an increase of the amounts which will be taken at specified prices, will ordinarily be to reduce the price per unit at which these larger amounts will be supplied. In a schedule of supply prices constructed on the assumption that sufficient time is allowed to permit the necessary economies to be effected, larger supply will be associated with lower prices When the longperiod schedule of supply prices is of this type, the commodity is said to be produced under conditions of decreasing costs or of increasing returns. When, on the other hand, because of the scarcity of some necessary productive factor, increased supply cannot be had, even in the long run, except at a higher price, the condition is described as one of increasing costs or of diminishing returns The factors which give rise to increasing returns should not be confused with the circumstance that in many industries certain outlays (e.g., for plant and equipment) have to be incurred in advance or with the further circumstance that in a growing industry such outlays are ordinarily considerably larger than the volume of output immediately in prospect would require. Under such circumstances the additional or "prime" costs incurred by reason of an increase of output may be relatively small. Furthermore, with a progressive increase of output there will be a progressive diminution of costs per unit of output. because the general, supplementary, or "overhead" costs will be spread over a large number of units But although when the market is sluggish or when competition is especially keen, prices may be cut to a point where they barely suffice to cover the additional or "prime" costs, this condition, which cannot be lasting, should not be confused with a true condition of increasing returns, for this last condition is to be found only when a gradual increase of output is attended, in the long run, with genuine economies

Interactions of Supply and Demand.—The results obtained by taking account only of the supply of and demand for a particular commodity in relation to its price are no more than a first approximation to the truth In isolating, for reasons of practical convenience, the factors which determine the price of any one commodity, taken by itself, economists are accustomed to assume that the value of money, to both buyers and sellers, is constant. This means that no account is taken of the way in which changes in the amount of money which consumers expend for the one commodity will affect their ability to buy other commodities, or the way in which an increase of the production of the one commodity will affect the ability of producers to supply other commodities There are many instances of joint or complementary demand, as for fruit and sugar or for automobiles and gasoline, and of joint supply, as of mutton and wool, of coal gas and coke, of cotton and cottonseed The general rule is, however, that consumers' outlays for any one commodity can be increased only by reducing the amounts which they expend for other commodities, and that more of any one commodity can be produced only by displacing other possible uses of productive resources This general rule is not inconsistent with the fact that, making abstraction of the use of money as a medium of exchange, the supply of any one commodity is an expression of the demand of its producers for other commodities and services

There is a sense in which supply and demand, seen in the aggregate, are merely different aspects of a single situation. It is for this reason that some of the older economists held that general overproduction is impossible-a theorem which, though not really erroneous, has proved to be misleading. The effective demand of the producers of one commodity for other products depends not only upon how much they produce, but also upon the relative demand of other producers for that particular commodity as compared with other products. Only so far as the demand for a particular commodity is elastic is it true in any significant sense that an increase of its supply is an effective increase of demand for other commodities. There may be and often are maladjustments of supply and demand. Furthermore, production in general may at one time outrun and at another time fail to keep pace with the expansion of money incomes In either event there will be general fluctuations of prices, attended, as experience shows, by changes in the relative levels of the prices of different classes of goods and

The general form of the relations of supply, demand and price which obtain when all products are taken into account can be depicted mathematically in systems of equations, and thus the general character of the whole interdependent structure of prices can be laid bare. But empirical (statistical) studies of the relations between the fluctuations of the production of various staple commodities and fluctuations of their prices have shown that the first approximation previously referred to is generally a useful and often a surprisingly accurate approximation. It is necessary, of course, to allow for the effects of contemporaneous changes of the general purchasing power of money, and it is sometimes necessary to allow also for the effects of other important disturbing circumstances. But it is not necessary to take account of complications of a secondary order of importance in order to obtain "empirical laws of demand" for such commodities as wheat. cotton, sugar, beef and potatoes which appear to be fairly reliable, at least over periods of some years.

Inclastic Supply—The rule that supply and demand may be regarded as functions of or dependent upon price must be so interpreted, of course, as to allow for the circumstance that the supply of something is fixed and is no way responsive to an mercase of price. As the production of other goods increases, the prices of these nonreproducible forms of wealth must inevitably increase, unless the demand for them falls off. If these nonreproducible things are necessary instruments in the production of other goods, and land is, then other goods will be produced under

conditions of diminishing returns, unless this disadvantage can be offset by improvements in productive processes or by cheaper supplies of other necessary productive instruments. For some purposes it is convenient to assume that the aggregate supply of reproducible goods, or of reproducible productive goods, is fixed for the time being. The problems of supply and demand then have to do merely with the apportioning, by exchange, of an existing stock of goods, or with the assigning of productive instruments to the most important of their various possible uses Thus the increase of the supply of labour in a given industry or a given locality may be taken to depend largely upon a possible transfer of workers from other industries or other localities. Whether labour in the aggregate may be said to have a supply price (se, to be responsive in the long run to an increase of wages) is a question to which the Malthusian theory of population gave a more nearly unqualified affirmative answer than would be supported by the present opinion of scholars (See also Demand, Economics, and Price) (A Yo)

SUPPLY AND TRANSPORT, MILITARY. An army may be divided unto two component parts the combat troops and the service forces. The combat troops cannot accomplish ther mission without the support of the service forces which help them to move and furnish them with the supplies and services necessary to be an affective force when the purple.

Militarily, the term "supplies" includes all things necessary to equip, maintain and operate armed forces. It includes such items as food, clothing, arms, ammumition, fuel, gasoline and libbreants, construction and maintenance materials, vehicles and varied types of machinery.

Supplies are obvously of little value to an army unless an adequate transportation system is available to move them to areas where they are needed Lack of adequate transport in a wartime stuation will frequently cause an army to abandon a tactical plan which is otherwise feasible. An army's transportation system includes all means of transportation—water, highway, rail and air—at its disposal both within its home country and within and air—at its disposal both within its home country and within and aroute to its theatres of operations. The establishment of such means creates lines of communication. The operation of the means of transport must be co-ordinated and controlled to eliminate bottlenecks, ensure that they are carrying the personnel and supplies they are capable of moving, and give the transportation system the flexibility necessary to function in changing tactical situations. Movements of troops and supplies are classified as tactical when surface contact with the enemy is considered possible, and as administrative when such contact is not expected

The basic principle of supply envisages a steady flow of supplies from care to front. Forces in rear areas are responsible for procuring and transporting supplies to combat troops. This refleves tactical commanders from such administrative burdens and permits them to devote their major attention to the defeat of the enemy. During the planning stage for a campaign or battle, an army commander informs the supply services supporting him of his operational plans. Thereupon the latter services estimate their capabilities to support the tactical plan logistically. Especially in a large-scale operation, the final tactical plan normally represents a balance between what the army commander wishes to accomplish and the ability of the supply services to furnish him with the matériel and transport necessary for success

Until the early 17th century, armies lived off the country. Sometimes they bought supplies; more offen they obtained what they needed by outright confiscation. This system of supply so rawshed various countries in Europe during the Thirty Years' War that it came into popular disrepute. Thereafter, army commanders customarily pand for supplies and stored them in warchouses to be used as needed. From this beginning a system of supply and transport evolved which became increasingly effective with continued improvements in mechanical transport. The huge armies of the 3oth century with their varied and specialized needs could not live off the land alone even if they wheel to do so

World War I.—This war taught the armies of the world two important lessons. The first was that, other things equal, the army that could best supply its troops in the field would be victorious.

The second was that the supply of a complex modern army involves the manpower and resources of an entire nation Germany enjoyed an initial advantage in the war because its army had built up a tremendous reserve of supplies of all classes and had worked out a detailed plan of distribution to its forces in the field The British, French and U.S armies were not so well prepared. However, as the war progressed, the combined weight of Alhed 1esources, which were speedily organized for war, began to tell Production in the farms, mines and factories of the Central Powers decreased as more and more workers entered the fighting armies Under the strain of providing for both their armies and their civilian populations, the Central Powers could not maintain the pace of production that the Albes had set. By the time the war had ended, it was clear that the ability of the Allies to produce more war materiel and move it faster was as much responsible for victory as were the efforts of their combat troops.

### WORLD WAR II

This conflict was also essentially a war of supply. The brilliant stategy of high commanders, the bold tactice of battle leaders, stall and courage of the fighting troops, all contributed to the final outcome; but vactory went to the nations who had best organised their total economic resources to produce the material of war and othe transport to move it, and fromes, to the world's battledge.

Logistical Preparedness for Wat.—Before war started on Sept. 1, 1939, with Germany's invasion of Poland, no nation even approached the state of economic and industrial preparedness for war that was to be required later. Under Hiller's leadership, Germany had steepped up production for war ance 1933 and was much stronge militarily than its neighbours by 1939. It industry and scientists had developed synthetic rubber and gasoline and had built plants to produce both these important war materials in which Germany was deficient. The extent of economic mobilization in 1939, however, was exaggerated; only on the eve of Germany's attack on Poland was there such a tlung as a multary procurement program worked out for a period as long as two years. Germany was not prepared for a long, sustained war.

Italy, unlike its ally, did not possess the economic resources necessary for even a short war involving a large-scale military effort—as the Italian general staff had informed Benito Mussolim prior to World War II This became apparent early when Italy's nability to supply its army invading Greece in the autumn of 1940 contributed heavily to the defeat of that efforts.

When Japan struck at Pearl Harbor, it was ostensibly well prepared for war Its merchant fleet was the third largest in the world and it possessed the world's third largest navy. In Japan proper, in Manchuria and in Korea were highly developed systems of railroads Japan had the industrial potential of Manchuria to supplement its home industries, which were harnessed to support the military effort For years it had exported the products of a flourishing textile industry-often at the expense of the civilian population which needed these products-in order to import scrap iron, oil and machinery required for war production. There was clear evidence, however, that Japan's estimate of the quantity and type of equipment and supplies required to prosecute a major modern war was based largely on its experiences in the Russo-Japanese and Sino-Japanese wars, and influenced only to a small extent by the experiences of the major powers in World War I and in the early phases of World War II. Throughout World War II, the Japanese high command was to display a surprising disregard for the logistical aspects of war. In this connection, a statement made by Gen. Toshio Nishimura, assistant chief of staff to Gen. Tomoyuki Yamashita, was significant. "In our army," he said, "the officers do not like to study logistics-it does not interest them-they want to study only how to fight. Even in the military academy it is difficult to get the cadets to study logistics."

Although the axis nations had apparently not visualized the U.S. found itself worfully short of equipment for the expanding scope of the supply and transport requirements which Word military establishment. Meanwhile, the demands of France and War II would entail, their state of military establishments when while the demands of France and War II would entail, their state of military preparedness was Great Britain for military matériel were swamping a small municalizary superior to that of the Allies who had done little to ready tions industry As this minustry expanded, it became apparent their economies for war. The U.S.S., however, was an exception of the property of the state of the s

both multially and economically for the impending conflict Following the advice of Nicola Lenin, the sovet leaders had created a large army with modern equipment. Moreover, through a series of twy year plans, they had built a sturdy heavy industry for the acknowledged purpose of providing a broad economic base for war—in addition to manufacturing the implements of peace. The agricultural machinery industry, for instance, built tractors needed for Russan collectivized farms, but these factories were enably converted to manufacture tanks. Aided by foreign capital and etchnical assistance, the US SR had also developed an arreaft and automobile industry necessary in providing transport for a modern army

More important yet, Russan leaders in the early 1930s had started to build up huge industrial centres beyond the Ural mountains which could function undisturbed during an enemy attack on the western USSR When Germany invaded the USSR, the Wehrmacht faced armes supplied by a civilian industry disposed in depth. The power of later soviet counteroffensives made by armes equipped with excellent tanks, planes and impressive numbers of artillery pieces was ample proof of the effectiveness of the USSR's war industry.

Meanwhile, the Red army was handicapped by deficiencies in the soviet transportation system. Roadnets in the USSR were not well developed, and the railway system had not kept pace with the industrialization of the country. In addition to supplying the amed forces, the railways were also needed to move dismantled factories eastward before advancing Germans. This was a serious strain upon the soviet railroad system, especially during the early stages of the war. Another transportation deficiency was the lack of merchant ships. Unlike Britain, the USS. R. could not dispatch fleets of supply vessels to Allied countries to pick up supplies which it lacked

The other major Alhed countries, Great Britain, France and the United States, had done little to prepare their economies for war prior to its outbreak. France had recognized the importance of total economic preparation for war in the Defense law of 1948 which provided for a minister of armaments. However, little or nothing had actually been accomplished in the way of economic mobilization when Germany struck. France depended more on the Maginot line and on manpower than on its military equipment, much of which was sesentially of World War I type

The general staff of the French army had prepared an elaborate supply plan to support field armies in a theatre of operations which was expected to be in northeastern France. This plan, however, was based on archaic World War I principles and was highly inflexible. It provided for supply concentrations in expected areas of battle operations and depended almost entirely or railroads to the exclusion of motor transport. It was to prove incapable of supporting field armies matched against highly mobile German forces.

Great Britain was similarly unprepared. Not until a month before Poland was invaded dut he Britais creat the minustry of suply, which was to be their major national co-ordinating agency for evuilian and military supples. The royal navy, of course, su superior to any that the axis nations could assemble, and the royal air force had ewe and modern planes. The British army, howers, lacked adequate modern equipment. Transportation was a major factor in the British supply scheme since much of the needed war matérial had to come from member nations of the British empire and later, through lend-lease, from the United States.

Like France, the United States had long recognized the principle of industrial mobilization for war. As early as 1922, the navy and the war department had planned for such mobilization through the medium of the army and navy munitions board. Lack of funds, however, prevented adequate measures for preparedness When World War II started in Burope in 1939, the U.S. found itself woefully short of equipment for the expanding military stablishment. Meanwhile, the demands of France and Great Bertain for military matériel were swamping a small munitions industry. As this industry expanded, it became apparent that a system of allocating the nation's materials to industry would have to be instituted; otherwise the country forced the

threat of uncontrolled competition among the various procuring agencies that had characterized 1917 procurement efforts. After several national agencies with limited authority had been created to supervise allocation, the War Production board was organized in Jan 1942 as the major co-ordinator of industry for the national defense program. In March of the same year, the army service forces, at first called the services of supply, was organized to coordinate the administrative, supply (including procurement) and service activities for the war department as a whole.

Early Phases of the War in the West,-In May 1040 England, France, Belgium and the Netherlands had troops on the continent with total numbers exceeding those of Germany Imtial superiority in transport and supply organization, as well as the tactical aggressiveness of the German armies, however, enabled Germany to defeat them with ease Less than a year after France had fallen, the Wehrmacht was driving deep into the USSR and in early 1042, the Afrika Korbs was threatening the Suez canal

At this time, however, Allied resistance began to stiffen, and the German field armies began to feel the effects of overstretched supply lines and the weaknesses of a supply policy designed primarily for short campaigns In an effort to pour as many new combat units into the field as possible and thus ensure quick victories. Adolf Hitler had insisted that 90% of newly produced equipment should be furnished to newly activated combat units The shortsightedness of this policy in a sustained war became apparent as the lack of replacements for worn, damaged or captured equipment impaired the efficiency of fighting units

which had been in combat for long periods

Preparing for the long war which they knew lay ahead of them, Britain and the United States started to build up the armies and the tremendous amounts of supplies and transport needed for a major offensive. Meanwhile, they launched smallerscale offensives in North Africa, Sicily and Italy. After the strength of the German eastward drives in the U.S.S.R. had been spent. Russian armies, supplied mostly by their factories beyond the Urals, mounted a large-scale counteroffensive

Logistical Aspects of Campaigns in the West.-In 1042. the British and Americans were considering a cross-channel invasion of France from England to aid the hard-pressed Russians The Alhes, however, lacked the large numbers of invasion craft and the supplies and troops needed to make such an assault and

thereafter to sustain an offensive Accordingly, it was decided to invade North Africa.

North Africa -The U.S. army service forces had built up enough matériel in the United Kingdom to equip the U S. troops there who were to invade Africa. However, they had transported combat units to England at the expense of enough service units to store and catalogue this equipment adequately. As a result much of the materiel could not be readily located, and duplicate shipments from the United States became necessary. This experience provided an object lesson to the U S. army, which thereafter attempted always to provide service troops commensurate with the amounts of supplies they were required to handle.

After North Africa had been invaded successfully, the transport factor immediately assumed importance in subsequent operations. Allied forces rushing eastward toward Tunisia soon outraced their supply support. Railroads along the North African coast line were single-track and had little usable rolling stock. Roads were poor and the Allies lacked adequate motor transportation As a result, the defeat of axis forces was delayed

Sicily.-One of the major factors influencing the Allied decision to attack Sicily was the desire to gain additional protection for the Allied supply life line through the Mediterranean to the Suez canal. The spectacular speed with which the Allies overran Sicily resulted in minimum losses of supplies. As a result, there was considerable excess equipment in North Africa and Sicily available for later assaults in Italy.

Tialy.-It was political and operational factors, rather than logistical factors, that in the main determined the Allied decision to invade Italy. Italy was not self-sufficient and the Allies were obliged to ship coal, food and clothing for the Italian people in addition to supplies for their armies in Italy. The narrow front

in the Italian peninsula made it difficult for the Allies to get behind the Germans to cut lines of communication Mountainous terrain and an inadequate road net hindered service forces supplying combat troops

Western Europe -Logistical considerations had played a major role in the decision to attack Festure Europa from Great Britain The United Kingdom provided a ready-made base of operations with modern transport and cargo facilities located only a few miles from the enemy While conducting their operations in the Mediterranean, the Allies had continued to build up troops and equipment for Operation "Overlord," the cross-channel invasion To keep British ports operating at full capacity, the United States preshipped equipment to the United Kingdom for the use of combat troops who followed later In the year preceding the invasion, the US preshipped a total of 5,530,000 measurement tons of such equipment and supplies During the same period 1,600,000 men were moved into the United Kingdom

The problem of moving supplies across the beaches to sustain the divisions employed in Operation "Overlord" was particularly difficult. Pending the seizure of French ports capable of handling large quantities of supplies, artificial harbours were built to be

used at assault beaches

In the Allied race across France following the Normandy invasion, supply lines stretched nearly to a breaking point Lack of adequate supplies, especially gasoline, caused the combat units pursuing retreating German armies to halt. Not until the Alhes captured Antwerp, Belgium, a port closer to their forward fighting elements, were the supply forces able to provide the masses of material needed to continue the plunge across the Rhine into the heart of Germany

Two months after the Normandy assault, the Allies' landing in southern France gave them the ports of Marseille and Toulon thus relieving some of the pressure on the congested channel ports of France. It also enabled the Allies to use the north-south railroad and road nets in France to supplement the congested east-west highways and railroads in northern France.

As this tremendous logistical build-up of the Allies increased, Germany could not keep pace The basic reason for this was that Germany had not mobilized its economy as effectively as had the Allies for war. In 1944, for example, only about one-third of all German output went for direct war purposes, whereas 40% of US production effort at the height of the war was used for implements of war. At one time, the percentage of British war production to total production may have gone as high as 45%. As Allied strategic bombing mounted in intensity, German transportation and industry suffered Faced with the crushing weight of Alhed matériel from east and west, its armies succumbed

Campaigns in the East,-Japanese strategy from 1932 onward was aimed at denying Chinese armies the support of the industrial areas of Manchuria, and China itself. Concurrently. Japanese armies attempted to starve China into submission by seizing agricultural areas or by making periodic forays in strength to confiscate or destroy harvests

In Dec. 1941 and Jan. 1942 the Japanese seized the ports of southern China, thus denying the shipment of Alhed supplies to poorly equipped Chinese armies In March 1942 the Japanese capture of Rangoon closed the Burma road, by which Allied supplies had been carried overland to the interior of China. Only by air shipment over the Himalaya (the "Hump") could supplies then be delivered. Planes, however, could not carry heavy construction machinery and fighting equipment, or adequate amounts of the supplies needed by Chinese armies. Accordingly, the Allies began the herculean task of constructing the Ledo road with parallel pipe lines through almost trackless wastes from Assam, India, to a point on the Burma-China border where the new road could link up with the portion of the old Burma road not controlled by the Japanese. Meanwhile, the Allies still had to get supplies from the supply base at Calcutta to the beginning of the Ledo road in Assam This necessitated the improvement of railroads and barge lines between these two points.

The rough terrain and lack of existing means of ground transport forced British and U.S. troops operating in the China-BurmaIndia theatre to rely on planes alone to move and supply them on many occasions

"Pacific Campaigns—Early in the war, the United States had decided to contain the Japanese advance in the Pacific while making the major effort against the ans in the European theatre Transportation was an important factor influencing the formulation of this strategic decision. The United States lacked enough shipping to move the troops and supplies required for powerful concurrent offensives in both the Pacific and Europe—and distances to Pacific fighting fronts were almost twice as far from U.S. supply bases.

supply oases.

While committed to a strategic defense in the Pacific, the United States launched limited offensives to seize advance bases for air and logistic support of later offensives in strength. The objective of the 1942 campaign in New Guinea was to shorten supply lines by establishing major bases along the New Guinea coast to support future operations. The primary reason for the assault on Guadalcanal was to seize a forward air base. The U.S. also built up supplies at such bases as New Caledonia, Espiritti Santo and Guadalcanal, so that by June 1943 there was sufficient strength for further attacks in the Solomons, The "shand-hopping" technique employed in the South Pacific consisted of amphibitious landings on shores that were trackless jumgles. Such operations required a rapid build-up of supplies for fighting troops and the speedy construction of roads and artifields by specially trained and equipode denineer units.

Meanwhile, the by-passing of islands by amphibious U.S. forces made the enemy-held garrsons liabilities rather than assets to Japan Cut off by U.S. submarine, surface and air blockade, Japanese troops could not be supplied and reinforced and rapidly lost their potentialities as combat forces.

By the summer of 1945 operations in the Mediterranean had stabilized sufficiently to release some shipping for other uses. These ships, along with large numbers of new ships produced by an accelerated construction program, were then available to carry large numbers of troops and supplies to the Pacific from the west coast of the United States or from the base facilities which had been developed in Hawaii. In accordance with long-range plans developed by the US army and anays, supplies and troops were moved to take part in the long-awaited major offensive in the central Pacific.

By mid-roa4 the joint chiefs of staff of the US, armed forces began to make detailed strategic plans for the seizure of the Philippine Islands to be used as bases for the eventual assault on Japan tself. There had been some question as to whether it was preferable to attack Formosa rather than Luxon in the Philippines for use as a major base Here again the logistical factor decided the question. The army service forces, which had made logistical studies of the Philippine Islands as early as 1944, declared that Luxon, with its superior ports, road nets and afrield fachties, would provide the better base. Accordingly, operational plans in line with the recommendation of the army service forces were adouted

In addition to the Allied offensive, there were two important logistical factors which contributed to the final Japanese capitulation in Aug. 1945. In the latter phases of the war, Japanese troops became deficient in almost all classes of supplies and equipment because of madequate home production and inability to transport war supplies and redinforcements to the far-fung garrisons in the areas they had conquered, especially after the Alles had secured air and sea superiority in the Pacific and secured air and sea superiority in the Pacific secured.

#### KOREAN WAR

Millary transport assumed a dominant role at the very outset, of the Korean war when it became obvious that without immediate reinforcement the Republic of Korea army was doomed. Troop transport planes of the United States air force ferried an understrength infantry battalion to Pusan less than 12 hours after the decision had been made to commit United States troops in Korea. Seaborne units followed rapidly.

As the fighting progressed, superior transport enabled outnumbered United Nations ground forces to hold the enemy and then counterattack Lacking adequate reserves during the defense of the Pusan bridgehead, the 8th army used trucks to shuttle ground units quickly from one threatened sector to another. Superior sea transport permitted UN troops to make an amphibious landge at Inchon on Sept 15, 1950, and to help support logistically a subsequent offensive that virtually destroyed the Korean Communist army.

By contrast, lack of adequate transport hampered the Chinese communists when they entered the war. After an offensive, the Chinese were obliged to halt for long periods while they moved up ammunition, equipment and food by oxcart, porters and a minted number of motor vehicles and railroad cars. Attacks by United Nations aeroplanes further complicated Chinese resupply and reinforcement. Thus delayed, the Chinese could not exploit their initial successes against an overettended but more mobile.

8th arms.

The United States assumed the major responsibility for funminising and transporting military supplies to United Nations forces in Korea. To fight a war 6,000 mi, from its shores, the United States expanded rapidly a military transport system organized after World War II. In 1949 the United States navy's Military Sea. Transportation service (MSTS) had assumed responsibility for all ocean shipping. From June 25 to July 31, 2950, the MSTS moved 4,000 me, 500,000 measurement tons of cargo, and more than 2,000,000 barrels of petroleum to the far east. The United States Military Air Transport service (MATS), operated under control of the air force but manufol jointly with air force and navy personnel, had been established in 1948. In any from the United States the Japan. Five weeks later, the Pacific air lift had increased its pre-Korean tonnage by 3,000%.

Pusa provided a major port for United Nations forces. Despite shortages of expensenced labourers, limited port and dock facilities and antiquated Korean equipment at Pusan, the United States army's transportation corps organized thousands of Korean stevedores and unloaded 300,000 tons of cargo at this port during July 1950 along

Kortes's roadnet was limited and primitive. To supply United Nations troops in positions distant from usable roads, the Republic of Korea formed the civilian transportation corps. This organization, later integrated into the Korean services corps, furnished thousands of porters who carried ammunition and supplies to the most forward infantry units. The military helicopier also proved invaluable as a means of supplying combat units in in-accessible locations and evacuating wounded.

Japan, with its excellent ports, rail and roadnet, provided a superb supply base close to the Korean battfeground However, United States army divisions in Japan at the outbreak of the Korean war were organized for occupation and lacked much of the combat equipment they required, especially tanks, motor vehicles and anti-tank weapons. This equipment was rushed from the United States. At the same time the United States army instituted an extensive reclamation and rebuilding program to salvage thousands of motor vehicles and other equipment left on Pradic islands after World War II. The rapid redeployment of troops is always the control of the program of the same program of the sa

When the Korean war brought audden demands for additional stipping, the United States navy took about 2,000 ships of all types out of "moth balls," The United States air force, experiening smilar problems in obtaining additional equipment rapidly, employed some commercial transport planes to help overcome shortages.

The Korean war again emphasized the critical importance of military supply and transport in modern warfare. In the first four months of this war, the United States shipped more men and equipment to Korea than it did to North Africa. Ir months after Pearl Harbor. Better supplied and better transported, outnumbered United Nations forces were able to defend the Republic of Korea with conspicuous success.

BIBLIOGRAPHY -"How Does It Get to You?" Armed Forces Talk, no. 412 (June 27, 1952); Army Information Digest, passim.

## MODERN MILITARY ORGANIZATION FOR SUPPLY

The supply services of a modern army are organized usually on a service, territorial and command basis

Service Organization .- Specialized military supply functions are assigned to various vertical organizations within an army which have staff officer representatives at nearly all echelons of army command In the United States army, for instance, the quartermaster corps has the special function of providing food and other supplies to the troops. There are quartermaster officers at levels from the division upward to perform this function. In addition to this staff organization, a service maintains troop units to perform the actual operations with which it is charged Many of the services also maintain combat type units which handle special equipment of the service in battle

Organization varies among armies, but the technical services of the United States aimy are typical. These services determine army requirements for the supplies in categories under their supervision and then procure, store and issue them They also perform maintenance and other duties Technical services, along with typical supplies which they handle and typical specialized duties which they perform, follow

Chemical Corps - Typical supplies which this service handles are smoke-producing equipment, bulk chemicals (toxic and nontoxic), flame-throwers, gas masks and decontaminating equip-ment Typical services performed are decontamination of equipment, training of troops in gas warfare and maintenance of chemical depots.

Engineer Corps -This service is responsible for such supplies and equipment as bridges, construction materials of all kinds, assault boats and maps. Among the services performed by engineer troops are the construction and maintenance of structures of various types, the clearing and operation of ports, surveying, mapping and reproduction of maps and the furnishing of electrical power

Medical Service,-Medical supplies include instruments, drugs, plasma and therapeutic apparatus. The medical corps treats the sick and wounded and supervises measures taken by troops to maintain health

Ordnance Corbs -This service handles most of the weapons. ammunition and motor vehicles used by the U.S. army Ordnance troops help service this equipment.

Quartermaster Corps -Food, clothing and gasoline are three of the major items which this service supplies. Among the services it performs are the operation of laundry and dry-cleaning facilities and graves registration.

Signal Corps,-Telephones, wire, radios, public address systems and photographic equipment are typical of the supplies for which the signal corps is responsible Signal units install and repair communication facilities of various kinds, and take and develop photographs.

Transportation Corps .- This service handles railway and certain types of floating equipment Its services include transportation of personnel and property of the U.S. army

Territorial Organization .- A theatre of war includes all the sea, air and land masses which are actually involved, or which may become involved in a war. The actual fighting takes place in only a small portion of the theatre. The remainder is filled with combat troops preparing for or moving to battle and the numerous supply agencies which operate the lines of communication . For operations, these supply agencies are frequently placed under area commands which co-ordinate their efforts There are such territorial supply commands in two of the major subdivisions of a theatre of war-the zone of the interior and the theatres of operations.

Zone of the Interior .- This area ordinarily includes all the territory of a nation exclusive of the theatres of operations. It may, under some circumstances, also include foreign territory, either allied, neutral or hostile. Within the zone of the interior is a major supply organization or group of organizations which co-ordinate the funnelling of troops and supplies to the theatres of operations,

the theatre of war necessary for tactical operations and for administration incident to these operations. Although there is no rigid organization of a theatre of operations, it normally contains a combat zone and a communications zone

The combat zone comprises the land, sea and air masses required for combat operations and for the immediate administration of the combat units operating therein. The combat zone is divided normally into army areas which are in turn divided into corps and division areas. In a normal situation, an army within the combat zone will designate an aimy service area which extends from the corps rear boundaries to the combat zone rear boundary In the army service area, supply and service units, organic or attached to the army, operate These units may, however, be located anywhere throughout the combat zone, including territory under the control of subordinate commanders. In a sense, the army service area is the communications zone of the army, providing a logistic link between the army and the theatre communications zone

The communications zone includes all the territory of the theatre of operations between the rear boundary of the theatre and the rear boundary of the combat zone. It provides space in which administrative units, including supply and transport agencies, function in support of the fighting units in the combat zone The communications zone is a link between the zone of the interior and the combat zone. It is established primarily to free combat commanders of such responsibilities as supply and administration of territory not directly concerned with combat For this reason, the communications zone is constantly pushed forward as the fighting troops advance. When practicable, the communications zone operates as a single unit, however, factors such as the territorial extent of the zone, enemy activity or the volume of support operations may necessitate decentralization of the zone into base sections and advance sections In such a situation, the base section is normally closer to the zone of the interior while the advance section provides the link between the combat zone and the base section The nature of combat operations and other special conditions determine the type of organization After the establishment of a beach head on a hostile shore, for example, all service units supporting an army might be pooled into an army service command under direct control of the army commander As more territory is gained, the army service command might be dissolved and an army service area and an army base established A final step might occur when the communications zone of an advance section of the communications zone takes over this army base

Command Organization.-In most multary commands, whether large or small, commanders are responsible for the immediate supply and transport of their subordinate units theatre commander, for example, is responsible for the distribution of supplies and transportation to the army, navy and air theatre commands An infantry regimental commander is likewise responsible for providing his battalions and companies with supplies and the vehicles needed to move them

Each commander has a staff or its equivalent to assist him in discharging this responsibility. In the U.S. army, the assistant chief of staff G-4, or his counterpart in a larger or smaller unit. is responsible for supply planning and the supervision of supply operations. The G-4 also handles transportation for administrative moves of the command The assistant chief of staff G-3 (plans and operations officer) supervises the transportation in combat operations

# SUPPLY OPERATIONS

On every level of command there must be a close haison between the unit commander and his supply services in order that adequate supplies will be available at the time and place needed to support tactical operations. Because there is a time lag between requisitions for supplies and their airival, all commanders must inform supply agencies of planned operations as early as

Supply Requirements.-This is a statement of all the sup-Theatre of Operations.-This area includes that portion of plies needed by a military organization over a specified period of time or to complete a particular project Requirements for an organization may include

Initial Equipment Requirements—This is the equipment which a unit, such as one recently mobilized, needs in its initial issue Replacement and Consumption Requirements—A unit needs issue of expedience and consumption of the 
issues of supplies to replace items worn out, destroyed or consumed

\*Reserve Requirements\*—Units are authorized to keep reserves

of equipment and supplies which they need in case normal resupply channels are interrupted

Project Requirements —A unit has requirements for supplies not included in normal allowances when it is given a special operation to perform

Levels of Supply—Supplies are not pumped into a theatre at an absolutely uniform rate because of enemy interruptions of the supply lines and the imperfections of even the best transportation system. In order, therefore, to maintain a continuity of operations a theatre is authorized to maintain levels of supply. These are quantities of supplies, usually expressed in days, which it keeps on hand for future needs. In turn, the theatre authorizes its subordinate commands to maintain levels of supply which units procure by requisition on higher headquarters.

Procurement.—A theatre of operations obtains the supplies it needs by shipment from sources such as the zone of the interior lying outside the theatre, or by exploitation of resources within the theatre

Supply from Zone of the Interior—When a multary force minitates a campaign that establishes a theatre of operations, it takes with it its initial equipment and supplies for replacement and maintenance for a specified period of time As the campaign progresses, it receives an automatic issue of supplies from the zone of the interior on a prearranged schedule, based on autoripated needs. Later, as the theatre becomes organized, it can calculate more realistically its own supply needs, it then starts to requisition supplies from the zone of the interior based on its actual experiences and the automatic issue eventually ceases.

Supply from Local Resources—Military forces habitually utilize local resources when possible to avoid the shipment of similar materials from distant multary supply bases. When in allied areas, arrangements are made with the friendly government to obtain supplies and services needed. In hostile territory, troops may procure supplies by purches, requisition, contributions or confusation. In any case, the theatre commander prescribes the procedure by which subordinate beautiful to the procedure of the subordinate beautiful to the subordinate law, rules of land warfate and regulations of higher authority. Any sensure of property not so authorized is pumbabble as looting.

Supply through Repair and Recovery—In battle, much equipment and many supplies are shandoned, lost or damaged either through emeny action or through madequate mantenance. Energetic efforts to collect the cupment which is attern over any battlefield and to salvage damaged material greatly case the strain on the supply system which must furnish replacements for lost or destroyed equipment. Every individual in an army is responsible for the recovery of sulvegachel supplies. When deemed appropriate, combat troops are often used to collect recoverable equipment after fighting is over. Commanders are responsible for the mantenance of supply discipline in their units to keep the loss and wastage of supplies to a minmum.

In divisions and higher units organic service troops salvage equipment as a normal function. When possible, they restore damaged equipment so that it can be used for the purpose originally intended. When this is not possible, they may convert the equipment for some other use. Within the theatre, some service units have the sole mission of retrieving abandoned and damaged cumble, and excriments.

supplies and equipment.

Marking and Packaging.—In order that supplies may go through the long supply line to their proper destination without confusion, it is essential that they be properly marked. Markings generally include the destination, type of supply, method of shipment, weight and cubage and the period in which shipment is to be made. For security reasons, some of this information is

often in code.

Factors influencing the method used to package supplies include the need to conserve shipping space, protection against the elements and rough handling, and the fragility of the supplies Often it is necessary to package supplies in such a way that they can be dropped from planes or broken down easily into one-man lark.

Storage.—At various points in a military transportation system, supplies are stored in depots where they are entered on stock records and held for further movement or distribution to the units which use them. Depots may be classified as branch depots (such as quatermaster or engineer services) according to the service which maintains them. Although general depots (which stock supplies used by two or more depots). Are sometimes organized, branch depots are the type more often used. Depots may also be classified according to the type of supply they handle

Within the communications zone is an elaborate depot system for storing supplies for further tunsportation. Within the combat zone are army depots from which are funnelled supplies to army railheads, truckheads or anwigation heads, where distribution to troops is accomplished. A dominant factor in the selection of depot states is proximity to means of transportation.

Distribution.—Distribution in a military sense includes all the operations incident to the movement of supplies within a command A distribution system must be flexible to ensure the adequate supply of troops in spite of rapid changes in the tactical substance.

Within a theatre of operations, the first step in the distribution process is usually the movement of supplies from ports to deposit within the communications zone. Such movement must be carefully controlled and expected to avoid port congestion. After the supplies are classified and picked up on stock records in these untial depots, they start through the chain of depots that store them until they are distributed to user agencies.

There are two general methods employed to distribute supplies to user organizations distinguished by the point at which supplies are delivered to them.

Supply Point Distribution—In this method, delivery of supplies is made by the supply agency of a higher echelon to a supplionit established by subordinate units. The units which are to use the supplies employ their own transportation to pick up these supplies.

Unit Distribution —Under this system, the higher echelon provides the transportation to haul the supplies directly to the bivouac areas of subordinate units or to some similar point of easy access

In the U.S. army, field armies and divisions ordinarily employ the supply point distribution method, while regiments use the unit distribution method.

### TRANSPORT ORGANIZATION

Nearly all units in an army are assigned means of transport on a more or less permanen basis—the units' organic transportation." Meanwhile, higher echelons may allocate additional transport to subordinate units when the occasion demands. A field army, for example, might assign additional truck companies to a corps when the corps's mission requires additional mobility.

In field armies, communications zone sections and in higher echolons, a transportation service is organized. This service has technical supervision over the transportation assigned to its own echelon and to subordinate echelons. It co-ordinates and court trols administrative moves made by means of this transportation.

Just as depots must be established for the assembling and storage of supplies as they move along the lines of communcation, so must "staging areas" be maintained to accummodate most expension of the supplies areas, established and maintained by the transportation service, are usually near normal stopping points such as rail terminals, articleds or highways. Staging areas vary in size and the number of facilities such as shelter, mess, supply and medical services which they provide.

Shipment by Water .- Ocean shipping used by military forces

may include troopships, troop-cargo ships, cargo ships and tankers These may be owned and operated by the military services or leased from civilian agencies A theatre commander has complete control over shipping allocated for intratheatre use Furthermore, he may direct shipping from the zone of the interior to unloading points in accordance with operational needs

Ports.-These include both ports of embarkation and debarkation Sometimes a port may serve both purposes Ports are operated by an organization responsible for conducting the operations incident to moving troops and supplies A typical organization of this type includes a headquarters and operational units such as truck or car units, port battalions, rail units and ship repair units

Beaches .- When ports are not available, or their facilities are madequate or damaged, beaches are frequently used to unload troops and supplies. Such an operation is complex and involves the use of specially trained units and special equipment

Highway Transport.—Militarily, this term includes trucks, buses, passenger cars and other miscellaneous vehicles intended to haul cargo and personnel over highways, roads and streets

Traffic Control .- Within the logistics section of each US army division, corps, army or other higher headquarters, there is a traffic headquarters which determines the capabilities of highways to support vehicular traffic and the maintenance and improvement which they need. This headquarters also makes plans for co-ordinating and controlling troop and supply movements by road Military police and designated personnel of units moving by motor convoy execute these plans The planning and supervision of motor moves in combat situations is accomplished by the operations officer of a unit

Cross-Country Transport.-The movement of personnel and supplies cross-country may be accomplished by vehicles, narrowgauge railways, aerial tramways, animals or men. Cross-country vehicles include such specially designed equipment as tracked and amphibious vehicles.

Railways.-When they are available, railroads form the backbone of the transportation system in a theatre of operations. A military railway system established by the U.S army is similar to its civilian counterpart. For maintenance and operation, the system is divided into a number of railway divisions, each under the control of a division superintendent. A railway operating battahon is assigned to a division. A grand division comprises usually from two to four of these operating battalions along with necessary shop battalions. The military railway service, headed by a general manager, is made up of one or more railway grand divisions

The general manager of a military railway service supervises operation throughout the communication zone and within the combat zone to the forward limit of rail traffic Commanders of ports, depots, railheads or other supply points are responsible for loading and unloading cars.

Pipe Lines .- When terrain is too rugged for other means of transport, or when road and rail capacity in an area is limited and traffic is heavy, pipe lines are often used to transport, distribute and store bulk liquids.

Air Transport.-In World War II, Germany, Great Britain and the United States made extensive use of transport planes, not only to move men and supplies administratively, but also to carry fighting troops which made assault landings from the air. In May 1941 German air-borne forces seized Crete. The Allies employed an air-borne corps in the Normandy invasion, during the extension of their northern flank in the Netherlands, and in the Rhine crossing. In the latter operation, the 18th air-borne corps's transport planes and gliders delivered a total of 17,122 troops 614 jeeps, 286 artillery pieces and mortars, plus hundreds of tons of gasoline; food and ammunition, to the corps air head in about two hours. After the war the Berlin "air lift, during which U.S. and British planes carried approximately 2,000,000 tons of supplies into blockaded Berlin and flew out more than 70,000 tons of cargo, furnished dramatic proof of the capabilities of air transport.

Advantages of air transport include the speed with which sup-

plies and men can be moved, unlimited choice of routes within aircraft range and freedom from ground obstacles to transport Disadvantages include the limits on the weight and bulk of equipment which planes can carry and weather restrictions on air travel Planes in the heavy transport class are further restricted by the limited number of fields on which they can land In wartime, transport planes are especially vulnerable to fighter planes and to anti-aircraft fire An air-borne operation into enemy territory requires surprise, air superiority, or both

The interest in air transport which the US army indicated during and after World War II was reflected in the postwar organization of both air-borne and standard infantry divisions The air-borne division acquired heavier equipment than its World War II counterpart to enable it to fight more sustained actions behind enemy lines Meanwhile, the standard infantry division's equipment was made lighter and less bulky, to facilitate movement by air

INTLUDY OF STATES AND A STATES vey, The Effect of Air Action on Japanese Ground Army Logistics (April 1947), Garrett Underhill, "The Story of Soviet Armor," Armored Cavalry Journal (May-June 1949) (B F D)

SUPRARENAL EXTRACT. In medicine, the sterilized glycerin extract of the suprarenal gland of the sheep, the dose being 5 to 15 minims The active principle adrenaline or epinephrine occurs only in the medulla of the gland It forms minute white crystals, soluble in weak solutions of hydrochloric acid, and is most frequently used in 1% solutions of the chloride

Adrenaline has no action on the unbroken skin, but applied to mucous membranes it causes blanching by stimulating the muscular fibres of the arterioles It acts rapidly in a similar manner when hypodermically injected The vessels of the uterus are strongly acted upon by it, but the effect on the cerebral vessels is slight, and the pulmonary vessels are unaffected. The heart is slowed and the systole increased. Adrenaline stimulates the salivary glands, produces a temporary glycosuria, and in poisonous doses causes haemorrhages in the viscera and oedema of the lungs.

In Addison's disease the use of suprarenal extract has been beneficial in some cases, but its chief use is in the control of haemorrhage For this purpose it is given in conjunction with local anaesthetics such as cocame in order to produce bloodless operations on the eye, nose and elsewhere. It is also useful in haemorrhage from small vessels, where it can be applied at the bleeding spot, as in epistaxis. In surgical shock and in chloroform syncope an injection of adrenaline often saves life through the rise of blood pressure produced. An attack of bronchial asthma may be cut short by a hypodermic injection of adrenaline solution should never be used in the treatment of haemoptysis. Similar commercial products on the market are hemisine, renaglandine. suprarenine, adnephrine, paranephrine and renostyptine Suprarenal snuff containing the dry extract with menthol and boric acid is of use in hay fever. Rhinodyne is of this type. Suppositories containing suprarenal extract are employed successfully to check bleeding piles

The chemistry of adrenaline has been mainly elucidated by the investigations of Pauly, Jowett and Bertrand; Jowett proposing a constitution (see annexed

HO HO Adrenaline renalme in increasing the blood

formula) now accepted as cor-CH(OH) CH, NHCH, rect Many substances having related constitutions have been synthesized, and resemble ad-

For example, the corresponding ketone, adrenalone (obtained in 1904 by Stolz), is active, and the methyl group can be replaced by hydrogen or another radical without destroying the activity. It seems that the parahydroxyl group is essential. For instance, parahydroxyphenylethylamine, HO CeH4CH2 CH2NH2, which is one of the active bases of ergot, closely resembles adrenalme (G. Barger, Journ. Chem. Soc., 1909, 95, pp. 1123, 1720; K. W. p 2193) Adrenaline is optically active, the naturally occurring isomer being the laevo form, like nicotine, the laevo base has a much greater physiological activity than the dextro. (See An-RENALINE )

SUPRARENALS: see Adrenal Glands.

SUPREME COURT OF JUDICATURE, in England, a court established by the Judicature act, 1873, consisting of the "court of appeal" and the "high court of justice." (See Court,

PRACTICE AND PROCEDURE )

SUPREME COURT OF THE UNITED STATES, THE. The supreme court of the United States occupies a unique role in the economic, political and social life of the country division of sovereign power between the federal government and the several states and the guarantees of the fundamental civil liberties of the individual against legislative encroachment by either federal or state governments demanded the establishment of an arbiter to adjust competing exercise of power between the states and between the states and the federal government and to protect individual citizens from any encroachment on their rights by either federal or state government The supreme court was established in response to this need It is one of the few among the high courts of the nations in the world which has and exercises the power to invalidate legislative enactments of both federal and state governments which are deemed contrary to the fundamental law of the land as it is expressed in the constitution-a power which is not expressly granted in the constitution but which it assumed by virtue of its interpretation of that instrument. The constitutional provision establishing the court and defining its iurisdiction is contained in article iii, sections 1 and 2, which

The judicial power of the United States shall be vested in one Supreme Court, and in such micror Courts as the Congress may from and inferior Courts as the Congress may from and inferior Courts, shall hold there offices during good Behaviour, and shall, at stated Times, receive for their Services, a Compensation, which shall not be dimnished during their Continuour in Office The judicial Power shall extend to all Cases, in Law and Equity, arsing under the Constitution, the Laws of the United States, and

aransg under taus Constitution, the Laws of the United States, and Treates made, or which shall be made, under thet Authority,—in all Cases affecting Ambassadors, other public Ministers and Consuls,—to to which the United States shall be a Party,—to Controversies between two or more States,—between a State and Cultiens of another States,—between cutterns of different States,—and the same State claiming Lands under Grants of different States, and between a State or the Cultiers thereof, and foreign States, Cultiens or the Cultiens thereof, and foreign States, Cultiens or the Cultiens thereof, and foreign States and Contients Subjects

In all Cases affecting Ambassadors, other public Ministers and Consuls, and those in which a State shall be Party, the Supreme Court shall have original Jurisdiction. In all the other Cases before mentioned, the Supreme Court shall have appellate Jurisdiction, both as to aw and Fact, with such Exceptions, and under such Regulations as the Congress shall make.

Because of the fear of the states of encroachment by the court on their sovereignty, this original grant of jurisdiction to the supreme court was limited by the 11th amendment, which became effective on Feb. 7, 1795. This amendment is as follows:

The Judicial power of the United States shall not be construed to extend to any suit in law or equity, commenced or prosecuted against one of the United States by Citizens of another State or by Citizens or subjects of any Foreign State.

While the jurisdiction of the supreme court is both original and appellate, it is only its original jurisdiction which is safeguarded by the constitution being limited to "all cases affecting Ambassadors, other public Ministers and Consuls" and those in which a state is suing either the federal government or another state. In all other cases, the court has such appellate jurisdiction as is conferred upon it by congress, which also sets up the various federal courts whose decisions shall be reviewed. Under the first Judiciary act passed on Sept. 24, 1789, congress provided for the establishment of the supreme court and of various inferior courts and provided in addition for appellate jurisdiction from the state courts in certain cases presenting federal questions. The extent of the court's appellate jurisdiction was subjected to various

Rosenmund, Ber, 1909, 42, p 4778), as does also its dimethyl de- changes which eventually crystallized in the Judiciary act of rivative, hordenine, an alkaloid found in barley (G Barger, ibid., 1925, at which time the court was granted a strictly limited appellate jurisdiction extending solely to cases involving constitutional questions and matters of national importance Thus the bulk of the court's work is confined to questions of public law and only in a comparatively few instances is it called upon to adjudicate private law disputes

The court as constituted in 1789 consisted of a chief justice and five associate judges. In 1807 the number was increased to six, in 1837 to eight and in 1863 to nine An act of 1866 would have reduced the associate justices to six, but before sufficient vacancies had occurred thus to reduce the court, the Act of 1869 was passed, which reconstituted the court with a chief justice and eight associate justices as it remains. To 1954 there had been 14 chief Justices 1 Although originally the chief justices were commissioned as "Chief Justice of the Supreme Court of the United States," in 1888 this title was changed simply to "Chief Justice of the United States"

The justices of the supreme court as well as all the federal judges are nominated by the president, confirmed by the senate and commissioned by the president Since the constitution does not prescribe the qualifications for holding judicial office, the president is left to his own discretion in the nomination of judges, as is the senate in its confirmation or rejection of his nominees Under the provisions of the constitution, in issuing the commission, however, the president exercises simply a ministerial power.

The term of the justices is during good behaviour, so that the term is for life unless a justice shall resign or by conviction on impeachment be expelled from office, as provided in section 4, article n, of the constitution. Only one justice of the supreme court has been impeached-Samuel Chase, who was acquitted in 1805 According to the latest revision of the United States judicial code at mid-20th century, a justice who has served for a period of ten years or more may resign or retire with pay upon reaching the age of 70.

In exercising its powers the court has generally been cognizant of its great responsibility. Thus, in determining issues of legislative constitutionality, the court has increasingly indicated its awareness of the importance of exercising judicial restraint Early in its history it refused to give advisory opinions on the constitutionality of legislation Later it sought to effectuate its policy of judicial self-restraint by rules which accord to legislation a presumption of constitutionality, which favour a construction of statutes so as to eliminate doubts as to their constitutionality, which enable the court to pass on constitutional issues only when essential to the determination of the case

However, the significance of the supreme court in US. life is derived not solely from its power to invalidate statutes, it comes also from its power to interpret the constitution, which can be said to be a necessary corollary of its judicial review function. In the exercise of this power the court has not felt obliged to exercise a similar self-restraint. It has by judicial construction determined that the individual fundamental liberties guaranteed by the constitution are not absolute but must yield to considerations of public policy as embraced in the police power of the state and federal governments to legislate for the general welfare. It has by this same interpretive power controlled not only the extent of social and economic legislation which could be enacted by state and federal governments, but also the relative powers of the state and federal governments to legislate in these fields. By its attitude as to the nature of its appellate jurisdiction, the court has exerted a direct influence on the growth of administrative bodies and on the significance of their existence as a "fourth branch" of the governmental process. While its decisions in these fields are of great significance, its work in the day-to-day adjustment of conflicts between the courts of the states, and between the lower federal courts sitting throughout the country. carries equal significance for the successful operation of the fed-

1 John Jay (1789-95); John Rulledge (1795); Oliver Ellsworth (1796-1800); John Marshall (1801-55); Roger Tanay (1856-64); Salmon P Chase (1866-72), M. R. Walte (1787-85); M. W. Fliller (1888-190); E. D. White (1910-17); William H Taff (1911-19); Charles E Hugges (1910-11); Harlan F, Stone (1944-40), Fred M. Vimon (1946-53); Earl Warren (1935-).

eral system of government established by the constitution.

Because of the power which the court wields, it has been subjected from time to time to considerable criticism especially in 1857 when the court decided in the Dred Scott case that congress had no power to abolish slavery in territories acquired after the formation of the national government, and more recently in the late 1030s when the court declared unconstitutional much of the early New Deal social and economic legislation Proposals for the court's abolition or for serious curtailment of its powers followed this criticism but failed of adoption, and, despite all attack, the court has generally held the confidence of the people The problems with which it has had to deal have involved the basic structure and development of the democratic system In resolving these problems, the court has of necessity been faced with the same fundamental question posed by Abraham Lincoln on the eve of the Civil War as to whether "a government must of necessity be too strong for the liberties of its own people or too weak to maintain its own existence."

Bibliogram—Paul A Freund, On Understanding the Supreme Court (1949), C G Haines, The Role of the Supreme Court in Amercan Government and Politics, 1796–183 (1944); H. Hartis, The Judicial Power of the United States (1940). E S Corvin, Court over Constitution (1948), Dean Allange, The Supreme Court and the National Will (1937); R. H. Jackson, The Struggle for Indical Supremacy (1942).

SUQ-ASH-SHUYUKH, a town in Mesopotamia in 31° N and 46° 30° E. The town les on the lower Rupirates in a region which has probably always been of considerable fertility. There is communication with Basra by river and also by land routes, the railway lying a few miles to the southwest. The population is estimated at 12,000, most of whom are Arabs. The town is noted for the manufacture of the "aba," the woollen closek worn by the Mesopotamian Arab. There is also a good deal of local metal work and a host building industry. The town is 65 miles above Qurna by river but the channel has now ceased to carry much water and is almost unnavigable, except at highwater.

SURABAYA (Dutch Soerabaja), the chief port in Java, Netherlands Indies; population (1930), 341,675, including 25,900 Europeans. One of the most important centres of trade and commerce in the far east, Surabaya is situated in the east of Java, on Surabaya strait, which divides Java from Madura, thus securing the shelter of that island for its roadstead, while its position on the Kalı Mas, one of the mouths of the Brantas river, affords facility for transportation to the heart of the city. From the entrance to Surabaya the lofty ranges of the Tengger and Arjuna mountains are seen with Semeru, the highest active volcano in Java, in the far distance. A look-out station, Wilhelmina Tower, flanked by a small park is situated at the river's mouth and from here railway, steam tramway and road run mland, in a southerly direction; past the old Ft. Prins Hendrik, to, first the old town, then the upper town, and beyond that to the suburbs of Gubeng and Wonokromo, where a new residential and well-planned Surabaya has arisen Surabaya, the principal Dutch naval base in the East Indies, was captured by the Japanese March 10, 1942.

The naval station on the south side of the canalized Kali Mas. with the commercial docks opposite (destroyed by the Dutch during the Japanese invasion) consisted of an outer and inner naval basin, with torpedo boat harbour, dock-yards and cholera barracks. The commercial port consisted of breakwaters on the west side of the Kali Mas enclosing a harbour basin. Alongside the west pier of the basin was a wharf, 920 metres (Genoa Quay), and the Holland pier, 1,650 metres long. The eastern part of the basin was for lighters, and in the north-eastern corner there was a harbour for three floating docks of 14,000, 3,500 and 1,499 tons capacity, also, north of the Genoa Quay, a wharf for the tankers of the Standard Oil company. On the west border of the basin a shipping canal had been constructed, the Kali Perak, and the Kali Mas had been improved as much as possible by widening and the construction of stone walls along the banks. All quays and warehouses were connected by direct, wide roads and railways with industrial centres in the hinterland. Shipping traffic in 1939 was somosoco cu.ft, net,

Exports from Surabaya in 1939 were 62,767,000, and imports

103,944,000 guilders The bulk of the chief product of Java, sugar, is shipped from Surabaya, reduction in sugar cultivation after 1931 decreased the port's traffic It is also an important market for coffee, tobacco, maize and tapioca, while the Java hides are sold there chiefly There is steamer communication ordinarily, with the chief ports of the world and with most of the ports of the archipelago, Juigo on the main route from Singapore and Batavia to Australia, Surabaya also benefits from this traffic.

SIIRABAVA, a residency in the east of Java, Netherlands Indies, area, 1,658 sq mi , bounded on the north by the residency of Bodjonegoro, on the west by that of Kediri, on the south by that of Malang, and on the east by the straits of Madura Surabaya is one of the flattest residencies in Taya, well watered by the Solo and the Brantas, and possessing a climate admirably adapted for the cultivation of sugar, the chief product (210,oco metric tons in 1939), while tobacco, cassava (tapioca), maize, coffee, cocoa, are grown, and the usual native cropsrice, pulses, fruit and vegetables Cattle are bied extensively, forests in the western and Rembang portion yield quantities of teak (there is a central lumber vard at Chepu), and in this part too are extensive oil-fields with a large refining installation of the Royal Dutch-Shell company at Chepu The population (1930) was 2,176,423, including 30,708 Europeans and 64,175 Chinese and other foreign Asiatics The capital is Surabaya, pop. 341,675 (qv). Other towns are Grissee, 25 mi. N. of Sulabaya (pop. 25,621), a port of the old Dutch East India company and one of the first places of Dutch settlement in Java, where there is a trade in edible birds' nests; Mojokeito (pop. 23,600), a sugar industry centre, and the site of the Majapahit empire, with a museum of relics; Jumbang (pop 20,380), a sugar centre, and Sidoarjo The main railway line from Batavia crosses the residency, there are lines from Semarang to Surabaya city and thence to Pasuruan along the coast, and there is also excellent sea communication from the port of Surabava In 1618 the Dutch allied themselves with the Adipati of Surabaya, who favoured the Dutch against his overlord, the Sultan Ageng, and this helped to establish Dutch power in Surabava. The residency was occupied by Japan in March 1942

SURAJ-UD-DOWIAH (d 1757), ruler of Bengal. The date of his brit is uncertain, but is generally placed between 1729 and 1736. His name was Mirza Mohammed, and he succeeded his grandfather Aliverdi Khan as nawab of Bengal on April 9, 1756. He was a cruel and profligate fanatic. Benne offended with the English for givrup protection to a native official who had escaped with treasure from Dacca, he attacked and took Calcutta on June 20, 1736. He then permitted the massace known in history as "The Black Hole of Calcutta". (See Calcutta". History, and Indu. History) This attocolous act was soon averaged. Calcutta was retaken by Cilve and Admiral Watson on Jan. 2, 1757, and on June 23, Suraj-ud-Dowlah, routed at Plassey, fied to Rajmahal, where he was captured. He was put to death of July 4, 1757, at Murshidabad, by order of Miran, son of Mir Jafar, who had conspired against Suraj-ud-Dowlah.

SURAKARTA, a government of central Java. Netherlands Indies; area 2,31 sq.mi. It is extremely hilly, except along the valley of the Solo, the principal river, which, with its tributaries, the Kaduan, etc., so of great value to the residency for agricultural purposes, watering the rich volcanic soil brought down from the mountains which flank either side of the Solo valley from north to south, and making Surakarta one of the most fertile portions of Java.

In the west the mountains are dominated by the Merbabu and Merapi groups; in the east by the Lawu group Surakarta is bounded on the N. by Semarang, on the W by Kedur and Jokjakarta, on the E. by Madfun, and on the S., a very small portion of coastline, less than ten miles long, by the Indian ocean Surakarta is a -major tobacco-growing centre in Java; the production here is mainly on estates, producing leaf tobacco (9,933 metric tons in 10,30).

Sugar is also an important export commodity, there being (1939) nine estates producing 161,000 tons of sugar. The sugar

the Merapi mountain Coffee is a less important product. The government has also the usual native cultures-rice, pulses, cassava, fruits and vegetables. Pop (1930) 2,564,848 (6,555 Europeans and Eurasians), almost entirely Javanese

The susuhunan, or sultan of Surakarta resides in the capital. Surakarta, pop 165,484 (3,225 Europeans and Eurasians), also known as Solo where, too, is the headquarters of the Dutch Resident. Except in the oldest part of the town (where there is an old Dutch settlement, and Ft. Vastenburg, as well as the native quarter), there are fine, wide streets, well-planned and with magnificent shade trees at their side, with many modern shops and residential buildings. Surakarta has also a zoological garden. some very interesting houses of native nobles, and a large market The city is on the banks of the Solo, and also on the main railway line from Batavia to Surabaya, which crosses the residency in the centre, from west to east, and it is the staiting point of a line of railway to Semarang, via Gundih Tram lines run from Surakarta south to Baturetno and west to Boyolati, the starting-point for the ascent to the sanatorium of Selo, 4,500 ft., on Mt Merapi. The Dutch agreement of 1755 recognized two native rulers in Java, the sultan of Jokjakarta and the susuhunan of Surakarta From about 1830 onwards the native princes of Iava ceased to be of any political importance

The city and district were occupied by Japan in March 1942, during World War II.

See T. S. Raffles, History of Java (1817); M. L. van Deventer, Daendels-Raffles (London, 1894). (E. E. L.; X.)

SURAT, a city and district of India in the Northern division of Bombay The city is on the site where the English first established a factory on the mainland, and so planted the seed of the British empire in India. In 1514 the Portuguese traveller Barbosa described it as an important seaport, and during the reigns of Akbar, Jahangir and Shah Jahan it rose to be the chief commercial city of India. At the end of the 16th century the Portuguese were undisputed masters of the Surat seas. But in 1612 Captain Best, and after him Captain Downton, destroyed the Portuguese naval supremacy and made Surat the seat of a presidency under the English East India company, while the Dutch also founded a factory. In 1664 Sir George Oxenden bravely defended the factory against Sivan, but its prosperity received a fatal blow when Bombay was ceded to the company (1668) and shortly afterwards made the capital of the company's possessions and the chief seat of their trade. From that date also the city began to decline. At one time its population was estimated at 800,000, but by the middle of the 19th century the number had fallen to 80,000; in 1941 it had risen to 171,443. It is still of commercial importance. The city is on the left bank of the river Tapti, 14 mi. from its mouth, and has a station on the Bombay, Baroda and Central India railway, 167 mi. north of Bombay. A most and city wall indicate the dividing-line between the city, with its narrow streets and handsome houses, and the suburbs The city is a centre of trade and manufacture. There are cotton mills, factories for ginning and pressing cotton, ricecleaning mills and paper, ice and soap works. Fine cotton and silk goods are woven, and there are special manufactures of silk brocade, gold and silver wire, carpets, sandalwood and inlaid work.

DISTRICT OF SURAT has an area of 1,695 sq.mi.; pop. (1941) 881,058. It has a coast-line of 80 mi., consisting of a barren stretch; behind this is a rich, highly-cultivated plain, nearly 60 mi. in breadth, at the mouth of the Tapti, but narrowing to only 15 mi. in the southern part, and on the northeast are the wild hills and jungle of the Dangs. Principal crops are cotton, millets, rice and pulses. Chief centres of trade are Bulsar and Surat. The district is traversed by the main line of the Bombay, Baroda and Central India railway, with a branch along the Tapti valley to join the Great Indian Peninsula railway at Almaner.

The SURAT AGENCY consisted of three native states: Dharampur (q v.), Bansda (q.v.) and Sachin, together with the tract known as the Dangs, Sachin has an area of 42 sq.mi ; pop. (1931) 22,107. The Agency has been absorbed by the Revakantha Agency.

SURBITON, a municipal borough in the Kingston parlia-

cane is grown extensively on the volcanic ground at the foot of mentary division of Surrey, England, 12 mi. S of Waterloo, London; on the Southern railway. Pop. (1951) 60,675. Area, 7.3 sq mi It has a frontage upon the right bank of the Thames opposite to Hamptom Court. The district is largely residential for people working in London. A public library was opened in 1932 and the county school for boys in 1925 Hillcroft college provides a one-year course of residential non-vocational education for working women from all parts of the country and from every trade. Surbiton was incorporated in 1936.

SURETY, in law, the party liable under a contract of guarantee (q v.). In criminal practice sureties bound by recognizance are means of obtaining compliance with the order of a court of justice, to keep peace or otherwise. (See PRINCIPAL AND AGENT )

SURFACE. There is no agreed definition of a surface may think of it as the boundary of a solid body, or as the division between two portions of space, or as the locus of an co2 set of points, selected by some law from the co3 points of space, and having a certain amount of continuity; in each case a plane is the simplest example, but none of these gives a precise or satisfactory definition. A very simple model illustrates the kind of difficulty that arises. If a surface partitions space, it must have two sides; but a long strip of paper, with the ends joined after one has received a half-twist, forms a surface with only one side.

At an ordinary point O of a surface, there exists a taneent plane, the unique limit of the plane OPO, when the adjacent points  $P,Q \rightarrow 0$  by any paths lying on the surface, the angle POQremaining finite. Any point where this limit does not exist is singular. The normal is the perpendicular to the tangent plane at its point of contact O.

A surface can also be regarded as the locus of a point satisfying a geometrical condition expressed by a single equation between its rectangular cartesian co-ordinates, say f(x, y, z) = 0. From this point of view, the definition of a surface depends on what types of function are admissible for f, and the question of continuity arises in another form. The surface is analytic if f is an analytic function, and in particular is algebraic if f is a polynomial. shall use f as the name of the surface whose equation is f=0.

We may also consider a surface as the locus of a curve varying according to some definite law Thus a sphere is the locus of a meridian circle which rotates about the polar axis, or of a circle of latitude whose centre advances along the axis, while the radius first increases from zero and then decreases. Any surface can be thus regarded, for it is always the locus of its own sections by a fixed pencil of planes.

In particular, a ruled surface is the locus of a variable line, whose different positions are the generators. The tangent plane at any point on a generator contains the whole generator. alternative situations can arise, the plane may touch the surface all along the generator, or it may vary in a pencil (rotating about the generator) as the point of contact moves along the generator. If every generator is of the former kind, the surface is a developable. Such a surface has only on tangent planes, one for each generator, whereas the general ruled (or nonruled) surface has \$\infty\$2 tangent planes in accordance with the principle of duality The simplest developables are cones and cylinders. Like them, any developable can be flattened out or "developed" into one plane, without tearing or stretching. Every developable that is neither a cone nor a cylinder is generated by the tangent lines of a certain twisted curve, the edge of regression of the surface tangent planes of the developable are the osculating planes of the curve. When the surface is developed into a plane, part of the plane is covered twice and part is uncovered, the edge of regression furnishing the boundary. The edge of regression may alternatively be described as the locus of the point on each generator that is closest to the "adjacent" generator. The corresponding locus on the general ruled surface is the curve of striction of the surface.

A surface f has cos tangent lines, each the limit of the join of two adjacent points. Except in the case of a developable, such a line is also the limiting intersection of adjacent tangent planes To touch f imposes one condition on the co lines of space, and has in general ∞2 bitangents, each touching it at two distinct points, and  $\infty^2$  inflexional tangents, each meeting f in three ad-

Order, Class, Rank.—The order of an algebraic surface is the degree of its equation, t = 0, of the polynomial f. It is the order of a plane section, and is also the number of intersections, real, concident or imaginary, of f with any line. These are particular cases of more general properties of the order. Two surfaces of orders  $n_f$ ,  $n_f$  intersect in a curve of order  $m_f$ , or in an aggregate of curves of this equivalent total order, when curves of contact and common multiple curves are counted a proper number of times. Three surfaces of orders  $n_f$ ,  $n_f$ , alwae  $n_f$   $n_f$  distinct points of intersection, or the equivalent of this when points of contact and common multiple points are properly counted.

The class of f is the degree of its equation regarded as an envelope, connecting the tangental co-ordinates of any one of its tangent planes. The properties of the class are dual to those of the order, it is the class of the tangent cone drawn to f from a general point, and the number of tangent planes through a general

The rank is an intermediate numerical characteristic, the number of the tangent lines that can be drawn through a given point and in a given plane through that point; it is the class of the plane section, and the order of the tangent cone

If the polynomial f falls into rational factors  $f = f_1 f_2$ , of degrees  $n_1, n_2$  where  $n_1 + n_2 = n_1$ , then each factor by itself represents a distinct algebraic surface, and if a point lies on either, its co-ordinates satisfy the equation of f, regarded still as a single surface, f is

degenerate, breaking up into the components  $f_1, f_2$ .

Polars.—The point  $P_1$  dividing the segment  $PP_0$  in the ratio  $\lambda$ : I has four homogeneous co-ordinates of the form  $x+\lambda x_0$ . The condition that  $P_1$  lies on f is that  $\lambda$  satisfies F=0, where

$$F = \lambda n_f + \lambda n^{-1} \Delta f_0 + \dots + \frac{\lambda^r}{(n-r)^1} \Delta^{n-r} f_0 + \dots + \frac{\pi}{n \cdot 1} \Delta n_f$$

$$= \frac{\lambda^n}{n \cdot 1} \Delta_0 f_f + \dots + \frac{\lambda^r}{r \cdot 1} \Delta_0 f_f + \dots + f_r$$
and  $f_0 = f(x_0, y_0, y_0, y_0, y_0), \Delta = x \frac{\partial}{\partial x_0} + \text{etc.}$ 

The surface  $\Delta u_f^f$  for  $r=u_1$ .  $, n=u_1$  is the rth polar surface of  $P_0$  with regard to  $f_a$  the first polar passes through all the multiple points of  $f_a$ . In particular,  $\Delta e^{-rf}/\sigma$  of  $f_0$  is its polar plane, and  $\Delta f_0^f$  its polar quadric. The locus of points whose polar quadric are cones is the Hessian of  $f_a$ . Its equation of degree A(n-2) expresses that the determinant of second derived functions of f vanishes.

If two roots of F = 0 are infinite, then  $P_0$  lies on f, and P on the tangent plane at  $P_0$ ; the two conditions are  $f_0 = 0$ ,  $d f_0 = 0$ . The latter represents the tangent plane at  $P_0$ , which is the polar plane of its point of contact. If  $P_0$  is a multiple point, the tangent plane does not exist, and all the first derived functions of f vanish there.

If two roots of F=o are equal and finite, its discriminant vanishes. This equation of degree  $n(n-1)^2$  in x, y, z, w is satisfied if  $PP_0$  touches f at  $P_1$ ; in general it represents the tangent cone from  $P_1$  to f. Hence the class of f cannot exceed n(n-1). It is less than this if f has multiple curves; for the condition is satisfied if  $P_0$  is a multiple point of f, and the cone vertex  $P_0$  standing on a multiple curve separates itself from the tangent cone.

If two roots of F = 0 are 0, then  $PP_0$  touches f at P, and f = 0,  $\Delta g = 0$ . The curve of contact of the tangent cone drawn from any point  $P_0$  to f is the whole or part of the intersection of with the first polar of  $P_0$  any residual intersection consisting of the multiple curves of f. This curve of proper contact passes through all the isolated multiple points of f.

Indicatrix; Curvature.—In order to examine a surface in the neighbourhood of a particular point, we take this as origin O of rectangular cartesian coordinates, and arrange f in homogeneous functions of  $\pi$ , y, z, say,  $f = w_t + u_t + \dots + u_{t-1}$ . If consists of a single homogeneous function  $w_t$  it represents a converge, O of degree n. If f is general, the condition that O lies of the surface is  $u_t = 0$ .

on the surface is  $u_0=0$ .

If  $P(u_0, y, z)$  is a general point of space near O, at a distance small of first order, then the perpendicular distances of P from

all general planes through O, vis, vs, vs, and all general linear functions of them, are small of first order. If P lies on f, the linear function us, being equal to -(us+1+us), is small of second order,  $u_1=0$  is the equation of the tangent plane, which in the neighbourhood of O less infinitely closer to f than any other plane. Whenever we can safely neglect small quantities of second and highes order, the surface can be replaced by its tangent plane

If we neglect terms of third and higher orders only, f can be replaced by the quadre  $u_1+u_2$ , or more generally by any of the family  $g=u_1+u_2+u_3$ , where  $u_1$  is a general linear function. These are the oscilating quadress of f at O, any one of which is a second approximation to the surface. The sections of f and g by any plane through O have the same curvature at O.

Let O be an ordinary point of f, with z as tangent plane, and therefore x=y=o as normal. Then  $f=z+u_z+\cdots+u_n$ , and the simplest osculating quadric is  $q=z+v_2$ , where  $v_2$  is the result of putting z=o in  $u_0$ .

A plane z=a small constant  $\zeta$ , parallel and close to the tangent plane, cuts f approximately in the conic  $v_1=-\zeta$ , with centre on the normal, called the *indicatrix* 

If a plane through the normal meets the indicatrix in a diameter of length ar, the radius of curvature of the normal section is  $\rho$ , where  $\frac{z}{\rho} = \frac{2\zeta}{r^2}$ . An oblique plane meeting the tangent plane

in the same line, and making a finite angle  $\phi$  with the normal, cuts f in a section of radius of curvature  $\rho$  cos  $\phi$ , the projection of  $\rho$  upon the plane (Meunier's theorem) This vanishes for the tangent plane, when the section is singular.

The major and minor axes of the indicatrix lie on the *principal* normal planes, making sections of maximum and minimum radii of curvature, say  $\rho_1$ ,  $\rho_2$ . For a normal section inclined at an angle

 $\theta$  to the first principal section,  $\frac{1}{\rho} = \frac{\cos^2 \theta}{\rho_1} + \frac{\sin^2 \theta}{\rho_2}$  (Euler's theo-

According to the nature of the indicatix, O is an ellsplic, hyperbolic or parabolic point of J. If it is elliptic, all the normal curvatures are of the same sign, and the surface bends away from the tangent plane on one side only. The part near O of the section by z=f is a small real closed curve for f of one sign, and imaginary for f of the opposite sign. The section by the tangent plane z=o has no real part in the neighbourhood except O itself, which is a double point with imaginary tangents. The surface is x-madatur.

At a hyperbolic point, the surface is anticlastic. The principal curvatures are of opposite signs, and f bends away from the tangent plane on opposite sides in these directions. Two normal sections have inflexions, the curvatures vanishing, their planes pass through the inflexional tangents at 0, which are parallel to the asymptotes of the indicatirs, and touch the section of f by the tangent plane, which has two real branches through O along which f crosses the plane. All sections near O have real branches there If there is a line lying of f, it is one of the inflexional tangents at each of its points. Conjugate tangent lines are those parallel to conjugate diameters of the indicatirs.

At a parabolic point, the inflexional tangents coincide; the section by the tangent plane has a cusp. These points lie on the Hessian.

The normal at O does not in general meet the normal at an adjacent point, unless this less on a principal section, in which case the normals intersect at one of the two centres of curvature of f at O. These coincide if the indicature is a carcle; then O is an ambiguith, all normal sections have the same curvature and all adjacent normals meet the normal at O.

Quadrics—A surface of order 2 is a quadric q; in general its class and rank are each 2 also. The sumplest example is the sphere (q.w.). Every plane section is a conic Parallel sections are similar and similarly situated conics, whose centres lee on a line, a diameter of q. The diameters concur at the centre (which may lie at infinity), which bisects every tord of q through it There are three mutually perpendicular planes of symmetry, the principal cases which

meet a in its vertices

Through each point P of q there pass two generators, real or imaginary, lying wholly on q, then plane is the langent plane to q at P, cutting q in this pair of lines. The generators faill into two systems, any one generator meeting all those of the other system and none of its own A quadic is determined by any three generators of one system, and may be defined as the locus of a line meeting three fixed skew lines. There are six directions (only two real) of planes of circular section, the points of contact of the tangent planes parallel to these are the simbility.

A quadric has three local contro (two real), to each point S of which there corresponds a directur, I, such that the datance of any point of q from S is proportional to its distance from I measured parallel to one of the planes of circular section, S and I are focus and directury of the section of q by the plane SI, which is the normal plane at S to the focal conic

A focus can also be defined as a point from which the enveloping

cone is right-circular

A quadre is fixed when its three principal sections are given; it, its determined by its inthefron of principal planes and the lengths of its principal axes. It depends on men planes from the lengths of its principal axes. It depends on men planes are in the centre is finite, there are three man types of quadric, according to the types of the principal sections self-broad (three ellipses, the hyperbolals) of one sheet (one ellipse, two hyperbolas), hyperbolad of uso sheets (two hyperbolas, one section imaginary). If the centre is at infinity, one principal section is wholly at infinity, the other two are parabolas, meeting in the one finite vertex, and q is an elliptic or hyperbolae parabolaed according as these parabolas is on the same or opposite sides of the tangent plane at the vertex. If the principal axes vensith, q is a quadric cone, if also the centre is at infinity, it is a cylinder. Finally, a degenerate quadric is a part of intersecting, parallel or comedicing planes.

The hyperboloud of one sheet and hyperbolic paraboloid have real generators, and models can be constructed by threads or wires, they are everywhere anticlastic The ellipsoid, hyperboloid of two sheets and elliptic paraboloid have imaginary generators, and are everywhere synclastic. Referred to its principal axes, an ellipsoid of semi-axes a, b, c has the equiton

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} = r$$
. An elliptic paraboloid referred to its vertex as

origin can have the equation 
$$\frac{x^2}{a^3} + \frac{y^2}{b^2} = \frac{zz}{c}$$
, and the other types of quadric can be represented by equally simple equations,

Cubic Surfaces.—A surface f of order 3 is of class 12, or lower if it is uniqual. It possesses 27 lines lying on it, of which each meets 10 others, arranged in 5 intersecting pairs. There are 45 the vertices. We can also select, in 36 ways, a double-six from the 27 lines, consisting of two sets of six lines, each line meeting five of the other set and none of its own. Any plane through a line I cuts f in a residual continuenting in two points, at which the plane touches f. For two positions of the plane through f, the contic touches f, at a parabolic point of f, lyting on the Hessian.

There can be as many as four double points on a cubic surface.

If these lie at the vertices of the tetrahedron of reference, the equation can take the form  $\frac{1}{x} + \frac{1}{y} + \frac{1}{z} + \frac{1}{w} = 0$ . Each of the six

is then ruled, each plane through the double line meeting it in a residual generator. Two of these pass through each point of the double line, and their plane meets f in a fixed line of the surface,

the simple directrix.

Singularities—A singular point of a locus is one at which there is no definite, single tangent plane. If the origin O is singular, and as above  $f=u_0+u_2+\dots+u_n$ , the four conditions are those involved by  $u_0=o$ ,  $u_0=o$ , . The simplest case is the conic node, an ordinary double point,  $e_0$ -presented by  $f=u_0+u_1+u_2+\dots+u_n$ ,

where  $u_t$  is a general quadratic function of  $x_t$ ,  $y_t$ ,  $x_t$  giving the proper tangent cone. Any line through O meets f in two points coinciding at O, a generator of  $u_t$  meets it in three points, and the six lines of dissest cointag given by  $u_t = u_t = 0$  meet it in four The section of f by a general plane through O has a double point with two quite distinct branches, the tangents being generators of  $u_t$ , that by a plane through a line of closest contact has an infection on one branch. The section by a plane touching the tangent cone has a cusp, the two branches merging into one cycle.

If a general line through O meets f in p points there, in the simplest case O is an ordinary s-fold point with a proper tangent cone  $u_n$  where  $f = u_n + u_{k+1} + \dots + u_n$ , this involves  $\frac{1}{2}s(s+1)(s+2)$  conditions. Any plane through O, or any surface having O as a ordinary point, meets f in a curve having an s-fold point there if O is s-fold on the second surface, the two tangent cones having no common sheet, the curve of intersection has  $s_0$  branches through O. If O is also s-fold on a third surface, the three have  $s_{s,0}$  points of intersection absorbed at O.

If the tangent cone breaks up, the simplest case is the binode, adouble point whose quadrate tangent cone consists of two biplanes, intersecting in the edge. The section by a general plane through chas a double point as for a cone node, that by a plane through the edge has a cusp, and that by one of the biplanes has a triple point. Taking the biplanes as planes of reference, we have  $v_0 = v_0$ , then the equation says that either x or y is small of second order, or else both are small of orders between x and x. A general point of f near O is close to a definite one of the two biplanes, and, in this sense, we can speak of two sheets of f, one touched by each biplane; they are not separate sheets, but become indisquishable near theedge x = y = 0. There are three lines of closest contact in each biplane, these are in general different from the edge, which meets f in three points only.

The contended and binode are ordinary singularities;  $i \, \epsilon$ , the tangent cone, proper or degenerate, has no repeated sheet. At an extraordinary singularity, the tangent cone  $u_1$ , not only breaks up, but has a repeated sheet,  $u_1$  say, so that  $u_2 = u_1^* v_2 - v_3$ . The simplest case is the  $u n o \theta_1 a$  double point with a repeated tangent plane,  $j = u_1 + u_2 + \dots + u_n$ . The surface has two connected half-sheets, the general section having a cusp. There are three lines of closest contact, the section by a plane through one of these has a tennode, that by the tangent plane has a triple point.

A general point 0 of a double curve is a binede of a special kind. The two sheets of f are quite distinct; every simple point of f near 0 belongs definitely to one sheet on the other, the points of the double curve belonging to both. There is no continuous passage at all from one sheet to the other near 0, but on the double curve there he a certain number of pinch-points, undes of a special kind (which may be absorbed in higher singularities), at which the two tangent planes coincide, and the two sheets become connected.

A tactode of the surface is a double point where the general plane section has a tacnode, which is the plane singularity equivalent to two adjacent double points. Thus O has an infinite set of double points of f adjacent to it, one m every direction in the tangent plane, which may be considered as an infinitesimal double curve adjacent to O. In a similar way, a tacnodal curve is equivalent to two adjacent ordinary double curves.

In general, a singular point, whether solated or lying on a singular curve, is characterized, first, by its multiplicity; i.e., the number of intersections of f with a general line through the point that are absorbed there; next, by the nature of the tangent cone and its sheets, and of the singularity of a general section; and currier by the nature end arrangement of the higher singularities of special sections. By a series of suitable transformations, any angular point or curve of a surface can be inalysed into an angular into an angular point or curve of a surface can be analysed into an types, and any surface can be transformed into curve and the elementary singularities, and in particular into one having no isolated singular points, but only ordinary multiple curves and such points of higher singularity as necessarily lie on them; or alternatively into a surface having only a double curve und a number of trule points which are also trulp for the double curve.

The complete theory is complicated Isolated singular points may give rise on transformation to singular curves, and a singular curve may give rise, from the transformation of its special points of higher singularity, to other singular curves, whose geniquiarity, to other singular curves, whose geniquiarity points may be of more complicated nature (though not of higher multiplicity) than the general points of the original curve

Singular inagent planes are defined dually to the above Any surface of order  $\geq 3$  must have singularities of one or other kind, or of both. A surface f of order n with no singular points of class  $f^m$  en $(p-1)^2$ : a surface of class  $f^m$  with no singular planes is of order  $n = m^*(n^*-1)^2$ . These two equations are incompatible unless  $n = m^* n = 1$ , in which case f is a quadrate

If f has no point ampularities, it has in general two series of double and stationary tangent planes, and its reciproral has a double and a cuspoial curve. The characteristic numbers of these modify the equations relating order and class, and make them compatible. If f has higher singularities, there exists a complicated set of relations between the numerical characteristics, the simpliciar are the Plucker equations for the general plane section and tangent cone.

Curves on a Surface—The interest of f depends partly on the sumpler curves lying on it. There are always its plane actions, and its curves of total intersection with other surfaces; lower curves may arise as partial intersections, components of a total intersection that breaks up through acquiring additional singulariues, the cutting surface either touching f or passing through one or more of its singularities. All curves on a plane are its total intersections with cones standing on the curves O na quadric, the conic section by a tangent plane acquires a double point at the point of contact and breaks up into a pair of generators. A cubic surface contains 27 pencils of conics, cut out by Palanes through the 27 lines, and many other systems of curves of orders 3,4, and 5, cut out by quadrics containing various sets of the lines

Other important curves on f are defined by infinitesimal properties. An asymptotic curve is one whose tangent at any point is one of the inflexonal tangents, parallel to an asymptote of the indicaturs. A curve of curvatures so one whose tangent at any point is a principal tangent, parallel to an axis of the indicaturs. Two curves of each of these kinds can be drawn through any gental point of f. A geodesic is a curve whose small arcs are each the abortest distance on the surface between their extremities. On a plane, these are lines, on a developable they are curves which become lines when the surface is fattened out. An infinite number of geodesics can be drawn through a general point of f, one starting in any direction.

Families of Surfaces—If an equation contains a parameter  $\lambda$  at represents a engly infinite family of surfaces, the most important case is the linear family or  $\rho$  sends, when the conflictants are linear functions of  $\lambda$  and the equation has the form  $f + \lambda \Phi = 0$  Just one member of the family passes through each general point of space. The total intersection of any two of the family is the same, being that of f,  $\phi$ . More generally, if f, f,  $\phi$  are any two algebraic surfaces, the equation of any other containing their total intersection can be expressed as  $\sigma f + \partial \Phi = 0$ , where  $\alpha$ ,  $\beta$  are polynomials (Noether's theorem). In the same way,  $f + \lambda \Phi + \Delta \Phi$  gives an  $\sigma^2$  linear family or  $\sigma$  of surfaces, one and only one passes through any two given points; any three surfaces of the net have the same base, or set of common points and curves,

as f,  $\phi$ ,  $\psi$ . If f is of order n, it has  $N=\frac{1}{2}(n+1)(n+2)(n+3)-1$  independent ratios of coefficients; all such surfaces form a linear family with N degrees of freedom, and one can be made to pass through N points in general position, each of which presents one independent condition to f. Thus a quadric can be drawn through nice points, and these determine it if they are general. However, seven points determine a net of quadrics, whose base consists of eight points, viz., the seven and another, associated with and determined by the seven, which offers no independent condition; but the passage of the quadric through it is a necessary consequence of its passage through the others: Thus nine points do not determine a quadric if any eight of them are an associated set of this stature.

To have a given point as a double point imposes four conditions on f, to contain a given line, n+1 conditions. The number of independent conditions presented to f by an assigned element of a my sort is the postulation of that element. The conditions for combination of elements may force f to contain other fixed elements, or to break up. If six out of nine points he on a plane, the only quadrac containing them all consists of this plane and the plane of the other three points.

Two surfaces are orthogonal if at every common point the angle between them, re, between their normals, as angh-tangle. If three surfaces are mutually orthogonal, their cuives of intersection are curves of curvature on each surface. If three linear families are such that the three surfaces through any point as a a right angles to each other, they form an orthogonal system, f can form part of such a system only if it satisfies a certain differential equation of thind order. In the same way, a cubic family, with three members through any point, can be an orthogonal system, e.g., the confocal quadros:

$$\frac{x^2}{a^2+\lambda} + \frac{y^2}{b^2+\lambda} + \frac{z^2}{a^2+\lambda} = x$$
,

where the members through a point consist of an ellipsoid, a hyperboloid of one sheet, and a hyperboloid of two sheets

Among the infinite number of surfaces having the same boundary, i.e., a given closed curve through which each is to pass, the minimal surface is that whose area is least. This is the form assumed by a soap film bounded by a wire in the form of the given contour. The same property must attach to any small portion of the surface, and leads to a differential equation of second order, the boundary conditions determining the arbitrary elements of the solution. A minimal surface is anticlastic everywhere. If it were synclastic at a point P, a plane near the tangent plane at P on one side would cut it in a small plane closed curve, approximately the elliptic indicatrix, whose area would be less than that of the cap on which P lies; and the total area could be reduced without affecting the given boundary.

Parametric Representation; Genus.—The co-ordinates of any point on f can be represented as functions of two parameters. We may consider s, y as the parameters, and g given as an implicit function of these by the equation f—o. More often it is convenient to express each co-ordinate as an explicit function of two other parameters, say  $= \phi(u, s)$ ,  $= \psi(u, s)$ ,  $= \psi(u, s)$ .

In general,  $\phi$ ,  $\psi$ ,  $\chi$  are many-valued functions, if there are ests of values of x, y, x for each set of w, and we take w, a as co-ordinates of a point of a plane, then f is represented on this plane by an (r, x) point transformation. The nature of the representation depends largely on the form of the expression for the element dx of length of a retraced on the surface, given by

$$ds^2 = dx^2 + dy^2 + dz^2 = Edu^2 + 2Fdu \ dv + Gdv^2$$
, say,

where E, F, G are certain functions of u, v. Here  $E^{\dagger}du$ ,  $G^{\dagger}dv$  are the elements of length along the curves represented by  $v = {\rm const.}, u = {\rm const.}, a$  the point whose parameters are u,v, while F depends also on the angle between these curves. If they are everywhere at right-angles, e, e, g, if they are the curves of curvature, then

Rational surfaces are those which can be represented on a plane by a (1, 1) point transformation. Then the co-ordinates of any point on fare rational functions of two parameters, the coordinates of the corresponding point of the plane. Of the different plane of the corresponding point of the plane. Of the different plane representations of f, the lowest is that for which the curves in the plane corresponding to the plane sections of f are of lowest order. Any two of these have n variable intersections, corresponding to the points of f on the common line of the two planes of section, he remaining intersections are fixed, at points of the plane fundamental for the representation. An important family of curves on f are those corresponding to the lines of the plane. Any two of these have one and only one variable intersection, the remaining at points of f fundamental for the representation. All quadrics and cubics are rational. Surfaces of higher degree are not, unless they have a sufficient number of sincular nonsta and curves.

vanish if it is rational, and may be regarded as answering to the genus of a curve The simplest is the genus as defined by Noether (Flachengeschlecht), the number of linearly independent advoint surfaces of degree n-4, passing s-1 times through every ordinary s-fold curve of f, and s-2 times through every ordinary isolated s-fold point, with other conditions at extraordinary singularities It is also the number of linearly independent double integrals of the form  $\iint F(x,y,z)dxdy$ , where F is a rational function and x,y,z are connected by f=0 If f has no singularities, its genus is  $\frac{1}{n}(n-1)(n-2)(n-3)$ 

\$\langle (n-1)(n-2)(n-3)\$
Bestlomary—The best-known textbooks are: \$\tilde{G}\$ Salmon, \$A\$
Treatise on the Analytic Geometry of Three Dimensions, vol. 1, often
Treatise on the Analytic Geometry of Three Dimensions, vol. 1, often
Gledwide des Surfaces (1889-90). Full references are given in the
Encyklopadie der malhematischen Wissenschaften, Band in
the Encyklopadie der malhematischen Wissenschaften, Band in

\$\text{L}\$ (P. Hu, H. S. M. C.) Full references are given in the

SURFACE TENSION. The title under which many surface phenomena-including Capillarity-are usually considered

When the surface of water (or other liquid) in a tank is carefully examined it is found not to be perfectly level. The statement that water finds its own level is only approximate. The surface in fact becomes considerably curved near its edges where the liquid comes in contact with the wall of the tank.

If a vertical tube with a very narrow bore is placed with one end in the water, the liquid rises some distance above the level of the outer surface. The rise is greater the smaller the chameter of the bore. The rise of oil through a wick is a phenomenon of the same kind

If a small quantity of mercury is poured on a horizontal plate it forms a drop. If the quantity is only a few cubic millimetres the drop is nearly spherical-a much larger quantity spreads out into a cake-shaped mass with a nearly flat top and with rounded

A drop of oil placed on a clean water surface spreads almost instantaneously so as to form a very thin film. The thinness of the film can be judged from the colours that flash out or from the size of the area covered by even a small drop.

The phenomena of soap bubbles and the formation of froth in solutions of soap are also familiar ones. In these cases, also, thin films are formed

The propagation of ripples of very short wave-length follows a

different law from the propagation of deep sea waves. When camphor is sciaped so that the fiagments fall upon a clean surface of water, they rush about on the surface with very rapid and rapidly changing motion. A minute quantity of oil placed on the surface brings them almost instantaneously to

These and many allied phenomena, can all be studied under one heading. They arise from the existence of surfaces separating one medium from another

The special forces which come into play are thence known as Surface forces. The rise in tubes of narrow bore-which are known as capillary tubes because the bore is as "fine as a hair" is due to these forces. From the special way in which the effects arise in this case the action is called capillary action. This name, though often applied in other cases, is hardly applicable except to the case of narrow tubes, while the term surface action is applicable in all. The forces which are concerned in these phenomena are those which act between neighbouring parts of substances. These also produce the effects of cohesion.

Newton in the third edition of his Opticks refers to them in the following passage -"The parts of all homogeneal hard Bodies, which fully touch one another, stick together very strongly . . . I . . , infer from their Cohesion that their Particles attract one another by some force which in immediate Contact is exceeding strong, at small distances performs the chymical Operations above mention'd, and reaches not far from the particles with any sensible Effect. . . . There are therefore Agents in Nature able to make the Particles of Bodies stick together by very strong Attractions. And it is the Business of experimental Philosophy to find them out."

There are several numerical characteristics of a surface that also act between the particles of matter because these latter can act over very great distances (The earth is controlled in its motion round the sun by gravitation ) Cohesion acts to any measurable extent only over minute distances. Sticks of chalk for drawing are made by highly compressing finely ground chalk and other materials. If a stick is broken and the two parts are brought into their original position as nearly as possible by hand they do not stick together because the neighbouring particles are still so far apart as to exert no sensible attraction. High pressure is needed for them to begin sensibly to attract each other. Before considering in detail how these attractions arise we give a historical summary of the development of the subject.

Historical .- (The following historical summary is taken from James Clerk Maxwell's classical article in the ninth edition of this Encyclopaedia, as modified by the 3rd Lord Rayleigh in the tenth edition.) According to J. C Poggendorff (Pogg. Ann. ci p. 551), Leonardo da Vinci must be considered as the discoverer of capillary phenomena, but the first accurate observations of the capillary action of tubes and glass plates were made by Francis Hawksbee (Physico-Mechanical Experiments, London, 1709, pp. 139-169, and Phil Trans. 1711 and 1712), who ascribed the action to an attraction between the glass and the liquid He observed that the effect was the same in thick tubes as in thin, and concluded that only those particles of the glass which are very near the surface have any influence on the phenomenon Dr. James Jurin (Phil Trans, 1718, p 739, and 1719, p 1083) showed that the height at which the hequid is suspended depends on the section of the tube at the position of the meniscus, and is independent of the form of the lower part. Sir Isaac Newton devoted the 31st query in the last edition of his Opticks to molecular forces, and instanced several examples of the cohesion of liquids, such as the suspension of mercury in a barometer tube at more than double the height at which it usually stands This arises from its adhesion to the tube, and the upper part of the mercury sustains a considerable tension, or negative pressure, without the separation of its parts He considered the capillary phenomena to be of the same kind, but his explanation is not sufficiently explicit with respect to the nature and the limits of the action of the attractive force.

It is to be observed that, while these early speculators ascribe the phenomena to attraction, they do not distinctly assert that this attraction is sensible only at insensible distances, and that for all distances which we can directly measure the force is altogether insensible. The idea of such forces, however, had been distinctly formed by Newton, who gave the first example of the calculation of their effect in his theorem on the alteration of the path of a light-corpuscle when it enters or leaves a dense body.

Alexis Claude Clairault (Théorie de la figure de la terre, Paris, 1808, pp. 105, 128) appears to have been the first to show the necessity of taking account of the attraction between the parts of the fluid itself in order to explain the phenomena He did not, however, recognize the fact that the distance at which the attraction is sensible is not only small but altogether insensible. I. A. von Segner (Comment. Soc Reg Götting, i. [1751] p. 301) introduced the very important idea of the surface-tension of liquids, which he ascribed to attractive forces, the sphere of whose action is so small "ut nullo adhuc sensu percipi potuerit."

In 1756 J. G. Leidenfrost (De aquae communis nonnullis qualitatibus tractatus, Dusburg) showed that a soap-bubble tends to contract, so that if the tube with which it was blown is left open the bubble will diminish in size and will expel through the tube the air which it contains

In 1787 Gaspard Monge (Mémoires de l'Acad. des Sciences, 1787, p. 506) asserted that "by supposing the adherence of the particles of a fluid to have a sensible effect only at the surface itself and in the direction of the surface it would be easy to determine the curvature of the surfaces of fluids in the neighbourhood of the solid boundaries which contain them; that these surfaces would be linteuriae of which the tension, constant in all directions, would be everywhere equal to the adherence of two particles, and the phenomena of capillary tubes would then present nothing which could not be determined by analysis." He applied These forces must be distinguished from those of gravity which this principle of surface-tension to the explanation of the apparent attractions and repulsions between bodies floating on a liquid

In 1802 John Leslie (Phil Mag, 1802, vol xiv p 193) gave the first correct explanation of the rise of a liquid in a tube by considering the effect of the attraction of the solid on the very thin stratum of the liquid in contact with it. He did not, like the earlier speculators, suppose this attraction to act in an upward direction so as to support the fluid directly. He showed that the attraction is everywhere normal to the surface of the solid The direct effect of the attraction is to increase the pressure of the stratum of the fluid in contact with the solid,

so as to make it greater than the pressure within the fluid In 1804 Thomas Young (Essay on the "Cohesion of Fluids," Phil. Trans , 1805, p 65) founded the theory of capillary phenomena on the principle of surface tension. He also observed the constancy of the angle of contact of a liquid surface with a solid, and showed how from these two principles to deduce the phenomena of capillary action. His essay contains the solution of a great number of cases, including most of those afterwards solved by Laplace, but his methods of demonstration, though always correct, and often extremely elegant, are sometimes rendered obscure by his scrimulous avoidance of mathematical symbols. Having applied the secondary principle of surface tension to the various particular cases of capillary action. Young proceeded to deduce this surface tension from ulterior principles. He supposed the particles to act on one another with two different kinds of forces, one of which, the attractive forces of cohesion, extends to particles at a greater distance than those to which the repulsive force is confined. He further supposed that the attractive force is constant throughout the minute distance to which it extends, but that the repulsive force increases rapidly as the distance diminishes He thus showed that at a curved part of the surface, a superficial particle would be urged towards the centre of curvature of the surface, and he gave reasons for concluding that this force is proportional to the sum of the curvatures of the surface in two normal planes at right angles to each other.

The subject was next taken up by Pierre Simon Laplace (Mécanique céleste, supplement to the tenth book, pub in 1806) His results are in many respects identical with those of Young. but his methods of arriving at them are very different, being conducted entirely by mathematical calculations. For those who wish to study the molecular constitution of bodies it is necessary to study the effect of forces which are sensible only at insensible distances; and Laplace has furnished us with an example of the method of this study which has never been surpassed. He found for the pressure at a point in the interior of the fluid an expression of the form

### $b = K + \frac{1}{2}H(1/R + 1/R').$

where K is a constant pressure, probably very large, which, however, does not influence capillary phenomena, and therefore cannot be determined from observation of such phenomena; H is another constant on which all capillary phenomena depend; and R and R' are the radii of curvature of any two normal sections of the surface at right angles to each other

The next great step in the treatment of the subject was made by K. F Gauss (Principia generalia Theoriae Figurae Fluidorum in statu Aequilibrii, Göttingen, 1830, or Werke, v. 29, Göttingen, 1867). The principle which he adopted is that of virtual velocities, a principle which under his hands was gradually transforming itself into what is now known as the principle of the conservation of energy. Instead of calculating the direction and magnitude of the resultant force on each particle arising from the action of neighbouring particles, he formed a single expression which is the aggregate of all the potentials arising from the mutual action between pairs of particles. This expression has been called the force-function. With its sign reversed it is now called the potential energy of the system. It consists of three parts, the first depending on the action of gravity, the second on the mutual action between the particles of the fluid, and the third on the action between the particles of the fluid and the particles of a solidion fluid in contact with it.

we may for the sake of distinctness call the potential energy) shall be a minimum. This condition when worked out gives not only the equation of the free surface in the form already established by Laplace, but the conditions of the angle of contact of this surface, with the surface of a solid

In 1831 Siméon Denis Poisson published his Nouvelle Théorie de l'action capillaire. He maintained that there is a rapid variation of density near the surface of a liquid, and he gave very strong reasons, which have been only strengthened by subsequent dis-

coveries, for believing that this is the case

The result, however, of Poisson's investigation is practically equivalent to that already obtained by Laplace In both theories the equation of the liquid surface is the same, involving a constant H, which can be determined only by experiment The only difference is in the manner in which this quantity H depends on the law of the molecular forces and the law of density near the surface of the fluid, and as these laws are unknown to us we cannot obtain any test to discriminate between the two theories

We have now described the principal forms of the theory of capillary action during its earlier development. In more recent times the method of Gauss has been modified so as to take account of the variation of density near the surface, and its language has been translated in terms of the modern doctrine of the conservation of energy See Enrico Betti, Teoria della Capillarità: Nuovo Cimento (1867); a memoir by M Stahl, "Ueber emige Punckte in der Theorie der Capillarerschemungen." Pozz. Ann. cxxxix. p. 239 (1870); and J. D Van der Waals' Over de Continuiteit van den Gasen Vloeistoftoestand A good account of the subject from a mathematical point of view will be found in Tames Challis's "Report on the Theory of Capillary Attraction."

Brit Assn Report, iv. p 235 (1834)

J A F. Plateau (Statique expérimentale et théorique des liquides, 1873), who made elaborate study of the phenomena of surface tension, adopted the following method of getting rid of the effects of gravity. He formed a mixture of alcohol and water of the same density as olive oil, and then introduced a quantity of oil into the mixture. It assumes the form of a sphere under the action of surface tension alone. He then, by means of rings of iron-wire, discs and other contrivances, altered the form of certain parts of the surface of the oil. The fice portions of the surface then assume new forms depending on the equilibrium of surface tension. In this way he produced a great many of the forms of equilibrium of a liquid under the action of surface tension alone, and compared them with the results of mathematical investigation The debt which science owes to Plateau is not diminished by the fact that, while investigating these beautiful phenomena, he never himself saw them, having lost his sight in about 1840.

G L van der Mensbrugghe (Mém de l'Acad Rov. de Belgique. xxxvii., 1873) devised a great number of beautiful illustrations of the phenomena of surface tension, and showed their connection with the experiments of Charles Tomlinson on the figures formed

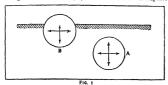
by oils dropped on the clean surface of water.

Athanase Dupré in his 5th, 6th and 7th Memoirs on the Mechanical Theory of Heat (Ann. de Chimie et de Physique, 1866-68) applied the principles of thermodynamics to capillary phenomena, and the experiments of his son Paul were exceedingly ingenious and well devised, tracing the influence of surface tension in a great number of very different circumstances, and deducing from independent methods the numerical value of the surface tension. The experimental evidence which Dupré obtained bearing on the molecular structure of liquids must be very valuable, even if our present opinions on this subject should turn out to require modification.

# GENERAL THEORY OF CAPILLARY ACTION

It is found by experiment that the forces between molecules to which cohesion is due only act preceptibly across very short distances. If we regard the forces between two particles as acting according to a law depending only upon their positions it must The condition of equilibrium is that this expression (which vary inversely as the distance according to a higher power than experiments of Quincke and others show that the extreme range through which sensible effect is produced by them is certainly much less than a thousandth of a centimetre and it is probably less than one millionth

In order to illustrate the important bearing of this limitation in range consider a molecule, A, well within a substance. A sphere



of a thousandth of a centimetre radius may be drawn round it and the molecules outside this sphere will have no sensible influence on A. Those within the sphere attract A but in the case of a homogeneous isotropic body their pulls will be uniformly distributed and the resultant force on A will be zero There will, however, be a pressure throughout the sphere due to the attraction: each spherical layer, being attracted, will compress the particles lying inside it But if we consider a particle B very near the surface-nearer in fact than the range of action-the state of things will be found to be different. There will be more particles pulling B downwards than upwards so that all such particles as B will experience a resultant-force downwards. There will also be a pressure at B but its value is less the nearer B is to the surface. There is, therefore, a thin, indefinitely bounded, layer near the surface which is in a different condition from the main body of the substances. Many of the properties will be different in this surface layer from elsewhere. For example, corresponding to the different pressure, the density will be different Since work is done in producing compression the potential energy will differ in the two regions. In the main body it can be written

$$\int \chi_0 \rho_0 dV = \chi_0 \rho_0 V_0$$

where V= volume,  $\rho$  density and  $\chi$  the potential energy per unit mass, in the film, owing to its minute thickness,  $\epsilon$ , which we divide up into still thinner layers, de, and surface S we write

Total mass = 
$$V\rho_0 - S \int_0^e (\rho_0 - \rho) de$$

while the total potential energy (in terms of  $\chi$  its value per unit mass) is

$$\int \chi \rho dV$$

$$V\chi_0\rho_0 - S \int_0^{\epsilon} (\chi_0\rho_0 - \chi \rho) d\epsilon.$$

Multiplying the total mass by  $\chi_0$  and subtracting from the last expression

$$E-M\chi_0=S\int_0^e (\chi-\chi_0)\rho de.$$

The right hand side is therefore an expression for that part of the energy which depends upon the existence of a surface S The integral which multiplies it is the constant (or rather, factor) known as the surface tension. This integral is a measure of the work done in increasing the area of the surface. It must be carefully distinguished from the corresponding increase in the total energy because heat is drawn in simultaneously if the change takes place at constant temperature. It is in strictness a measure takes place at constant temperature. It is a statemess a measure of the change in the "free-energy." (See Thermodynamics Thermodynamics and Physical Chemistry.)

By the principles of energy the potential energy (at constant

that of the inverse square which is obeyed by gravitation The temperature) tends to a minimum, in other words, any change that takes place spontaneously involves a diminution of this energy Hence, whenever the surface tension is positive there will be a tendency for the surface to decrease, and the diminution will in fact take place unless it is resisted by other forces This diminution takes place not by a contraction of the liquid but by a passage of the surface molecules into the body of the liquid. The properties of the body are not changed thereby. In this respect the phenomenon is quite different from the case of a stretched india-rubber film. In the case of the liquid the surface tension remains constant during the contraction of the surface area; in the case of the stretched india-rubber it diminishes along with the contraction

We may express it otherwise by saying that if an imaginary straight line be drawn anywhere in the surface, when equilibrium exists there must be a force acting across the line in such a direction as to prevent further contraction of area It is easy to show that this force per unit length of line is numerically the same as the surface-tension as defined above

Dupré has described an arrangement by which the surfacetension of a liquid film may be illustrated A piece of sheet metal is cut out in the form AA' (fig 2). A very fine slip of metal is laid on it in the position BB' and the whole is dipped into a solution of soap When it is taken out the rectangle AA'CC' is filled by a liquid film. This film tends to contract on itself and the loose strip of metal will, if let go, be drawn towards AA'. If S is the area of one face of the film the potential energy is  $\sigma S$ . If AA'=b and AC=a it is equal to  $\sigma ab$  Hence if F is the force

If 
$$AA'=b$$
 and  $AC=a$  it is equal to  $\sigma ab$  Hence if  $F$  is the force by which the slip is pulled towards  $AA'$ ,  $F=\frac{d}{ab}(\sigma ab)=\sigma a$ ; so that the force per unit length for one face is  $\sigma$ . Hence,  $\sigma$  is either

the force per unit length or the potential energy per unit area.

It must be added that we have only considered one of the two faces and the force due to it. There is an equal force on the strip due to the second surface so that the total force is twice as great as the value taken. But the total area is twice as great also so that the conclusion remains unchanged.

There are other ways of illustrating the existence of the tension. Form a film as before but in a fixed frame. Tie a short length of spider line or fine unspun silk so as to form a flexible ring If it is placed carefully on the film it usually takes an irregular shape. If the film inside the ring is destroyed by piercing it with a hot wire the spider line opens out into a circular form, this being the form which makes the surrounding surface least for a given length of line. Again, a small drop of mercury or a falling rain drop is practically spherical-the sphere being the form which has the smallest area for a given volume. A large drop fails to be spherical because gravitational forces are then strong enough to compete successfully with surface forces. Sometimes a difficulty is felt in connection with the assertion that the surfacetension is constant. Take a film



such as we considered and place it vertically The upward force on  $AA' = 2\sigma a$  for the two faces, the downward force at the level CC' is also 200. The remaining force on the portion of the film between these lines is its weight Hence the resultant force on the mass of the film is its weight and its acceleration should therefore be that of a freely falling

body. Yet whatever may be found true for a pure substance, it cannot be true in general that the tension is the same at all parts of a large area. In the case of a soap film some adjustment must automatically take place (either by alteration of concentration or otherwise) which makes the upper tension a little greater than the lower. It is probably the power of such an adjustment being made in the case of a soap solution which is the leading requisite permitting a durable film to be made. Otherwise the film would literally fall to pieces.

Theory of Cohesion.-The mode in which cohesion is ex-

plamed by assuming the existence of forces between elements (if e, infinitesimal volumes) of matter can be illustrated by supposing the substance of a body to be distributed continuously unstead of partitioned into molecules. Such was the mode in which Laplace, more than a century ago, legarded it, and indeed it is the assumption that has always been made until recent times regarding the distribution of the substance of a body

Let the force between two elementary volumes be supposed

proportional to the product of the volumes and inversely as the nth power of their distances apart. The force required is that across unit area drawn anywhere well miside the body arising from the volumes on each side of it. The calculation is made in successive stages.



(i) Take a lamina of thick-

ness dy The force on an elementary volume v due to a zone of radius x and width dx is  $v \cdot \frac{2\pi x dx}{a} \cdot \frac{a}{dy}$  since the tangential com-

ponents will cancel each other. Hence the whole lamina attracts the element with a force

$$2\pi va \int_{a}^{\infty} \frac{x dx}{r^{n+1}} \cdot dy = 2\pi va \int_{a}^{\infty} \frac{dr}{r^{n}} dy$$

This becomes  $\frac{2\pi va}{(n-1)a^{n-1}} dy$  or  $\frac{2\pi v}{(n-1)a^{n-2}} dy$  since we assume the

forces to vanish at infinity.

(ii.) Let v be an element in a parallel lamina of thickness da. Then the total force per unt area on such a lamina II. is obtained by putting v=da. Hence we find the force on a semi-infinite solid above lamina II due to lamina I. by integrating from o to ∞ that is

m o to 
$$\infty$$
 that is

Force on semi-solid (per unit area) =  $\frac{2\pi dy}{n-1} \int_{0}^{\infty} \frac{da}{a^{n-2}}$ 

=  $\frac{2\pi}{(n-1)(n-3)} \left| \frac{1}{a^{n-3}} \right|_{0}^{\infty}$ 

(iii.) The force (per unit area) on such a semi-infinite body due to a semi-infinite body in contact with it is obtained by integrating with respect to y from y=0 to y= $\infty$  This force is the cohesion per unit area and is given by

$$K_0 = \frac{2\pi}{(n-1)(n-3)(n-4)} \left| \frac{1}{a^{n-4}} \right|_0^{\infty}$$

The unit of force used is that between two unit volumes separated

by unit distance.

Lord Rayleigh remarks: "The pressure will therefore be infinite whatever n may be. If n-4 be negative the attraction of infinitely distant parts contributes to the result; while if n-4 be

finite whatever w may be. If n-4 be negative the attraction of infinitely distant parts contributes to the result; while if n-4 be positive the parts in immediate contiguity act with infinite power. For the transition case, discussed by W. Sutherland (Phil. Mag. xxiv. p. xxy. 3.887) of n-4, K is also infinite. The adds "It seems therefore that nothing satisfactory can be arrived at under this head."

In more recent times, however, it has been realized (particularly by the Dutch school of physicists) that to treat the body as a continuum is bound to give erroneous results. Every substance is known to be built up of molecules. If we assume the existence of attractions depending on the distance between the existence of attractions depending on the distance between the existence of attractions depending on the distance between the existence of attractions depending on the distance personal to absolute contact. The lower limit in the last integration should be the Past distance of separation between the lines of centres of familiarous layers. This will be a magnitude comparable with the indectinar diameter, say s. The value we seek then becomes  $\frac{s}{s} = \frac{s}{(n+2)(n-3)(n-4)} \frac{s}{s^{n-4}}$ 

There is now no objection on the above grounds to the power law provided that n>4

There can be no doubt that if the amount of matter compressed into unit volume (\*e, 'the density p) be increased the value of the nutrunisc pressure would be increased Moreover, a factor I (akin to the gravitation constant) is also needed if K is to be expressed in ordinary dynamical units Hence finally

$$K = \Gamma \cdot \frac{2\pi\rho^2}{(n-1)(n-3)(n-4)} \cdot \frac{1}{s^{n-4}}$$

The quantity, K, is called the Laplace pressure or intrinsic pressure. More generally we could assume that the force between elementary volumes is  $f\left(r\right)$ . The successive integrals then become

i. 
$$2\pi a \int_{a}^{\infty} f(r) dr dy = 2\pi a \phi(a) dy;$$
  
ii.  $2\pi dy \int_{y}^{\infty} a \phi(a) da = 2\pi dy \psi(y),$   
iii.  $K_{0} = 2\pi \int_{y}^{\infty} \psi(y) dy$ 

where  $\phi a$ ,  $\psi y$  are written as the values of successive integrals Finally K is obtained in ordinary units by multiplying by  $\Gamma \rho^2$  For example if  $f(r) = \epsilon^{-kr}$  where k is a constant we have

$$\psi(s) = \frac{ks + 1}{k^3} e^{-ks}$$

The difficulty in testing these formulæ arises from the occurrence of three variables (k<sub>s</sub>, k<sub>s</sub>)? The only one of these about which we know the value independently is s which for hquids must be of the same order as the molecular diameter Caution is necessary in considering forces which vary so fast with the distance as cobesive forces undoubtedly do. A small error in the assumed value for s would lead to very considerable error in k and I. The intrinsic pressure at the breaking point of a solid in tension should be the breaking stress itself. The latter as actually measured is, however, only a lower limit of K since flaws in the material and irregularities in the application of the tension will lead to fracture occurring at a value lower than the ideal stress. The effect of cohesion on the characteristic equation of a gas was allowed for by van der Wals who, following Laplace, took the intrinsic pressure as varying with the density square alone. The equation becomes

$$(p+a\rho^2)(v-b) = RT$$

where at the same time b is introduced to represent the fact that the volume of the gas cannot be reduced to ears. Here K and which for water at ordinary densities is between the value of the fact that the equation turns out to be approximationally makes caution necessary. Moseover of is found to vary nearly inversely as the absolute temperature. We are obliged to assume, therefore, either that  $\Gamma$  as a function of the temperature or, what is more lakely, that s is such a function. The last average distance of approach of the molecules must be affected by the motion of agitation amongst them and this increases as the square root of the absolute temperature.

Besides these considerations if must be pointed out that the modification worked out by the Dutch school only partly allows for the effects arising from the molecular character of matter. Knowing the forces between two molecules at a given distance apart, the actual value of the intrinsic pressure could only be correctly obtained by summing up the components (normal to the interface at which the pressure is being calculated) of all the forces between every pair of molecules each being calculated for the actual positions in which the molecules instantaneously are. It is true, that with forces that varys or fast with distance are. It is true, that with forces that varys or fast with distance individual contributions are important; the contributions of the contributions of the contributions of the contributions of the contribution of the start followed by Laplace. Something has been done in this direction (Lenard-Joses, Paraday Society, "Discussion on co-

hesion." 1927) but the fact remains that though the law of molecules. Hence force is probably greater than the inverse fifth it may vary up to the inverse seventh so far as present knowledge goes. If we take the higher of these two estimates the force between molecules which are neighbours and those that are next door to neighbours will be as 27 to 1, 18., in the ratio 128 to 1 or that between any layer and the next and next but one contiguous layer as 26 to 1, 16, in the ratio of 64 to 1 Hence all but a small percentage of the intrinsic pressure is due to the molecules in a small volume surrounding the point. This conclusion is important since it signifies that in any material (gas, liquid, solid) the intrinsic pressure will be uniform at all points except for a thin layer of usually negligible volume near its boundary.

Theory of Surface Forces .- This surface layer has theoretically no inner boundary but it may be taken, for most purposes. as being only - few molecules thick (mol. diameter is of the order of 10-8 cm) The most prominent peculiarity is that it possesses more potential energy than the rest of the body per

unit volume

Now increase of free energy at constant temperature is equal to the external work done on a system If we write dW = odA σ is called the surface tension To determine its value theoretically we estimate dW for the formation of a surface of unit area. Now if a body is split by a plane section and the two halves separated, a fresh surface is formed. The attraction per unit area between the halves at any distance x is

$$2\pi \int_{-\infty}^{\infty} \psi(y)dy = K(x)$$
 say.

The total work of separation is  $\int_{-\infty}^{\infty} K(x) dx$  and in the process a

fresh area of 2 units is formed Hence expressing the work done in ordinary units

$$2\sigma = 2\pi\Gamma\rho^2 \int_0^{\infty} K(x)dx$$

(In previous editions many theorems were given [some of which date from Laplace which depend, however, upon the lower limit being zero It is sufficient to say that these theorems are not applicable to the formulae given here)

If a power law is taken as the law of force between molecules it follows that

$$\sigma = \frac{\pi \rho^{\text{e}\Gamma}}{\left(n-1\right)\left(n-3\right)\left(n-4\right)\left(n-5\right)s^{n-4}}.$$

 $\frac{K}{\pi} = \frac{2(n-5)}{3}$ 

$$\sigma = s$$

For water at ordinary temperature, approximately

K=10,000 Atm = 10<sup>10</sup> dynes/sq.cm.  

$$\sigma = 75$$
 dynes/cm.  
 $s = 4 \times 10^{-8}$  cm.  
 $n - 5 = \frac{10^{10} \times 4 \times 10^{-8}}{2 \times 75} = \frac{8}{3}$ 

The Change

It must not be forgotten, however, that K and s are obtained by very approximate methods only.

Interfacial Tensions .- When two liquids are in contact there is in general a surface-tension at the interface which is called interfacial tension. Denoting this by o12 and the tensions of the liquids as o1 and o2 respectively, and carrying out a separation of the two liquids the value of out can be determined. In the above process the interface between 1 and 2 disappears and two fresh surfaces appear at which the tensions are  $\sigma_1$  and  $\sigma_2$ . Hence

$$\sigma_2 + \sigma_1 - \sigma_{12} = 2\pi \rho_1 \rho_2 \int_{\underline{a_1 + a_2}}^{\infty} K(x) dx$$

$$\sigma_{12} = \pi \rho_1^2 F(s_2) + \pi \rho_1^2 F(s_1) - 2 \pi \rho_1 \rho_2 F\left(\frac{s_1 + s_2}{2}\right)$$
.

Young took the functions F as being identical being all the same function of zero instead of the molecular diameters,

$$\sigma_{12} = \pi (\rho_2 - \rho_1)^2 F(0)$$

$$\sqrt{\sigma_{12}} = \text{const} \times (\rho_2 - \rho_1)$$
.

Hence for three liquids taken pair by pair

$$\sqrt{\sigma_{12}} + \sqrt{\sigma_{23}} + \sqrt{\sigma_{21}} = 0$$

These simplified relations are known not to be true On the other hand if the power law is valid and is the same law for different substances the equations given here lead to

$$\sigma_{12} = \left(\frac{\rho_{2}^{2}}{\sigma_{2}^{n-6}} + \frac{\rho_{1}^{2}}{\sigma_{1}^{n-6}} - \frac{2\rho_{1}\rho_{2}}{\left(\frac{n+n}{2}\right)^{n-6}}\right) \frac{\pi}{(n-1)(n-3)(n-4)(n-5)}$$

and the square root law should not be expected to be true excepting in special cases in which the molecular diameters of the three substances were the same.

All surface-tensions with which we have to deal are in reality interfacial tensions since a liquid is always in contact with its own vapour or the gas in which it is immersed. The effect due to the gas is known, however, to be very small

The normal pressure to be expected from the existence of a superficial tension is best obtained by considering in the first place a cylinder.

Consider an element of surface, ds x unity. The tensions acting at its extreme edges are inclined to one another and have a resultant inwards Their resultant is a normal force  $2\sigma \sin \frac{d\theta}{d\theta}$ or in the limit  $\sigma d\theta$ . But  $\frac{ds}{d\theta} = R$  (the radius of curvature), hence

the normal force is  $\sigma \frac{ds}{p}$  Since this acts over an area equal to ds, the normal pressure is  $\sigma/R$ .

If we take a body of any shape and select a square-bounded element of the surface, the tensions in the plane of the diagram

are equivalent to a normal force  $\sigma ds_1 \times \frac{ds_2}{R_1}$  and those acting on the other two edges to  $\sigma ds_2 \times \frac{ds_1}{R_1}$ . Hence per unit area

$$p = \sigma \left( \frac{1}{R_1} + \frac{1}{R_2} \right).$$

Here  $R_1$  and  $R_2$  are the radii of curvature in two planes at right angles. Owing to Gauss's theorem of integral curvature the sum of two such curvatures at a point is a constant. The above the orem is therefore true whether the two rectangular planes considered are principal planes or otherwise. In the case of a sphere

$$p = \frac{2\sigma}{R}$$

Effect of Temperature,-The variation of surface tension with temperature was not taken into account in Laplace's theory.

The forces between molecules were taken, like gravitational forces, to be independent of temperature. The rise in a capillary tube was supposed to vary merely because the density varied Experiment has shown, however, that the tension itself in all cases diminishes with rise in temperature. That it must ultimately

diminish to zero can be inferred from the fact that according to the usual conceptions as to the critical state a liquid and its vapour will at that point become identical with one another; the tension at the interface must then be zero. Eotvös introduced the conception of molecular surface tension. By means of somewhat doubtful reasoning he concluded that  $\sigma(Mv)$  (where Mvwhere the lower limit is the sum of the radii of the two kinds of is the molecular volume), plotted against temperature should give

the same kind of curve for different substances, and he found in fact that it was representable by  $K(T_0-T)$  where  $T_0$  is the critical temperature and K a constant According to Ramsay and Shelds K should be the same constant for all non-associated substances. In realty K vanes betyeen 15 and 26 and it is necessary also to change  $T_0-T$  to  $T_0-T-\delta$  where  $\delta$  is a small constant, so that the law is only a rough one According to this equation the curve would be a straight line cutting the temperature axis a few degrees below the critical point

In connection with this, it is important to remember that  $\sigma$  is only the free energy per unit area and not the total energy per unit area (n) Lord Kelvin was the first to prove that the variation of  $\sigma$  with temperature, involves that  $\sigma$  must be greater than  $\sigma$ ,  $\sigma$  in other words, when an expansion of the surface takes place heat must be added to keep the temperature constant The connection between these quantities he proved thermo-

dynamically to be 
$$u = \sigma - T \frac{d\sigma}{dT}$$
 (vide Thermodynamics applied

to chemistry). Now, at the critical point, u (which is only the extra energy due to the existence of unit surface and not the total energy of the whole body) must also vanish But if both u

and 
$$\sigma$$
 are then zero so also must  $T \frac{d\sigma}{dT}$  be zero.

Hence, if our conceptions of the critical state are correct the curve of  $\sigma$  plotted against T instead of being a straight line must become horizontal at the critical point. In 1894, van der Waals showed that a formula of the type  $\sigma = A(T_s - T)^s$  was to be expected and gave the average value of  $n = 1 \cdot 2 \tau$  as deducible from the experimental values. In 1916 A Ferguson (Phil. Mag, Jan. 1916), examining the data for 14 different organic substance showed that the best values of n ranged from 1:137 to 1  $\tau_2 4 s$ . The advantageous character of this power countion is that it

makes 
$$\sigma$$
,  $u$ , and  $\frac{d\sigma}{dT}$  all equal to zero at the critical point and it

thus satisfies all that is required of it theoretically. Liquids, however, which are believed to be associated do not follow the above simple law

The surface energy, u, also falls to zero at the critical point, but according to a different law For taking the equation

$$u = \sigma - T \frac{d\sigma}{dT}$$

it follows that  $u=A(T_c-T)^{\alpha-1}(T_c+[n-x]T)$ . The curves for  $\sigma$  and u are shown in fig. 5 for the case of benzene The curves show he nearly a straight line law satisfies the values of  $\sigma$  until the critical point is closely approached. An interesting relation has been given by Prof. E. T. Whittaker between u and the latent heat (internal) of esoporation. The internal latent heat  $(L_i)$  botalised by subtracting the external work done from the ordinary obtained by subtracting the external work done from the ordinary

latent heat. The relation in question is that 
$$\frac{T_a}{T} \cdot \frac{u}{I_a}$$
 is nearly a

constant, and that (in C.G.S. units) this constant is about unity for ethyl oxide, methyl formate, benzene and chlorobenzene and about 2 for carbon tetrachloride. The degree of constancy is indicated in the following table for benzene (Crit temp. = 561 56)

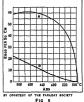
T°A.	$\frac{T_{e}u}{TL_{\bullet}}$	T°A.	$\frac{T_{e^{\mathcal{U}}}}{TL_{i}}$
353	1·106	493	1.089
403	1·100	503	1.106
453	1·067	513	1.129

The relation is important since it indicates the close connection there is between the surface energy and the volume energy of the substances.

General Properties of Surface Tension.—The notion of surface tension, though it is only a derived one, enables us to deal with all the phenomena which were enumerated at the head of this article without making explicit reference to the more fundamental notion of molecular attractions, upon which they in

reality depend. It is appropriate to summarize here the leading characteristics of this property

The tension of a liquid across any straight line drawn on the surface is normal to that line and is the same for all directions of the line and is measured by the force across an element of the line divided by the length of



that element

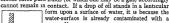
For any given homogeneous liquid surface, as the surface which separates water from air or oil from water, the surface tension is the same at every point of the surface and in every direction. In the case of mixtures, however, when circumstances demand it (e.g., when the surface is inclined and the flects of a given in the surface is the surface in surface in such a way as to produce a corresponding as to produce a corresponding

variation in the value of the surface tension sufficient to satisfy the conditions of equilibrium. This effect is very minute and in nearly every problem may be ignored.

When the surface is curved the effect of the surface tension is to make the pressure on the concave side greater than that on the convex side by the amount  $\sigma(C_1+C_2)$  where  $C_1$  and  $C_2$  are the curvatures in mutually perpendicular normal planes

The tension of the surface separating two liquids cannot be deduced by any reliable method from the tensions of the liquids when separately in contact with air. The experiments of C. G. M. Marangon, van der Mensbrugghe, and Quincke have led to results which show that the common surface between two liquids has a tension always less than the difference of the tensions of the separate liquids. This is usually referred to as Marangoni's rule.

If three liquids meet along a line the interfaces at the common edge must be parallel to the sides of a triangle proportional to the three tensions  $\sigma_{13}, \sigma_{23}, \sigma_{34}$  otherwise equilibrium cannot obtain (Neumania's rule) This triangle cannot exist unless two of the interfacial tensions are greater than the third. Marangoni's experimental rule ahows that the triangle is always imaguary, thence three pure fluids (of which one may be a gas) accordingly



greasy film.

When a solid body is in contact with two fluids the surface of the solid cannot alter its form but the angle at which the surface of contact of the two fluids meets the surface of the solid must depend on the values of the three surface tensons. For equilibrium

# $\sigma_{31} - \sigma_{32} = \sigma_{21} \cos \alpha$ .

The angle α is known as the angle of contact.

For pure substances the angle is definite It varies from zero (or very nearly so) for

liquids that "well" the solid to 150° or 140° for mercury on glass. In regard to the experimental behaviour of water on mercury the wealth of papers is equalled by the remarkable lack of unformity in the results obtained even when elaborate precautions are taken. A drop of water which fails to spread when placed on a mercury surface is often caused to spread by the action of pouring the mercury out of the dish—thus involving the creation of a new surface! Water shows a positive tendency to spread in vacuo on a drop formed in vacuo! (Burdon, Faraday Society, May, 1927).

Form of a Capillary Surface.—The form of the surface of a liquid acted on by gravity is easily determined if we assume that near the part considered the line of contact of the surface of the liquid with that of the solid bounding it is straight and horizontal.

This will be the case, for example, near a flat plate dipped into the liquid Let A2P2 be the vertical plate supposed to be so wide that the edge effects do not count. We will consider the forces per unit depth (perpendicular to the paper) and will consider  $A_1A_2$  as the standard level of the liquid far from the plate. The curvature of the surface at the point x, v, is

$$\frac{d\theta}{ds} = \sin\theta \frac{d\theta}{dy} = -\frac{d(\cos\theta)}{dy}$$

 $\frac{d\theta}{ds} = \sin\theta \frac{d\theta}{dy} = -\frac{d(\cos\theta)}{dy}$  and consequently the pressure in the liquid at that point is less than the pressure outside it by  $-\sigma \frac{d(\cos \theta)}{d\theta}$ . But the pressure is

less than that at a distant point where the surface is flat by goy

or  $g(p - p_0)y$  if allowance is made for the surrounding gas Hence the differential equation for the surface is

$$-\frac{d\left(\cos\theta\right)}{dy} = \frac{g\left(\rho - \rho_0\right)}{\sigma}y$$

the integral of which is  $1 - \cos \theta = 2 \sin^2 \frac{\theta}{2} = \frac{g(\rho - \rho_0)}{\sigma}$ .

The shape of the surface is therefore the elastica, ie, the form taken by a uniform spring when equal and opposite forces are apphed at its ends (see Thomson and Tait, Natural Philosophy, vol i. p. 455). The equation might have been found by considering the elementary volume of a strip of liquid, dx, sustained above the normal level of the liquid by the surface forces at its outer and inner edges The difference of the vertical component of



these is  $\sigma d(\sin\theta)$  and the weight of the strip is  $g\rho ydx$  but since  $\frac{d(\sin \theta)}{d(\sin \theta)} = -\frac{d(\cos \theta)}{d(\cos \theta)}$  the same result is obtained.

If the angle of contact is  $\alpha$  the value of  $\theta$  at the plate is  $\frac{\pi}{2} - \alpha$ ;

1/2

$$1-\sin\alpha = \frac{g(\rho-\rho_0)}{g} \cdot \frac{Y^2}{2}$$

which gives the greatest height through which the liquid is raised. A thin sheet of glass suspended from the arm of a balance

and just dipping into a liquid provides a simple way of determining the surface tension The increase in the apparent weight of the sheet when the liquid has been raised by capillarity is  $\sigma$ multiplied by twice the horizontal length of the sheet. A sensitive form of this apparatus is known as Worthington's multiplier in which the strip is rolled into a vertical cylindrical spiral.



BY COURTERY OF THE PARADAY SOCIETY

Ascent up a Capillary Tube .-- A capillary tube dipped in a liquid provides a simple method of determining surface tension To connect the surface

tension with the rise (or descent) of the liquid in the tube measured from the level part of the outside surface we equate the effective weight of the liquid raised to the total force due to the tension. The effective weight (with the symbols shown on diagram) is

$$g(\rho-\rho_0)\int_0^{\pi} 2\pi x(h+y)dx$$

for an inner cylinder of radius x where  $\rho$  is the density of the liquid and  $\rho_0$  that of the surrounding gas or vapour. The vertical component of the surface force acting all round the edge of the liquid surface of this cylinder is  $2\pi i \sigma \sin \theta$  or  $2\pi x \sigma \cos \alpha$  where  $\theta$ is the angle between the surface and the horizontal and  $\alpha$  is the 'contact-angle" which is measured with respect to the solid surface (in this case the vertical). These two expressions are to be equated to one another.

If we can neglect y altogether compared with h and integrate between the limits o and r we obtain  $2\pi r \sigma \sin \theta = g(\rho - \rho_0) \pi r^2 h$ whence  $\sigma \sin \theta = \frac{1}{2}g(\rho - \rho_0)rh$ . To seek for a better approximation we first differentiate the two sides of the equation whence

$$\frac{d\left( 1\sin\theta\right) }{dv}=\frac{g\left( \rho-\rho_{0}\right) }{\sigma}\left( h+y\right) =\frac{x\left( h+y\right) }{\beta^{2}}\,.$$

We may consider this as the standard exact equation. The left side is

$$\frac{r d \sin \theta}{d v} + \sin \theta \quad \text{or} \quad v \left( \frac{\cos \theta d \theta}{d x} + \frac{\sin \theta}{x} \right).$$

But  $\cos\theta \frac{d\theta}{dx} = \frac{d\theta}{ds}$  (where ds is an element of the curve AC) and is : the curvature in the plane of the diagram at B; and

 $\frac{\sin \theta}{\sin \theta}$  is the curvature of the surface at B in a plane at right angles to the diagram. Hence, calling these curvatures  $\frac{1}{R_1}$  and  $\frac{1}{R_2}$  we have  $\sigma\left(\frac{1}{R_1} + \frac{1}{R_2}\right) = g(\rho - \rho_0)(h+y);$ 

both of the terms here are expressions for the difference of pressure between the two sides of the surface at the point B

Narrow Tubes .- The equation shows that the sum of these curvatures increases with the height; but when h is big and y small, as it is for a very narrow tube, the sum is nearly constant. Going back to the differential form of the equation and taking the case where the liquid wets the tube, we may consider the curve as practically circular, of radius r: the corresponding value of  $y=r-\sqrt{r^2-x^2}$  and

 $\frac{d(r \sin \theta)}{dv} = \frac{1}{\beta^2} (h+y)v = \frac{v}{\beta^2} (h+r - \sqrt{r^2 - v^2}) \text{ nearly whence, by}$ integration

$$x \sin \theta = \frac{1}{\beta^2} \left[ \frac{h v^2}{2} + \frac{r x^2}{2} + \frac{1}{3} \left\{ (r^2 - x^2)^{\frac{3}{2}} - r^3 \right\} \right].$$

or since  $\sin \theta = 1$  when s

$$1 = \frac{r}{2\beta^2} \left( h + \frac{r}{3} \right).$$

By putting the radius of the circle as  $R = \frac{\tau}{\cos \alpha}$  when the angle of contact is a instead of zero this becomes

$$\cos \alpha = \frac{r}{2\beta^2} \left[ h + \frac{r}{3\cos^2 \alpha} \left\{ 1 - 3\sin^2 \alpha - 2\sin^3 \alpha \right\} \right].$$

By calculating  $tan\theta$  from  $sin\theta$  and bearing in mind that  $\tan \theta = dy/dx$ 

we can by subsequent integration obtain a closer value of vin terms of x which can, in turn, be introduced into the differential equation and so on. By such successive approximations Lord Rayleigh has obtained the equation for the case  $\alpha = 0$  in the form

$$\sigma = \frac{1}{3}g(\rho - \rho_0) hr \left[ 1 + \frac{1}{3} \frac{r}{h} - 0.1288 \frac{r^2}{h^2} + 0.1312 \frac{r^3}{h^3} \right]$$

in which the coefficients are claimed to be correct to the approximation given. The equation can only be used in the case when r is small compared with h. It may be mentioned that a very near approach to the equation can be obtained by considering the surface as ellipsoidal with its minor axis vertical. This was first shown by Hagen and Desains. Various methods are employed for determining surface tension experimentally .

(a) From the rise in a capillary tube making use of the above equation.

(b) Sentis's Method .- A capillary tube is partly immersed in the liquid. It is then withdrawn vertically and a drop remains clinging to the lower end, the position A of the vertex of the drop is noticed The liquid in the vessel is then raised until it touches the vertex (when the column falls) and then raised further till the upper surface is at the same level C as at first The liquid in the vessel is then at the level B The vertical distance AB corresponds to h in the ordinary method but in the correcting terms h must be put negative. The width of the drop is in this case to be small compared with h

(c) Jaeger's Method -In this method an orifice (a "tip") is placed just under the surface of the liquid and the pressure of gas is increased until bubbles form The maximum pressure of the gas (which is fairly sharply marked) is observed The deduction of the applicable equation is a somewhat delicate matter because the problem is really a kinetic, not a static, one The formula em-

FIG 9

$$\sigma = \frac{p_{\max} r}{2} \left[ 1 - \frac{2}{3} \frac{r}{h} \right]$$

where  $p_{max}$  is the maximum dif-

ference of pressure between the

level of the end of tube inside and outside, and r is the internal radius of the tube. The bubble is assumed to form within the internal circumference. In practice, however, it sometimes forms on the outside circumference. To obviate the uncertainty it is recommended to make the two circumferences as nearly equal as possible, but this is an experimental matter of great difficulty. The final accuracy depends chiefly on the measurement of the radius r. The subject of the formation of bubbles and drops requires much more study than it has received.

(d) Drop Weight Method,-This method is connected with the preceding one because the drops considered are those issuing from a narrow tube. It was employed by Tate (1864) who gave as the result of his observations .- Other things being the same, the weight of a drop of liquid is proportional to the diameter of the tube in which it is formed Later, Quincke used it and gave the value 2 mr o as the weight of the suspended drop just before falling provided that the inflow of liquid is sufficiently slow. A portion of the drop is always left behind when the main part falls; but he considered that it might be neglected in the case of very small drops.

Rayleigh has discussed the question from the "dimensional" point of view. (See DIMENSIONAL ANALYSIS ) Assume that the mass M of the drop depends only upon the surface tension, o, the value of acceleration due to gravity, g, the density of the liquid, p, and the inside radius, a, of the tube. Rayleigh shows that  $\sigma a/g$  has the same dimensions as a mass and that  $\sigma/g \rho a^2$  is a pure number. Since quantities that can be equated together must be quantities of the same kind, it follows that  $M \infty (\sigma a/g) F(\sigma/g\rho a^2)$ where there is no restriction, imposed by this method of inquiry, upon the function F of the quantity in the second pair of brackets. Rayleigh finds by experiment that gm/oa is fairly constant for wide ranges in the diameter of the tube For thin-walled tubes in the case of water the following values were obtained:

gpa <sup>5</sup>	<u>gΜ</u>	σ	gM
	σα	1 gρα <sup>2</sup>	σa
2.58 1.16 1.768 fi	4413 3.97 3.80 4.1373	·277 ·220 ·16g	3·78 3:90 4·06

The mean value of the constant is thus about 3.8 instead of 27 which the imperfect theory gave. Further experiments by Harkins and Brown show that the constant approaches Quincke's value as the diameter becomes very small " to all daulst in.

As a means for measuring surface tension this method is obviously not satisfactory, but for rough comparative values for liquids of like kind it is a very quick and easy method.

Wide Tubes -When a is not small the approximations made above for narrow tubes are not suitable

The question has been fully discussed by the late Lord Rayleigh to whose papers reference should be made (v Rayleigh, Proc Roy Soc A, 92, 184, 1915)

Bubbles and Drops .- These can be dealt with by similar methods Air bubbles in a liquid can be formed of any size, from minute ones which are nearly spherical to large ones shaped like a flat cake. The excess pressure  $p-p_0$ , which is easily found by experiment, determines the total curvature at the lowest point N;

being equal to  $\frac{2}{R}$ . If y is reckoned upwards as before, then

$$\frac{d(x\sin\theta)}{dx} = \left(\frac{z}{R} + \frac{y}{\beta^2}\right)x.$$

thus  $\frac{2}{p}$  replaces  $h/\beta^2$  in the previous problems. For very large bubbles, as for wide tubes, a good approximation can be obtained

by neglecting the second curvature and also  $\frac{2}{n}$ , so that

$$(\mathbf{1} - \cos \theta) = \frac{y^2}{2\beta^2} = 2\sin^2 \frac{\theta}{2}.$$

If H is the value of y for which the tangent to the curve becomes vertical we have  $H = \sqrt{2 \cdot \beta}$ . This method has been used by Quincke and others but not always with bubbles large enough to justify the approximation that is made. The bubble is conveniently formed under a slightly concave surface so as to prevent it from escaping. Drops of mercury are easily formed above a concave surface. If y is measured downwards from the summit the same formulae hold as for bubbles

Great attention has been paid to these methods owing to their use in determining surface-tension The most thorough treatment from the practical point of view is given by Bashforth and Adams (Capillary Action, 1883). By means of infinite series calculated for each of the variables each term in the differential equation can be calculated to very high accuracy and tables are drawn up enabling the form to be determined for given weights of material and given surface tensions.

Thin Films.-In this section we consider than films. The first group of cases consists of those in which the substance forms a thin sheet with gas on both sides, as for example, a soap bubble. Here we have always two surfaces to consider. When the thickness is considerably greater than the value of the range, e of molecular forces the two surfaces are independent of one another; the surface-tension must then have the usual value for each For very thin films this will not be so. If the thickness is less



than the range,  $\epsilon$ , the tension for each surface will be certainly less than the normal value, When the variation of density at different levels in the film is taken into account it is clear that the reduction in the surface-tension must begin when the thickness is twice €.

A soap film is simply a small

quantity of soapsuds spread out so as to present a large surface to the air. The soap solution may with great advantage be specially prepared The addition of glycerine and resin enables more permanent films to be prepared. Bubbles may easily be blown 20 in. in diameter in the open air using a clay pipe or a small glass funnel. (The method needs no precise description.) Sir James Dewar has obtained bubbles that last almost indefinitely if evaporation be prevented by blowing them in a confined space saturated with water vapour.

The pressure inside a bubble is greater than that outside by

$$_{2\sigma}\left(\frac{\mathrm{I}}{R}+\frac{\mathrm{I}}{R}\right)$$
, i.e , by  $_{4\sigma}/R$  where  $R$  is the radius of curvature.

The factor z arises because both surfaces give rise to normal components of forces. This result is easily obtained by considering the equilibrium of each half of the bubble. The force at the cut edge is  $2\sigma \cdot \pi R$  and this is balanced by the excess pressure acting over the plane area  $R^{2R}$ . Hence the excess pressure is

$$\frac{2\sigma \cdot 2\pi R}{\pi R^2} = \frac{4\sigma}{R}.$$

If the end of the pipe or funnel is opened the bubble will contract because of the escape of high pressure art from inside As it contracts the pressure rather paradoxically increases. It may be added that (neglecting gravity) the bubble is spherical beauth this shape makes the surface area (and therefore the potential energy) least for a given volume.

If bubbles are blown on the expanded ends of two funnels (the stem of the property of the fingers) they can be made to coalesce by carefully bringing them into contact (A slightly electrified rol brought not too near will assist the coalescence) On drawing the funnels slowly apart a cyfindrical bubble is obtained. The excess pressure is now 20/R where R is the radius of the opening of the funnel Further separation causes the cyfinder to contract in the middle, one of the two curvatures is now negative; the surface is an anticlastic one With further excession of leight the surface becomes unstable and the film collapses. It has been shown by Clerk Maxwell that a cylindrical film becomes unstable

when its length is greater than its circumference.

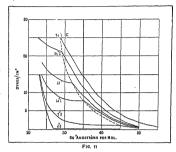
Films on Liquids .-- In the second group of cases a liquid or solid is on one side and a gas on the other. To this group belong all cases of the spreading of oil or other substance on water or other liquid or solid. This old familiar subject has recently acquired very great importance in its bearing upon molecular structures. The first to experiment in detail on such films was F. H R Ludtge (Pogg. Ann cxxxix, p 620), who showed how a film of high surface tension is replaced by one of lower surface tension Akin to these are experiments made on the erratic movements that are observed when fragments of camphor are sprinkled on a clean water surface. A trace of grease such as may be communicated to the surface by dipping a finger in the water may be sufficient practically to stop this motion The thickness of oil which is required may be spoken of as the "camphor-point." The first to determine it was (the ard) Lord Rayleigh who in 1800 (Roy, Soc. Proc.) showed that the thickness of the film of olive oil, calculated as if continuous (i.e., non-molecular) which corresponds to the camphor-point is about 2×10-8 mm.; ie., it is only a moderate multiple of the supposed diameter of a gaseous molecule and perhaps scarcely exceeds at all the diameter to be attributed to a molecule of oil; and he ultimately realized that this phenomenon was therefore entirely outside the scope of a theory of surface action such as Laplace's in which matter is regarded as continuous and that an explanation required a direct consideration of molecules.

In 1891 Miss Pockels (Nature, XIII., 437 [1891]) showed by means of a novable slider on water (the surface tenson being measured by means of the attraction on a small disc) that the contaminating material on the surface could be squeezed up and concluded from her experiments that the water-surface can exist in two sharply-contrasted conditions; the normal condition, in which the displacement of the partition makes no impression on (the value of) the tension, and the anomalous condition in which every increase or decrease (of the surface) alters the tension.

The question was taken up again by Lord Rayleigh in 1899 (Phil. Mag. XVIVII. 369) with apparatus designed on the lines of that of Miss Pockels (but employing a different way of measuring the surface tenson) and he concluded that the first drop in tension corresponded to a complete layer one molecule thick and that the diameter of a molecule of oil is about >0XIVIS min.

Later investigations have been made by I. Langmuir (in America: J. Amer. Chem. Soc., 2015 to 1918) and N. K. Adam (in England) and their coworkers. By measuring the surface area

that can be completely covered by a weighed quantity of material Langmur determined both the cross-sectional area and the length of a molecule and proved that the length for organic molecules like those of palmitic, stearnc, cerotic acids, etc, was nearly five times the breadth, while in cetyl palmitate it is nearly ten times. Adam has developed the technique and has very much evended the theoretical interpretation (Rey Soc.



Proc. A. 1921 to present time). Both Langmur and he measured the amount of "oil" and measured directly the force required to compress the surface to any given area by means of a floating barrier. The actual force measured is the length of the barrier multiplied into the difference of the surface tension on the two sides of it. On the outside the surface is that of pure water—on the inside that of water on which a thin film has been formed. It is found that when the molecules in the film are so sparse as to be widely separated from one another the force due to the film is an expansive one.

This cannot be explained on Laplace's theory: it is necessary to modify it by allowing for the effects of thermal motion; the film in such a case is analogous to a two-dimensional gas. If the barrier is now moved so as gradually to compress the film various changes take place successively which are depicted in fig. 11 for the case of a film of myristic acid on weak HCI (N/100). The unit of area adopted is a square each side of which is an Angstrom unit (i.e, 10-10 metre), and the area specified is that occupied by one molecule of the acid. The ordinates of the curves are the difference of the tensions on the two sides of the barrier, The curves are isothermals extending from 2.5° to 34 4° C. They exhibit some of the characteristics of the p, v, curves for a condensible substance. At high temperatures the curves appear to be approximately rectangular hyperbolas. For small values of the area they approach the form for liquids. At intermediate stages, however, there is no constant pressure isothermal as in the analogous case of the vapour pressure of a liquid below the critical point (the form is more nearly that for the vapour pressure of a mixture of two liquids; this fact may indicate that the underlying water takes a part in the changes that occur).

It is not to be expected that there should be complete correspondence between the two classes of phenomena. There is, however, sufficient indication that the effects of thermal motions in the films cannot be neglected. The analogy with liquids and gases can be further illustrated by plotting  $\mathcal{F}A$  against  $\mathcal{F}_i$ , where  $\mathcal{F}$  is the force applied per unit length; the resemblance to an Amagat diagram for a find is very striking, (Schofield and Rideal, Roy. Soc. Proc. A. 10.9, p. 67; 110, p. 170). It is clear from the diagram that a film of myristic acid can be squeezed up until a molecule occupies less than <math>24  $A^2$  At the opposite and where the behaviour approaches that of a gas it is to be expected

that the equation would take the form RA=RT where the value of R (allowing for only two degrees of freedom) should be 1372 per molecule, at room temperature therefore FA should be about 400. This has been experimentally verified as a limiting value for very low surface pressures. With the long-chain fatty calde, seters and intriles it is approached within 2%, the pressure being below 0.1 dyne per centimetre. With the dibasic ester CAHOCO (CAH), COO CAH is the shee neverified within 10%

The unterpretation of the experimental results is still in a somewhat fluent state and it is clear that we must not press any simple gas analogy too far. A thin film upon a body of different material cannot be treated as in a similar state to the molecules in the body of a gas. Forces must exist between the film and the liquid beneath. This may account for the fact that at any rate some films do not spread indefinitely as a gas expands into a vacuum Further, the most compressed state can only give an upper limit to the lesst cross sectional area of the molecule. The molecules are resting on the rapidly moving molecules beneath them and must share to some extent in their agitation. Sail it must be mature of films and on the demensions of molecules. Where corroboration is possible, measurements made by means of X-rays are in good accord with hose obtained by this method.

For certain properties of solutions see Solutions; Thermo-

DVNAMICS.

Billiadopanty.—In addition to the specific references in the text, further sources of information are (the grd) Lord Rayleigh's Collected Papers (several articles), A. W. Reinold and Sir A. W. Ricker, Phil. Trans., (1885), Sir W. Ramsay and J. Shelds, Selischer, Phys. J. Chem. 1997, S. Robert Spectrum, and J. Shelds, Selischer, Phys. J. Chem. 1997, S. Robert Spectrum, and J. Shelds, Selischer, Phys. J. Chem. 1997, S. Robert Spectrum, and Larver, Am. Chem. Soc. 1997, S. Robert Spectrum, and Larver, Am. Chem. Soc. 1997, S. Robert Spectrum, and Larver, Am. Chem. Soc. 1997, Chem. 1997, S. Robert Spectrum, and Larver, Am. Chem. Soc. 1997, Chem. 1997, S. Robert Spectrum, and Larver, Am. Chem. Soc. 1997, Chem. 1997, S. Robert Spectrum, and Larver, Am. Chem. Soc. 1997, Chem. 1997, Chem. 1997, S. Robert Spectrum, and Larver, and Lar

SURFBIRD, a stoutly built, sandpiperlike bird (Aphriza wrgata), dark gray and white in colour and about ten inches long. Its relationships have been disputed but it seems to be a member of the snipe-sandpiper family (Scolopacidae), closest to the turnstones.

Its summer home is in the mountains of south central Alaska, where its nest, placed on rocky ground above timber line, was first discovered in 1926. In winter it lives along the Pacific coast of the Americas, from British Columbia to the Straits of Magellan. It feeds along the water line, preferring rocky or stormy shores where its favourite food, barnacles and mussels, is exposed at low tide. It is a rather quite, inactive species, found in small flocks in winter, and is one of the lesser-known shore birds.

SURGE, in general terms, is a sudden increase to an excessive or abnormal value and a fall from such a value subsequently. In meteorology, "surge" is the name applied to those long-period progressive changes of barometric pressure which occur simultaneously at many locations over a wide region and which are superimposed on short-period pressure fluctuations of a diurnal nature or variations caused by travelling atmospheric disturbances of a local character. A pressure rise or fall of two millibars in 24 hours that occurs simultaneously within an area of 3,000,000 sq mi. corresponds to the order of magnitude of the phenomenon. Such pressure surges are commonly noted in regions close to the large semipermanent pressure centres of the earth such as the highpressure area of the southern North Atlantic ocean. "Surge" is also a meteorological term often applied to a sudden increase in velocity of the large atmospheric wind streams, especially in the tropics. Such a wind surge occurs simultaneously over a large area and frequently spreads from place to place so that its progress can be followed on weather maps. In the trade-wind belts, meteorologists frequently refer to this event as the "surge of the trades" and, in the regions of the mousoon currents, as the "burst" or "surge of the monsoon" At a given location, an increase of wind speed from about 10 m p h to 35 m p h or more at all levels from the ground up to approximately 15,000 ft can be expected in connection with a well-marked surge of the trades. (D C McD)

SURGERY. Surgery is that division of medicine in which the knowledge and skill of the physician are predominantly associated with manual operations (In Great Britan, the term is also used for a physician's office or treatment room). This distinction has obtained in some degree from the earliest times, in part because of skill on the part of the surgeon in the treatment of fractures, dislocations and wounds, in the perfection and use of ointiments, purges and enems and in the befeetion and use of ointiments, purges and enems and in the befeetion and use the treatment of the property of the more sophisticated there developed in the middle ages the bather-aurgeon (France), the wound-surgeon (Germany) and the surgeon-apothecary (Great Britain).

By the 18th century, with increasing knowledge of anatomy, operative surgery such as amputations of the extremities, excision of tumours on the surface of the body and removal of stones from the urinary bladder led to increased respect for surgery. In the early 19th century surgeons were tentatively exploring the further possibilities based on increasing knowledge of anatomy and physiology. However, the pain of operative procedures limited expansion of the field until the introduction of anaesthesia in 1846. The number of operations thereafter increased markedly but only to accentuate the frequency and severity of 'surgical infections.' Concomitant with the development by Louis Pasteur of an understanding of the relationship of bacteria to infectious diseases, Joseph Lister Introduced in 1869 his antiseptic method for the modern surgery.

The control of pain and infection remained basic requirements for surgery, although great development was made, particularly after 1930. Anaesthesiology passed from the simple administration of ether or chloroform, or even a gas, to the choice from a dozen agents for general anaesthesia and as many more for local while several drugs came to be used as accessory agents. Use of these agents is closely associated with the immediate care of the patient in preparation for the operation, general supportive major access used using it, and recovery from the general effects of it. As a result of the knowledge and skills required, ansesthesology bear recognized as a specialty for which the physician undertakes medical trainine and receives specific recognition.

The prevention and control of infection is a primary responsibility of the surgeon in every operation as well as in those diseases which are caused or accompanied by infection. In the first instance the making of an operative wound necessarily breaches the barrier of the skin, which normally protects the person from bacteria. Some of these may be harmless; others are relatively so except where the tissues traversed are damaged sufficiently to encourage their growth; and still others once present in the wound have the ability to multiply in and about it or even spread away from it, thus causing a dangerous infection. Unfortunately, the last, while not so commonly present, may be so anywhere and at any time, and then give rise to serious and even fatal infection.

The "antisepsis" of Lister, which involved the use of chemical agents for the killing of bacteria, lowered very materially the incidence of infection, so much so that it became possible to perform operations in such regions of the body as the joints, bones, soft structures and the abdominal cavity with a high degree of safety. With the simpler methods of "asepsis"-that is to say, the use of heat for sterilization where possible and the prevention of contamination of the wound directly in the course of the operationthe serious infections became relatively rare. Latterly, a more rigorous routine in the operating room, combined with a realization that damage to the tissues of the wound by rough manipulation or introduction of gross amounts of nonviable material set up a situation favourable for infection, led to a further lowering of the incidence of serious infection to the order of 1% or less. An added factor of safety was gained by the introduction of the sulfonamides, drugs which interfere with the growth of bacteria although they do not directly kill flow, and of other substances derived from certain of the lower orders of fung, which are very effective in a similar fashion. These agents continuousle that treatment of infections and made operations represent the in the presence of infection or unavoidable contamination by bacteria. In many instances their use in established infection obviated the necessity of operative procedures. It became unusual for a patient to die from an infection unless the infection had got completely out of hand before consultation with a physician or

The control of infection is of particular importance as regards injuries incurred in war and scarcely less so in civilian life. In World War II and the Korean war, of those wounded in combat and surviving to come under surgical care promptly, relatively few died. This was a marked improvement over the experience of previous wars and was due in considerable degree to the control of infection.

"Shock."—In obtaining these results, a better understanding of what was formerly called "surprised abode" played a major role. "Shocke" is usually characterised by what has formerly called "surprised by major processing a rapid, thready pulse which can be easily our research as the same a rapid, thready pulse which can be easily our pressure. The condition is most striking when occurring suddenly or unexpectedly and is by no means confined to surprised patients. Where the heart is primarily not at fault, as is the case in most instances of "shock" resulting from injury, the failure is essentially that of an inadequate return of blood to the heart so that, no matter how vigorously it beats, its output is Insufficient to maintain circulation throughout the body. This perpiperal circulations is dependent not only upon the output of the heart but also upon the total capacity of the vessels and the volume of the blood within them.

In most instances of "shock" encountered by the surgeon the cause is a decrease of blood volume. The simplest cause and also the commonest in war is loss of whole blood from one or more vessels either in large amounts abruptly or in smaller amounts over a longer period This may be external and obvious or internal into tissues and cavities and therefore not easily ascertained. If the loss is severe and the state of "shock" profound or continued, the decreased interchange of the gases, salts and proteins carried by the blood causes profound change in the functions of the tissues and organs, and if the damage becomes severe and irreversible leads to death. It is obvious that the treatment is prompt control of the bleeding and an equally prompt restoration of the normal blood volume This can be done most effectively by the introduction of whole blood obtained from a blood bank. If blood cannot be obtained, plasma or artificial substitutes for it may serve temporarily. Or if none of these is available, a physiological salt solution can be administered by mouth and intravenously.

The same situation may obtain in the course of an operation. Previously and traditionally the surgeon operated with great speed in an effort to avoid "shock," on the supposition that it was caused by pain. Even after the introduction of annesthesia, it was still fell necessary to operate rapidly, by reason of the presumed toxic effects of the agents used. This was accompanded in most instances by the loss of large amounts of blood. Later it was recognized that annesthesia, given by a competent annesthesia, better of the control of the hypothetical effect of pain was set it is practically always due to the loss of blood externally or into the tissues which have been roughly handled. If it does occur, prompt restoration of the blood volume with whole blood outley tretives the situation.

There are, however, instances of "shock" in which, although there is no gross break in the vessels, the plasma leaks through their walls into the tissues or body cavities rangidy and in considerable volume, to a point where loss of blood volume leads to failure of the peripheral circulation. This type of "shock" may be caused by severe mechanical injury, chemical agents, infection

Prompt and skilful treatment will save a considerable percentage of patients suffering from severe burns! For the first few days the problem is 'predominantly that of treating "shock." It then becomes one of control of infection; the removal as soon as possible

of skin which has been damaged beyond repair, and the covering of the denuded areas with skin grafts at the earliest possible moment. If this is not accomplished, a prolonged illness ensures in which the nutrition is impaired, mostly because of a loss of protein throughout the body and in the blood itself, and a resulting relative diminution of the blood volume been poorly termed "chronic shock."

This condition has been poorly termed "chronic shock."

"Chronic shock" occurs also in many patients suffering from wating illnesses in which there is a protein deficiency, by reason of protein loss from the body or inadequate intake or both Resistance to infection and, more important to the surgeon, the ability to withstand an operation are lowered Treatment by blood transfusion, by increased intake of protein and vitamins and by other measures does much to lower the operative mortality. Particularly is this true in cancer, where the only hope of a cure or pullation often tests in radial operations

Postoperative Care.—Care of a patient following an operation involves the prevention or treatment of complications Formerly such complications were common, notably the so-called "jost-operative pneumonia" attributed incorrectly to the anaesthetic agent. With better administration of anaesthesia, particular attention to breathing, early mobilization of the patient and control of infection by the sulfonamides and antibutics, the inodence of complications decreased notably. The gwing of adequate fluids and the maintenance of nutrition also did much to avoid the postoperature discomfort and at times serious ulleas formerly occurring. There presided, however, a low but significant indeveloped to control it.

A better understanding of the process of healing led to earlier discharge of patients from the hospital, to avoid the enfeebling effect of long bed rest. This type of ambulatory rehabilitation involves both psychic and physical factors.

Specialization.—As a result of the development of new operations in fields prevously considered maccessible, and of better means of diagnosis and more highly specialized skills, surgery came to be categorically divided into certain areas for which special training is required and in which the competence of each surgeon is authenticated by the individual professional groups ophthalmology, otolarynagology, orthopaedics, urology, neurosurgery, thoracic surgery, plastic surgery, gynaecology, proctology, etc. While this partition of surgery led to greater knowledge and skill in restricted areas, it also resulted unfortunately in less knowledge and skill with respect to areas outside the specialty.

Prior to specialization, except in a few of the larger cities, there was not a large enough volume of practice in the entire field of surgery to occupy the full energies of a practitioner or to provide him with a reasonable momen. Most physicians did surgery deven those who were known to be particularly skilled in it continued general practice.

Wounds .- Surgery, while still requiring as its distinctive skill the operative procedures, does not differ fundamentally from other fields of medicine which in the same period of time underwent a similar development with an increasing knowledge of diagnosis and treatment of disease. There are many areas of common interest in which the physician and the surgeon combine their knowledge and skill. Specifically illustrative is the change that took place in the treatment of injuries. Laster's first contribution to the control of infection was in compound fractures, in which the skin had been damaged so seriously that there was direct exposure of the mjured bone and the surrounding soft tissues to the air, thus permitting contamination by bacteria. Immediate closure by a dressing with phenol (carbolic acid) which blocked off this communication mechanically and chemically enabled him to report a series of cases in which the mortality had been remarkably lowered. Previously, nearly all such injuries had become infected, and the majority of the patients died. It was considered good practice to amputate at once an extremity in which there was a severe compound fracture, in a desperate attempt to avoid this sequence of events. Unfortunately, amputation was also accompanied in the majority of instances by infection and death. Other surgeons adopted Lister's methods and modified them by applying dressings stentized by chemicals less caustic than phenol or by heat. Rigorous methods were developed to avoid direct contamination by other potential carriers of bacteria such as instruments in the hands of the operators. It was found that amputations required by irreparable injury or for other reasons could be carried out with relatively low mortality. Precautions were then adopted for all operative procedures involving incision of the skin

As bacteriology developed, it became apparent that certain organisms were responsible for the more serious infections, and that one variety was not infrequently present in the throats and noses of persons who were at the moment or had been infected by them Consequently masking of the operator and others in the operating room was introduced The rubber glove was used to prevent transfer of bacteria from the operator's hands to the wound The effectiveness of these precautions had been so satisfactory in civil life that it came as a great surprise at the onset of World War I in 1914 to find that wounds from projectiles, a large portion of which were high-explosive shells, became grossly and viciously infected. Tetanus, gas gangrene and virulent streptococcus infections were rampant Conditions in the hospitals resembled those of the American Civil War and the Crimean War, both of which antedated the contributions of Lister. Rigorous administration of tetanus antitoxin at the dressing stations, however, and improvement in the evacuation of wounded to hospitals where adequate surgical care could be given improved the situation somewhat. But the concept of the "mobile hospital" (the ambulance of Dominique Larrey, in the Napoleonic wars), in which the surgeon and operating facilities were brought close to the combat zone, although introduced was not uniformly accepted until World War II. It finally became recognized that if infection was to be controlled effective measures must be taken within six hours of the injury Foreign material such as gross dirt, patches of cloth and fragments of the projectile itself must be removed by careful block excision of the wound if possible, including all nonviable tissue. It was found possible to close a great majority of wounds at once by suture and obtain healing with little or no infection. An occasional patient, however, would develop an infection which, for lack of care, became serious. It was therefore the rule to leave these wounds open until they could be sutured a few days later at a hospital in the rear if not infected In wounds of the brain, thorax, abdomen and joints, however, it was essential that the closures be made at the time of the primary operation.

The fundamental lesson learned in World War I was that the presence of dead dissue and other foreign material is the most important factor in the incidence of infection of wounds. The lesson was confirmed and the underlying principles were followed more uniformly in World War II and the Korean war. It is probable that with the subsequent development of drugs for the world was the second of the probable of the world of the subsequent wounds can be closed at once after excision with still fewer cases of the subsequent of the duration and extent of disabilities.

It should not be assumed, however, that only in war are advances made in the knowledge of surgery and its application. The principles used in the care of wounds during war had been recognized and used by many surgeons in civilian life, and war meant only their application in mass.

Research and Education.—The surgeon is necessarily dependent upon his colleagues in other fields of medicine and in the sciences not immediately related to medicine. Pasteur, a chemist, established the science of bacteriology, while Lister applied it. W. K. Röntgen discovered X-rays, which found their use first in the diagnosis of fractures. Nuclear physicists have discovered invaluable substances for investigation, diagnosis and treatment in all fields of medicine, including surgery. Conversely, surgeons have contributed materially to the knowledge not only of disease but also of the structures and functions, normal and abnormal, of man, Major contributions resulting from clinical experiences have been reinforced by carrying problems into laboratories for research. Research in surgery, as in other sciences, represents in a large degree the area of most intensive growth. Parsicularly important in this connection is the training of surgeons. The surgeon who remains unaware of the advances in his pro-

fession, even though he does not take a productive part in them, will become increasingly ineffective as time goes by A concerted effort in the United States was directed at providing continuing opportunities of learning by those established in practice. This was one of the objectives of the American College of Surgeons, formed in 1913 and modelled upon the Royal Colleges of Surgery in Great Britain It was soon realized that more specific opportunities were necessary for the surgeon about to enter into practice, and for this several graduate schools were established which for the most part employed didactic methods of teaching Finally in 1937, following the examples of other divisions of medicine, the American Board of Surgery was established, under the auspices of the Council on Medical Education of the American Medical association, for the examination and certification of surgeons. Requirements for admission to examination, limited at the start but later more rigorous, involve a minimum of four years' training in accredited hospitals following graduation from a school of medicine, this in turn to be followed by one more year in certain institutions, or two years under suitable preceptorships. The immediate effect was to improve markedly the quality of those entering practice. As a result of these advances surgery is costly; but the financial benefits to society materially exceed the expenditures. The costs of hospitalization and the concomitant professional care are increasingly covered by various forms of insur-(See also Abdomen, Surgery of; Brain. Surgery of the Brasm; DENTISTRY; GYNAECOLOGY; HEART AND LUNG, SUR-GERY OF, ORTHOPAEDIC SURGERY; SPINAL COLUMN. SURGERY OF See also under specific diseases, eg., Bone, DISEASES AND IN-JURIES OF, CANCER; GOITRE; HAEMORRHOIDS, TUBERCULOSIS.)
Surgical Appliances.—The history of surgical instruments begins in the Neolithic or later Stone Age, when ground or polished stone weapons were used for opening the skull. In the early civilizations these were replaced by bronze and then by iron and steel.

Descriptions of surgical instruments by Greek and Roman medical writers were confirmed by the findings of modern atchaeologasts. Later pictorial representations in manuscript, the only written method of communication until the 15th century, were for the most part crude and diagrammatic. By the 16th century, for the purposes of the surgery of the time, the instrumentation was surprisingly good. As the field was subsequently broadened by advances in anatomy, physiology and pathology, new instruments were devised and the standard ones further refined.

The introduction of anaesthesia in the middle of the right century resulted in a remarkable broadening of the scope of surgery. This was followed shortly by an understanding of surgical infections and their prevention,

With the increase in the number and variety of surgical operations it was soon found that the customary instrument chest was inadequate and that the procedures for the prevention of infection in the home or in the open wards of a hospital were very difficult if not impossible. Therefore it became necessary to construct operating rooms in which the walls and floors could be maintained free from infectious agents For the same purpose the furniture within these rooms was made of metal, properly treated to prevent corrosion. Likewase, the surgical instruments were redesigned, eliminating wooden handles and crevices that made it difficult to keep them scrupulously clean.

At first chemical solutions were employed generally to avoid infection, but by 100 these had been abandoned for the most part For purposes of sterility the hands of the operator and his assistants, after thorough cleansing, were encased in rubber gloves. The area of exposure of the skin of the patient necessitated by the operation, after mechanical cleansing and treatment with an antiseptic, solution, was walled off with "drapes." These, as well as the gowns, dressings and instruments, were sterilized by subjection to high temperatures, either by boiling water or by baking in an oven. With the assistance of trained nurses and other personnel it then became possible to carry out operative procedures in all parts of the body with reasonable assurance that they would not be complicated by infection.

Consequently, in the subsequent half century the surgeon was able to keep pace with the advancing knowledge of the medical

sciences, adapting his tools and facilities to the opportunities as and copra they arose The enlargement of the field of surgery led to a high degree of specialization both in diagnosis and operative treatment, with each specialty having its own particular instruments and appliances The catalogue of a surgical supply house is a massive volume carrying many thousands of items The great majority of these are custom-made

Each operating room is in itself compact and not planned as a theatre for students or spectators Convenient dimensions comprise a floor space of 20 by 30 ft. with a ceiling of 10 ft and a capacity of 6,000 cu ft At least an equivalent cubage is required as accessory space for sterilizing equipment, dressing and wash rooms and bed accommodations for the immediate postoperative care of patients

The whole as a suite is air-conditioned at a temperature of 70° to 75° F with a relative humidity between 55 and 60 In order to avoid dust that may carry infection, the air is turned over once every 15 minutes and filtered through suitable screens About four-fifths of this should recirculate while one-fifth is introduced from without These conditions provide the optimum of comfort and safety for the patient

Static sparking of electricity which may be dangerous in the presence of anaesthetic agents is avoided by grounding apparatus and personnel Even the floor should be of a rubberoid material that is conductive of electricity and is likewise grounded. Electric outlets and switches must be gastight, and, together with other leads for air pressure and suction and similar facilities, installed in a wall panel about three feet above the floor.

There is no fixed furniture within the operating room, and apparatus that is necessary in any specific operation is moved in at the time, for the purpose of ease of handling this is mounted upon large swivel casters with ball bearings. Aside from the anaesthesia apparatus, these are for the most part instrument and operating tables The latter are usually designed for multiple nurposes. They may be raised and lowered as well as rotated and tipped as deemed desirable by the operator. Nevertheless, each of the various specialties may require a table that is adapted to its own procedures.

Covers, gowns and hoods as well as surgical gauze are sterilized after being bundled in large autoclaves (pressure cookers) adjacent to the general supply rooms of the hospital, while small sterilizers of this same type, for instruments and solutions to be used in the operating rooms, are installed close at hand. At the tute of the operation these are assembled in an orderly fashion upon ancillary tables convenient to the operation.

The surgical instruments proper are stored in cabinets, preferably in a common room which is under close supervision by the administrative staff. When needed the appropriate set is sterilized and placed on the instrument table in the operating room. The number of these varies with the operation; in a major procedure, such as a radical operation for tumour of the breast or of the brain, a considerable variety and a large number may be required, BIBLIOGRAPHY —E. R. Carling and J. P. Ross (eds.), British Surrical Practice (London, 1947); Allen O. Whipple (ed.), Nelson New Loose Leaf Surgery (1927), Frederick Christopher (ed.), A Textbook of Surgery, 4th ed. (1948).

SURICATE or MEERKAT (Suricata suricata), a small South African mammal of the Viverridae, ranging from Cape province to the Transvaal. The head and body are about 14 in, long and the tail half as much; the fur is long and soft, light grizzled gray in colour and banded with black on the lower part of the back. Meerkats are sociable animals, living in holes in the rocks on the mountains and burrowing in the sandy soil of the plains. They feed chiefly on succulent bulbs, which they scratch up with long curved, black claws on their forefeet. They are often domesticated as pets. (See CARNIVORA.)

SURIGAO, a municipality, capital and port of the province of Surigao, which is located in northeast Mindanao, and adjacent small islands, Philippines, 459 mi, from Manila. Pop. (1948) 46,109 (a gain of 29,877 since 1918). Timber is in the neighbouring forests, and there are gold and iron deposits in the region. The chief agricultural products are abacá (Manila hemp), maize (corn)

(C.S L; X) SURINAM: see GUIANA. Surinam or Dutch Guiana.

SURINAM TOAD (Pipa pipa), an aglossal (tongueless), tailless Amphibian (qv). It inhabits South America east of the Andes and north of the Amazon and 1s thoroughly aquatic. It has an extremely flattened head, the snout and the angles of the jaws bear several lappets, the fingers terminate in a star-shaped appendage and the eyes are minute and without lids

The eggs are carried on the back by the mother, and the skin thickens and grows round the eggs until each is enclosed in a dermal cell, which is finally covered by a horny lid The eggs may number about 100 and measure 5-7 mm in diameter They develop entirely within these pouches, and the young hop out in perfect condition. Pairing takes place in the water, the male clasping the female round the waist During oviposition the cloaca projects from the vent as a bladderlike pouch, which is inverted forward, between the back of the female and the breast of the male, and by this means the eggs are evenly distributed over the hack

See Gadow, Amphibia and Reptiles (1901)

SURMA or BARAK, a river of Assam, India, and East Bengal, Pak It rises in the Barail range to the north of Manipur, its sources being among the southern spurs of Japvo Thence its course is south with a slight westerly bearing, through the Manipur hills. The name "Barak" is given to the upper part of the river, in Manipur and Cachar. A short distance below Badarpur in Cachar it divides into two branches. The northern, which passes Sylhet, is called the Surma. The southern, which is called the Kustara, subdivides into two branches, one called Bibiana or Kalnı, and the other the Barak, both of which rejoin the Surma. At Bhairab Bazar in Mymensingh the Surma unites with the old channel of the Brahmaputra and becomes known as the Meghna until it joins the Ganges between Narayangan; and Chandpur

The river is navigable by steamers as far as Silchar in the rains.

The total length is about 560 mi. SURPLICE (Lat. super, over, and pellicia, furs), a liturgical vestment of the Christian church. It is a tunic of white linen or cotton material, with wide or moderately wide sleeves, reaching, according to the Roman use, barely to the hips, and elsewhere in the churches of the Roman communion to the knee It is usually decorated with lace. The surplice originally reached to the feet, but as early as the 13th century it began to be shortened. In the 15th century it still fell to the middle of the shin, and it was not till the 17th and 18th centuries that it was considerably shortened. It underwent other, more drastic modifications in various places in the course of time, and subsidiary forms were developed alongside the original type. Such were the sleeveless surplice, which was provided at the sides with holes to put the arms through the surplice with slit-up arms or lappels (so-called "wings") instead of sleeves; the surplice of which not only the sleeves but the hody of the garment itself were slit up the sides; and a sort of surplice in the form of a bell-shaped mantle, with a hole for the head, which necessitated the arms being stuck out under the hem. The first two of these forms were developed early, and in spite of their prohibition by a number of synods (eg., that of Liège in 1287) they survived in various places to modern times. The latter two only appeared after the close of the middle ages, the first in south Germany, the second more especially in Venetia, where its use is attested by numerous pactorial records. As a rule, however, these subsidiary forms of surplice were worn mostly by the lower clergy. They were the result partly of the influence of secular fashions but more particularly of considerations of convénience.

The surplice belongs to the vestes sacrae though it requires no benediction. It is proper to all clerics, even to those who have only received the tonsure, the bishop himself vesting with it those who have been newly tonsured by him. Its use in divine service is varied. It is worn in choir at the solemn offices; it is the official sacral dress of the lower clergy in their liturgical functions, it is worn by the priest when administering the sacraments, undertaking benedictions and the like.

The older history of the surplice is obscure. Its name is derived

from the fact that it was formedly put on over the fur garments which used to be worn in chuich as a protection against the cold In all probability the surplice is no more than an expansion of the ordinary liturgical sib, as a result of the necessity for wearing it over thick furs. It is first mentioned in the 17th century, in a canon of the symod of Coyaca in Spain (1050) and in an ordinance of King Edward the Confessor. In Haly it was known at least as early as the 12th century. It probably originated outside Rome and was imported thence into the Roman use.

Originally only a choir vestment and peculiar to lower clergy, it gradually (certainly no later than the 13th century) replaced the alb as the vestment proper to the administering of the sac-

raments and other sacerdotal functions

In the oriental rites there is no surplice nor any analogous vestment. Of the non-Roman Catholic churches in the west the surplice was continued in regular use only in the Lutheran churches of Denmark, Norway and Sweden and in the Church of England

Church of England.-The surplice was prescribed by the second prayer book of Edward VI as, with the tippet or the academical hood, the sole vestment of the ministers of the church academical nood, the sole vestment of the ministers of the church at "all times of their ministration," the rochet being practically regarded as the episcopal surplice. Its use was furnously assailed by the more extreme reformers but, in spite of their efforts, was retained by Elizabeth's Act of Uniformity and enforced by the advertisements and injunctions assued under her authority. which ordered the "massing vestments" (chasubles, albs, stoles and the like) to be destroyed (see VESTMENTS). Its use has never been confined to clerks in holy orders, and it has been worn since the Reformation by all the "ministers" (including vicars-choral and choristers) of cathedral and collegiate churches, as well as by the fellows and scholars of colleges in chapel. The distinctive mark of the clergy has usually been the tippet or scarf, a broad band of black silk worn stolewise but having no liturgical significance The surplice was formerly worn by the clergy only when conducting the service, being exchanged during the sermon for the "black gown," but this custom became almost completely obsolete. The traditional form of the surplice in the Church of England is that which survived from pre-Reformation times; viz., a wide-sleeved, very full, plain, white linen tunic, pleated from the yoke and reaching almost, or quite, to the feet. Toward the end of the 17th century, when large wigs came into fashion, it began for convenience to be constructed gownwise, open down the front and buttoned at the neck, a fashion which partially survives, notably at the universities.

SURPLUS PROPERTY DISPOSAL (U.S.). Surplus properly disposal was first recognized as a special function in 333 when the procurement division of the U.S. treasury department was assigned responsibility for disposing of the surplus property of World War I and even some property dating from previous wars.

World War II increased the importance and, in an enormous degree, the magnitude of the task. At a breath-taking pince war production rushed to meet the demands of modern war. A virtually endless assortment of property of almost very description began to accumulate as surplus as the war developed and war requirements changed. Implements became outmoded almost before they had left the production line; for example, 800 modifications were made in the original specifications of the B-17 bomber each involving thousands of "change orders" and throwing into the surplus hap millions of parts.

At the request of Pres. Franklin D. Roosevelt, Bernard Baruch and John Hancock made a report which, among other things, recommended a central authority. The Surplus War Property administration (S.W.P.A.) was created under an executive order of Feb. 79, 7944, and charged by the president with general supervision and directions of the surplus disposal unorgam.

On Oct, 3, 1044; the Surplus Property act was approved. Its major sins, while conflicting in some respects, were to make maximum uses of surplus property, establish a system of priorities for the disposal todgetuplus and to use existing facilities for additional confliction of the disposal. The act created a three-member hoard to carry out its proxisions;

On Sept 18, 1945, congress amended the act to replace the board by a Surplus Property administration headed by a single surplus property administrator. The centralization of authority in one individual was the only effect of the amendments, the SPA carried on the same functions as the predecessor board The two final redistributions of the functions originally assigned to the Surplus Property board were brought about by an executive order effective Feb 1, 1946. By that time the SPA had largely completed an initial task of policy formation. World War II was over, and surplus was accumulating at an increasing pace. The time for more active disposal had arrived. The executive order accordingly provided for the abolition of S.P.A. and for the transfer of its function to the War Assets corporation. Excluded from the transfer was authority over surplus property abroad, which became the responsibility of the state department. As a result of the same order, the War Assets administration came into being on March 25, 1946, taking over the functions of the W A C.

Previously the various disposal agencies had operated under and as subsidiaries of other and more permanent agencies using the facilities of such agencies for actual disposal operations. The WAA, however, was created as a separate unity. It co-operated with other agencies but functioned primarily on its own, handling the entire disposal program for more than own, of all summits.

Of the \$27,100,000,000 worth of war surplus property declared to the War Assets administration, \$25,500,000,000 had been disposed of by Oct. 1, 1949. In that year the W.A.A. was abolished and its functions were transferred to the General Services administration for the express purpose of lequidation. (H. E. Br.; X)

SURRENDER, m law, a mode of alienation of real estate its defined by Lord Coke to be "the yielding up of an estate for life or years to him that hath an immediate estate in reversion or remander" (Coke upon Littleton, 327 b). It is the conveyance by the reversioner or remainer man to the tenant of the particular estate. A surrender was then usual means of effecting the alienation of copyholds (q.v.). A surrender was required, after the Real Property act, 1845, to be by deed, except in the case of copyholds and of surrender by operation of law. (See REMANDER, REVERSION)

In Scots law surrender of a lease is represented by renunciation. The nearest approach to surrender of a copyhold is resignation in remanentiam (to the overlord) or resignation in fourorm (to a purchaser). These modes of conveyance were practically

superseded by the Conveyancing act, 1874.

In the U.S. surrender divides itself unto express surrender and surrender by operation of law. The former is the surrender known to the early common law; the latter takes place when the tenant and the reversioner have performed acts inconsistent with the continued existence of the two former distinct estates, from which acts the law implies that a surrender has been made. Thus where there is an acceptance by the tenant of a new lease to begin at any time during the ensience of the previous lease, or the relinquishment of possession by the tenant and the resumption of possession by the landlord, a surrender by operation of law is deemed to have taken place.

SURRENTUM: see SORRENTO.

SURREY, EARLDOM OF. This carldom is of uncertain but unquestionably early origin. A Norman count, William de Warenne (c. 1030-88), is generally regarded as its first holder and is thought to have been made an early by William II about 1088. William and his successors were styled earls of Surrey or Earls Warenne indifferently, and the family became extreme the william, the grd earl, filed in 1148. The second family to hold the earldom of Surrey was descended from Isabel de Warenne (d. 1799), daughter and heiress of Earl William, and her second husband, Hannelm Plantagenet (d. 1202), an illegitimate half-brother, of King Henry II. Their descendants held the earldom until Earl John died without legitimate issue in 1347.

The earldom and estates of the Warennes now passed to John's nephew, Richard Fitzalan, earl of Arundel (c. 1307-76), being forfeited when Richard's son, Richard, was beheaded for treason in 1337. Then for about two years there was a duke of Surrey, the title beans borne by Thomas Holand, earl of Kent (1374-

SURREY 607

1400), from 1397 until his degradation in 1309. In 1400 Ruchard fritalan's son, Sr. Thomas Fitzalan' (3361-1425), was rectoached in his father's honours and became earl of Arundel and earl of Surrey, but the latter earlboarn reverted to the Crown when he died. In 1451 John Mowbray (1444-1476), afterwards duke of Norfolk, was created earl of Surrey but the title died with, him.

Norfolk, was created earl of Surrey, but the tule died with him.

The long connection of the Howards with the earldom of Surrey began in 1483 when Thomas Howard, afterwards duke of Norfolk, was created earl of Surrey Since then, with brief exceptions, the title has been borne by the duke of Norfolk.

See the articles NORFOLK, EARLS AND DUKES OF, and ARUNDEL, EARLS OF, also G E. C. (ockayne), Complete Perage, vol vii (1806).

SURREY, HENRY HOWARD, EARL OF (15187-1547), English poet, son of Lord Thomas Howard, afterwards 3rd duke of Norfolk, and his wife Elizabeth Stafford, daughter of the duke of Buckingham, was born probably in 1518 He succeeded to the courtesy title of earl of Surrey in 1524, when his father became duke of Norfolk His early years were spent in the various houses of the Howards, chiefly at Kenninghall, Norfolk; he used also to stay at Windsor with young Henry Fitzroy, duke of Richmond, of whom his father was guardian. Anne Boleyn tried to arrange a marriage between the princess Mary and her kinsman, Surrey The Spanish ambassador, in the hope of detaching the duke of Norfolk's interest from Anne Boleyn in favour of Catherine of Aragon, seems to have been inclined to favour the project, but Anne changed her mind, and as early as October 1530 arranged a marriage for Surrey with Lady Frances de Vere, daughter of the 15th earl of Oxford This was concluded at the earliest possible date, in February 1532, but in consequence of the extreme youth of the contracting parties, Frances did not join her husband until 1535. In October Surrey accompanied Henry VIII to Boulogne to meet Francis I., and, rejoining the duke of Richmond at Calais, he proceeded with him to the French court, where the two Englishmen were lodged with the French royal princes Surrey created for himself a reputation for wisdom, soberness and good learning Meanwhile in spite of his marriage with Frances de Vere, the project of a contract between him and the princess Mary was revived in a correspondence between the pope and the emperor, but rejected by the latter Surrey returned to England in the autumn of 1533, when the duke of Richmond was recalled to marry his friend's sister. Mary Howard Surrey made his home at his father's house of Kenninghall, and took his father's side in a dispute which led to a separation between the duke and duchess.

In May 1536 he filled his father's functions of earl marshal at the trial of his cousins Anne Boleyn and Lord Rochford'. In the autumn of that year he look part with his father in the bloodless campaign against the rebels in Vorshave and Linconshire, in the "Pilgrimage of Grace" Hasty in temper, and by no means friendly to the Seymour faction at court, Surrey struck a man who insanuated that he had secretly favoured the insurgents. For breaking the peace in the king's domain he was arrested (1757), but thanks to Cromwell, he was merely sent to reside for a time at Windsor. During this retirement he had lesure to devote himself to poetry In 1539 he was again received into favour In May 1540 he was one of the champions in the iosust celebrated at court.

The fall of Thomas Cronwell a month later increased the power of the Howards, and in August Henry VIII. married Sur-rey's cousin, Catherine Howard. Surrey was knighted early in 344, and soon after he received the Gaster and was made chancellor of the duchy of Lancaster. In 1542 he was imprisoned again for quarrelling, but was soon liberated. Shortly after his re-lease he joined his father on the Scottish expedition They laid waste the country, but retreated before the earl of Huntly, taking no part in the victorious operations that led up to Solway Moss.

Surrey's ties with Wyst, who was fifteen years his closer and of opposite politics, seem to have been rather literary than personal. He appears to have entered into closer relations with the younger Wyst, with whom he got into trouble for breaking the windows of the citizens of London on Feb. 2, 7543. In prison for this offence he probably wrote the satire on the city of London, in which he explains his escapade by a desire to rouse Londoners to a sense of their wickcheness. In October he joined the English army

co-operating with the imperial forces in Flanders, and in the campaign of the next year he served as field marshal under his father, and took part in the unsuccessful siege of Montreuil. In August 1565 he was again serving in France

Surrey had always been an enemy to the Seymours, whom he regarded as upstarts, and he thwarted the proposed marriage of his sister, the duchess of Richmond, with Sir Thomas Seymour, He thus increased the enmity of the Seymours and added his sister to the already long list of the enemies which he had made by his haughty manner and brutal frankness. He was now accused of quartering with his own the arms of Edward the Confessor The charge was a pretext covering graver suspicions Surrey had declared that his father, the duke of Norfolk, as the premier duke in England, had the obvious right of acting as regent to Prince Edward He also boasted of what he would do when his father had attained that position. This boast was magnified into a plot on the part of his father and himself to murder the king and the prince. The duke of Norfolk and his son were sent to the Tower on Dec. 12, 1546 The duchess of Richmond was one of the witnesses (see her depositions in Herbert of Cherbury, Life and Reign of Henry VIII., 1640) against her brother, but her statements added nothing to the formal indictment. On Jan. 13. 1547 Surrey defended himself at the Guildhall on the charge of high treason for having illegally made use of the arms of Edward the Confessor, before hostile judges. He was condemned by a jury, packed for the occasion, to be hanged, drawn and quartered at Tyburn This sentence was commuted to beheading Surrey was executed on Tower Hill on the 10th of the month

Surrey's name has been long connected with the "Fair Geraldine," to whom his love poems were supposed to be addressed. The story is founded on the romantic fiction of Thomas Nashe. The Unfortunate Traveller, or Life of Jack Wilton (1594), according to which Surrey saw in a magic glass in the Netherlands the face of Geraldine, and then travelled throughout Europe challenging all comers to deny in full field the charms of the lady At Florence he held a tournament in her honour, and was to do the same in other Italian cities when he was recalled by order of Henry VIII. The legend, deprived of its more glaring discrepancies with Surrey's life, was revived in Michael Drayton's England's Heroicall Epistles (1598) Geraldine was the daughter of the earl of Kildare. Lady Elizabeth Fitzgerald, who was brought up at the English court in company with the princess Elizabeth (See James Graves, a Brief Memoir of Lady Elizabeth Pitzgerald, 1874) She was ten years old when in 1537 Surrey addressed to her the sonnet "From Tuskane came my ladies worthy race," and nothing more than a passing admiration of the child and an imaginative anticipation of her beauty can be attributed to Surrey

His poems, which were the occupation of the leisure moments of his short and crowded life, were first printed in Songs and Sonsteins written by the rygit homomable Lorde Henry Howard late Earls of Surrey, and other (apud Richardum Tothet, 1557). A second edition followed in july 1557, and others in 1599, 1565, 1567, 1574, 1585 and 1587 Although Surrey's name, probably because of his rank, stands first on the title-page, Wyat wag the earlier in point of time of Henry's "courtly makers." Surrey, indeed, expressly acknowledges Wyat as his master in poetry. His sonnets, his elegy on Wyat and his lyrics served as models to renerations of court books.

As their poems appeared in one volume, long after the death of both, their names will always be closely associated. Surrey's contributions are distinguished by their impetuous cloquence and sweetness, and he introduced new smoothness and fluency into side the Miscellary His translation of the second and fourth books of the Aensel into blank verse—the first attempt at blank verse the English—was published separately by Tottel in the same year Certain Books of Virgiles Aensis turned into English meter.

See Professor. E. Arber's regions on write the surgain reservafine the professor of the seed of the seed of the seed of the depths, 1800); the Southernic Chin reprint of Certain Boke of Vinland of Survey (1815); and The Podical Works of Heavy Howard, Earl of Survey (Aldine edition, 1866). The best account of Survey's life is in Edmond Bayest Deux Genilhommer-point de la cour de Heavy 608 SURREY

VIII (1891), which rectifies Dr. Nott's memoir in many points. See also Brewer and Gairdner, Letters and State Papers of Henry VIII, Lord Herbert of Cherbury, Life and Raigne of Kinge Henry the Eighth (1649), J. A Froude, History of England (chs. xxi and xxll), W. J. Courthope, History of England (chs. xxi and xxll), where the extent and value of Surrey's mnovations in English poetry (are estimated; F. M. Paddiord, The M.S. Poems of Henry Howard, Earl of Surrey (1906), O Fest, "Ober Surreys Virgiludersectumg," in Paddiors, vol. xxiv (Berlin, 1930).

SURREY, a southeastern county of England, bounded north by the Thames, separating it from Buckinghamshire and Middlesex, east by Kent, south by Sussex, and west by Hampshire and Berkshire. The administrative county of London bounds that of Surrey (south of the Thames) on the northeast. The area is 721 6 sq.mi. The north of the county is low lying, the eastern part consisting of the London clay, the western of the Bagshot beds Near the western boundary the land rises into the low Chobham ridges. Across the middle of the county, from east to west, run the North downs, composed of chalk. In the east they form a wide band with an extreme height of 852 ft., but westward they narrow into the Hog's Back The line of the Downs is broken at two points; by the river Mole between Dorking and Leatherhead, and by the Wey near Guildford. These are the two chief rivers in the county, and they join the Thames at Molesey and Weybridge respectively. The northern slopes of the Downs are flanked by a narrow strip of Lower London Tertiary beds, the southern by narrow bands of Upper Greensand and Gault. These beds, like the chalk, have a wider extent in the east than in the west. To the south of the Gault is a wide band of Lower Greensand, which narrows eastward. On this greensand is found the highest land in the county, Leith Hill (965 ft.) near the centre, and Devil's Punch Bowl (895 ft ) in the west. The rest of the county, except for a small triangle of Hastings beds in the extreme southeast, is composed of Weald clay.

The chief evidence of the presence of Palaeolithic man in Surrey comes from various gravels near Limpsfield (in the east of the county), near Guildford and Godalming, and near Farnham. The Weald region in early times was very thickly forested, and traces of Neolithic man, indicated by finds of implements, are therefore most numerous on the chalk and greensand, especially in the west, but finds of this age are not rare on the lower lands in the northeast of the county. Bronze weapons have not been found in such great numbers as those of stone, but their distributions are, roughly, coincident except that the metal weapons have been found at several places along the Thames Near the chalk ridge of the North downs runs the ancient track of the Pilgrims' way A track here was used in very early times to connect the cultural centre of Kent with Hants and Wiltshire; in the middle ages the route regained importance as the path of pilgrims from the west to the shrine of St. Thomas at Canterbury. The Romans did not occupy Surrey very closely, but there are traces of their influences in the remains of one or two small settlements and a few villas.

The county was penetrated by the English invaders at a fairly early date, and its position between the Thames and the Weald decided its northern and southern borders. The Kentish boundary probably dates from the battle of Wibbandune, between Ethelbert of Kent and Ceawlin of Wessex, while the western limit in a wild, uncultivated district was not then strictly defined. In the 7th century Surrey was under the overlordship of Wulfarer, king of Mercia, who founded Chertsey abbey, but in \$32, when the Mercians were defeated by Eghert of Wessex, it was included in the kingdoin of Wessex, as the Audio-Saxon Chronicle relates.

Surrey was constantly overrun by Danish hordes in the oth century and until pose was established by the accession of Conute. In 857 a great pational victory over the Danes took place at Octley, near Leith. Hill. The Norman army traversed and ravaged the county, in their march on London. A large portion of the county having been in the hand; of Edward and Harold, fell to the share of William, threshif is the noist inportant tenants in chief being Odo of Bayoux. and Alichard. de Tonbridge, son of Count Gilbert, attenwades "de-Glare." The church also had large possessions in the county of the county

dreds was 14 as now, but the hundred of Farnham was not so called, the lands of the bishop of Winchester being placed in no hundred, but coinciding with the present hundred of that name. The western boundary of the county was probably definitely fixed about this time Until quite recently Surrey had never been in any diocese but Winchester, of which it was an archdeacoury in the 12th century. Croydon was a peculiar of Canterbury, in which diocese it was included in 1201. The shire court was almost certainly held at Guildford, the seat of the royal court at times during the reigns of John and Henry III. From 1290 to 1832 the share returned two knubits to parlament.

Architecture.-The only ecclesiastical ruins worthy of special mention are the walls of Newark priory, near Woking, founded for Augustinians in the time of Richard Coeur de Lion: and the Early English crypt and part of the refectory of Waverley abbey (1128), the earliest house of the Cistercians in England Among the more interesting churches are Albury (the old church), near Guildford (Saxon or very early Norman tower), Chaldon, remarkable for its 12th-century frescoes; Compton, worthy of notice for its two-storied chancel and its carved wooden balustrade surmounting the pointed transitional Norman arch separating the nave from the chancel; Leigh, Perpendicular, possessing some very fine 15th-century brasses; Lingfield, Perpendicular, containing some fine stalls (the church was formerly collegiate); Stoke d'Abernon, Early English, with the earliest extant English brass (1277). Of ancient domestic architecture, examples include Beddington Hall, retaining the Elizabethan hall, Crowhurst Place, built in the time of Henry VII, portions of Croydon palace, an ancient seat of the archbishops of Canterbury; Archbishop Abbot's hospital, Guildford, in the Tudor style; the Elizabethan house of Loseley, near Guildford; Sutton Place near Woking, dating from the time of Henry VIII, possessing curious mouldings and ornaments in terra cotta; and Ham House, of red brick, dating from 1610.

Industries.—Surrey was at first agricultural. The stone quarties of Limpsfeld and the chalk of the Downs were captured, the latter chiefly for Immemaking Fuller's carth is obtained from Reigate and Nutfled; and the facilities afforded by many small streams, and the excellent sheep pasture, made it of importance in the manufacture of cloth, of which Guilder's was a centre. Glass, at Chiddingfold as early as 1266, and iron were made in the Weald district, whose forests produced men because and the macessary charcoal for smelting. Chilworth was famous for its prower mills in the 46th century. The carliest Delft ware munifactory in England was at Lambeth, which remains a centre of eartherware manufacture.

The total acreage under crops and grass in 1939 was 171,652, of which 44,199 ac. were arable land. This represents 9,6% of the total area (excluding water) of the county. Wheat and oats were the chief grain crops, with 7,632 ac. and 6,910 ac respectively; mangolds and turnips and swedes occupied 3,373 ac., while the area under potatoes was 2,469 ac. Clover and rotation grasses for hay took up 5,728 ac. and orchards 1,410 ac Signif best made a start with 20 ac During the first two seasons Signif best made a start with 20 ac During the first two seasons with the control of the dairy type, the milk being sain to London, while sheep are reared on the chilk downs. A large area is occupied by market gardens on the alluvial soil along the banks of the Thames, The National Trust owned 4,873 ac in Surrey in 1942.

The county is chiefly residential, for those people who have business interests in London. Manufactures are chiefly confined to London and its immediate nelighbourhood, though gloves and hosiery are made at Godalming, and oil-paper, sunif and sheet ron, for which there are numerous mills, on the Mole and Wandle. There are also paper mills, and brush and broom making is a considerable business. Communications include the navigation of the Thames and Wey, and the Basingstoke canal, communicating with the Wey from Frindley and Woking The county is served by the Southern railway, whose lines intersect the county from north to south and from east to west. There were 685 mi of roads, in 1942. Near Croydon is the London terminal aero-drome.

istrative county is 701 8 sq mi., with population (1951) of 1,351,-963. Population movements as a result of World War II had caused no change in the Surrey population up to Feb 1941. It was the only English county unaffected The county contains 14 hundreds Croydon is a county borough, and the 13 municipal boroughs are Barnes, Beddington and Wallington, Epsom and Ewell, Godalming, Guildford, Kingston-upon-Thames, Malden and Coombe, Mitcham, Reigate, Richmond, Surbiton, Sutton and Cheam, and Wimbledon There are seven parliamentary divisions -Chertsey, Fainham, Mitcham, Epsom, Eastern, Reigate, Guildford-each returning one member. Croydon returns two members. and Richmond, Kingston and Wimbledon one member each The assizes and county quarter sessions are held at Kingston, where, also, the county council sits. Croydon and Guildford have separate courts of quarter sessions. There are 12 petty sessional divisions After 1876 Surrey, with the exception of 10 parishes, was not included in any circuit, though commissions are issued not less than twice a year for the discharge of civil and criminal business. The central criminal court has jurisdiction over the ten parishes, which are adjacent to London. All those civil parishes within the county of Surrey, of which any part is within 12 mi of, or of which no part is more than 15 mi. from, Charing Cross, are in the metropolitan police district. The county is mainly in the dioceses of Southwark (1905) and Guildford, the latter having been created in 1927 from Winchester. Of the two archdeaconries, Dorking was created in 1928 A small portion in Canterbury diocese includes the archdeaconry of Croydon.

See Topley's Geology of the Weald and Whitaker's Geology of Set Topicy's Geology of the Weald and Whitaker's Geology of Candon Samp, formung have of the Remain of Geological Surveyor Candon Samp, formung have of the Remain of Geological Surveyor of Survey, § vol. (1978-10); D. Lysons, Baurons of London, § vol. (1980-11); Buxte, Domenday Book of Survey (1879). O Manning and W Bray, Instancy and Astingsities of Survey, § vol. (180-14); B. W. et al. (1981). Archaeological Colcius (1981). Archaeological Colcius (1981). Archaeological Colcius; Gurray Archaeological Society from 18:88); Pictoria County History Survey, a vol.; The Land of Brains (Report of Land Utshans Survey); Pts. (1991).

SURROGATE, a deputy of a bishop or an ecclesiastical judge, acting in the absence of his principal and strictly bound by the authority of the latter (Lat. surrogare, to substitute for) Canon 128 of the canons of 1603 lays down the qualifications necessary for the office of surrogate, and canon 123 the regulations for the appointment to the office. The office is of some importance in the United States as denoting the judge to whom the jurisdiction of the probate of wills, the grant of administration and of guardianship is confided

SURTAX. A surtax is any levy designated as such by the taxing authority, usually imposed as a supplement to a normal tax, standard rate or other existing tax. In America and the British Commonwealth, surtax is commonly associated with progressive income taxation. One of the most famous is Britain's surtax on personal income over £5,000, dating back to its 1909 super-tax; 1954 surtax rates, for example, ranged from 5% to 50% (atop the 45% standard rate). Except for a vestigual 3% normal tax, the entire U S. personal income tax was labelled "surtax" beginning in 1944 Canada's income tax includes a low-rate surtax on investment income. (See Income Tax: in Practice.) (W. W. Hr.)

SURTEES, ROBERT SMITH (1803-1864), English novel-ist and sporting writer, was the second son of Anthony Surtees of Hamsterley Hall, Durham. Educated to be a solicitor, Surtees soon began to contribute to the Sporting Magazine, and in 1831 he published a treatise on the law relating to horses and particularly the law of warranty, entitled The Horseman's Manual In the following year he helped to found the New Sporting Magazine, of which he was the editor for the next five years. To this periodical he contributed between 1832 and 1834 the papers which were afterwards collected and published in 1838 as Jorrocks's Jaunts and Jollities. This humorous narrative of the sporting experiences of a cockney grocer, which suggested the more famous Pickwick Papers of Charles Dickens, is the work by which Surtees is chiefly remembered, though his novel Handley Cross, published in 1843, in which the character of "Jorrocks" is reintroduced as a master of fox-hounds, also enjoyed a wide popularity.

Population and Administration .- The area of the admin- The former of these two books was illustrated by "Phiz" (H. K. Browne), and the latter, as well as most of Surtees's subsequent novels, by John Leech, whose pictures of "Jorrocks" are everywhere familiar and were the chief means of ensuring the lasting popularity of that humorous creation. Surfees wrote other novels, the last of which, Mr Facey Romford's Hounds (1865), appeared after the author's death (March 16, 1864).

See R. S. Suttees, Jorocki's Janus and Jollities (London, 1869), containing a hographical memoir of the author; W. P. Frith, John Leech, Hu Life and Work (2 vols, London, 1851), Samuel Halkett and J. Lang, Dictionary of Anonymous and Pseudonymous Literature of Great Brain (4 vols, Edmburgh, 1852–1864).

SURVEYING, the technical term for the art of determining the position of objects on the surface of the ground, for the purpose of making therefrom a graphic representation of the area surveyed. The general principles on which surveys are conducted and maps constructed from such data are in all instances the same, certain measures are made on the ground, and corresponding measures are protracted on paper on whatever scale may be a convenient fraction of the natural scale. The method of surveying varies with the magnitude of the survey, which may embrace an empire or represent a small plot of land All surveys rest primarily on linear measurements for the direct determination of distances; but linear measurement is often supplemented by angular measurement which enables distances to be determined by principles of geometry over areas which cannot be conveniently measured directly.

History.-It is very probable that surveying had its origin in ancient Egypt. But long before the dynastic period in Egypt, we may imagine that neolithic man was able, like the savages of to-day, to make a rough kind of map based on his journeys, or a primitive plan to show tribal or property boundaries. Apart from such speculations, however, we find, in a Theban tomb of the XVIII. dynasty, a plan of the villa of a great Egyptian noble: in the tomb of one Menna at Thebes, there is a representation on the walls of two chainmen surveying a field of corn: and in Ptolemaic and Roman papyri in the same country, measurements of plots of land are described. That the early Egyptians could carry out measurements with a considerable degree of accuracy,

is certain from a study of the dimensions of the Great Pyramid. In Roman times we meet with the groma, which consists of two pairs of plumb-lines suspended from the ends of two horizontal rods, at right angles to each other: the use of the instru-



THE U.S. BUREAU A PLAN MADE BY GEORGE WASH. their slow voyage from the Indus INGTON IN 1746, INSCRIBED IN HIS to the Persian gulf three cen-OWN HANDWRITING

ment being to lay out lines at right-angles. The metal parts of one of these gromas was found in 1912, in Pompeii. An early grorna of the same type, but rougher construction has been found in Egypt. The Romans also used to foot rods, and bronze terminal pieces of such rods have been found at Enns in Austria, the foot in this case being 13.2 inches. The Romans certainly made use of an instrument not unlike the plane-table for determining the alignment of their roads. The Greeks used a form of log line for recording the distances run from point to point along the coast whilst making

turies B.C. Still earlier (as early as 1600 B.C.) it is said that the Chinese knew the value of the loadstone and possessed some form of magnetic compass. The earliest maps of which we have any record were based on inaccurate astronomical determinations; not till mediaeval times, when the Arabs made use of the astrolabe (q.v), could nautical surveying really be said to begin. In 1450 the Arabs were acquainted with the use of the compass, and could make charts of the coast-line of those countries which they visited. In 1498 Vasco da Gama saw Guiarati. Plane-tables were in use in Europe in the 16th century and the principle of graphic triangulation and intersection was practised by surveyors in England and elsewhere. In 1615, Willebrord Snell, the Dutch mathematician, measured an arc of meridian, by instrumental triangulation.

The Different Kinds of Surveys .- Surveys may be classed in a variety of different ways. We may describe them by their scales, as large-scale or small-scale; the large-scale surveys would be those on a scale larger than, let us say, 1.25,000 On the other hand small-scale surveys would be those on scales of 1'25,000. and smaller. Or we may describe surveys by the technical method employed Thus we sometimes find the expressions, trigonometrical survey, compass survey, chain survey. Or surveys may be described by the purpose for which they are carned out. There are for instance, geodetic surveys, of which one of the chief objects will be the furtherance of the study of the figure of the earth and allied matters; cadastral surveys, whose purpose is to facilitate the collection of land revenue, hydrographic surveys, the purpose of which is the production of charts of the sea, for use in navigation, railway surveys, which are carried out to enable a line of railway to be economically located; and so on. Or we may describe a survey by the character of the resulting map. A topographical survey is intended to determine and depict the relative positions of the surface features of the earth, such features being either natural or artificial. A topographical map differs from a cadastral man in that the latter does not show any natural surface features which do not affect property boundaries.

Methods of Survey.-The simplest and most ancient method of making a plan or map is by means of direct measurement on the ground, with a rope, a chain, or a tape, of known length, suitably divided. As a simple illustration let us take the case of a level field of which a plan is wanted.

Suppose the field is as represented in fig. 1, the boundaries of Suppose the near is as represented in ig. 1, the boundaries on the field being the irregular lines ABCD. Then, to survey this field with a chain or tape, put pickets at the points ABCD, somewhere near the corners of the field, these four points being intervisible and the lines between them being free from obstruction. vising and the lines between them being free from bost duction. Then measure, with the chain or tape, the direct straight-line distances, AB, BC, CA, AD, DC, BD. This will provide the necessary frame-work. It will be seen that for the plotting of the frame-work, only one diagonal, that is, either AC, or BD, is required. The measurement of both gives a check on the work and shows the surveyor how much reliance he can place on his measurements: it also enables gross errors to be detected. This principle of providing checks, and of never depending upon one measurement, is of great importance. To survey the irregular boundaries, all that is necessary is to measure "offsets" from the main chain lines, at known distances along the lines, and to note these in the field book. The offsets are measured with an offset rod or a tape at right-angles to the chain line. With all this information in the field book there is no difficulty in plotting the

plan on paper to any scale that may be required. It is usual to lay down some limit for the offcate

An elaboration of this simple method is the scheme which was adopted by the Ordnance Survey of Great Britain and Ireland. when large-scale surveys were first commenced officially in 1825. The country was covered with a triangulation, of which the sides



FIG. 1

averaged, for the original six-inch map, some 5 miles. Each of the sides of these triangles was chained, and notes were made in the field book of points where the chain lines crossed detail, such as edges of roads, banks of streams, hedges, walls, and so on. The great triangles were broken up by other chain lines into smaller triangles, and lines tying on to these at their extremities were run along the detail to be surveyed, offsets being measured as usually.

Modern Methods.-We may now consider the system which

a chart of the coast-line of India, which was shown him by a would be adopted in a perfectly up-to-date, modern state. In such a case, there would be a geodetic survey covering the whole country with a system of triangulation of the first order; that is to say, the country would be reconnoitred beforehand, and mutually intervisible stations would be selected, some ten to thirty or forty miles apart, covering the country with a net-work, or series of chains, of triangles At the apices of these triangles horizontal and vertical angles would be observed with a theodolite, one of the triangles would be connected with a measured side, called the base or base-line From the known length of this side the lengths of all the other sides would be calculated. The latitude and longitude of one point in the triangulation would be determined by astronomical means, and also the true bearing of one line is obtained. it is then clearly possible to determine the latitude and longitude of every other point. The meaning of the term "first order." used above, is that the average triangular error of the net-work, or system of chains, of triangles, that is, the error of the sum of the 3 angles of a triangle, should not exceed one second

Now we have to hang all other surveys upon this frame-work A frame-work of the kind described has the fixed points too widely separated to be of much use for the detail survey, so the first thing to be done is to provide a closer frame-work; and this would usually be done by executing another triangulation, of less accuracy than the first, but depending upon it. There would be more points in this secondary triangulation, and the points would be distant from each other some 5 to ro miles. The triangular error would not exceed 5 seconds. If now it were required to make a map on a scale of, say, 1:100,000 the frame-work would be sufficiently close, and the detail could, in suitable country, be carried out by plane-tabling which would be based upon the points so provided

But, if it were required to construct a map on a large, cadastral scale, more fixed points still would be needed, and a tertiary tri-angulation would be carried out, depending upon the secondary work. This tertiary triangulation would have its points only a mile or two apart, and its triangular error would not exceed 15 seconds. It is now customary to classify a triangulation according to its accuracy, thus, a triangulation of the 1st order has a triangular error not exceeding a second; a triangulation of the 2nd order has a triangular error not exceeding 5 seconds; a triangulation of the third order has a triangular error not exceeding 15 seconds; and one of the 4th order has a triangular error greater than 15 seconds

But it will easily be imagined that certain areas do not readily lend themselves to triangulating, and in such areas, occasionally, traversing is resorted to for the frame-work. This will be described later. Also, in the rapid exploration of a new country it may be necessary that the frame-work be astronomical. But this is an inaccurate make-shift, and should always be avoided whenever possible.

It should be emphasized that whatever may be the extent of the area to be surveyed, whether it be a backyard or a continent, the area should be dealt with as a whole, and the frame-work should be designed to stiffen the whole area. Anyone who is charged with the execution of a survey should, therefore, carefully consider how he can best design the control or frame-work.

Bases.—The length of every side in a triangulation depends upon the length of the measured side, called the base, or base-line. Bases for geodetic work are measured with very great refinement, and the probable error of such a base would be of the order of one in one-million Such bases in times past have been measured with glass rods, wooden rods, steel bars, and compound bars of brass and steel. But now almost every accurate base, whether for geodetic purposes, or for secondary work, or for very good topographical work, would be measured with metallic (usually invar) wires or tapes supported in catenary, i.e., allowed to hang free in a natural curve, being slung over trestles. Invar is an alloy of steel and nickel, containing 36% of the latter, and this alloy is used because it has the smallest known expansion of any metal or alloy. Invar wires and tapes require, however, careful handling, and testing, and on this account are not freely used for rapid topographical bases. It is possible to get quite good along the surface of the ground.

Let us then, take the case of the measurement of a topographical base with steel tapes laid along the ground. The first thing to do is to select the site and the positions of the terminal points These must be so chosen that well-conditioned triangles can be built up on the base, connecting it with the main points of the triangulation. (See fig 2)

Then the site must be cleared of obstructions, and small undulations levelled Then the base terminals must be marked, and a

theodolite set up over one of them and directed to a pole put up over the other. Intermediate marks, in the form of pickets driven in flush with the ground, should be fixed The actual measurement is made with a steel tape, kept at a fixed tension with a spring balance, and marks are made on the tops of the pickets,



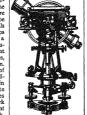
which are at tape-lengths from centre to centre; the tops of the pickets may be conveniently covered with strips of zinc, on these strips the positions of the ends of the tape are marked when measuring A convenient length of tape is 300 ft., with a width of \$ inch. A convenient tension is 20 pounds A base so measured requires corrections for standard, temperature, slope if any, and height above sea The chief difficulty in this sort of measurement

is to ascertain the temperature of the tape

A base of this kind might be some two or three miles long: but it should be remembered that it is more important to be able to extend the base by well-conditioned triangles than to measure a long base The base having been measured, it is now necessary to proceed with the execution of the triangulation Fig. 2 shows the base extension, and in the case shown, the longest side reached is more than 8 times the length of the base. so that if the base were 2 miles long, the side of the main triangulation would be more than 16 m. long

The process of triangulating consists of observing the angles at the apices of the triangles and at the two ends of the base The apices and the ends of the base must be marked The permanence of the marks will depend upon the character of the triangulation Thus, in first-order work, a mark-stone would be

buried deep in the soil, and isolated from the platform surrounding it. Vertically over the mark, when the observations were finished, a stone pıllar would be built In such work the signals would be luminous, either lamps or heliographs. But in work of a lower order the marks would usually be opaque; various different patterns have been used, poles, baskets, quadripods and so on In very rapid work the tops of spires, pagodas, temples, or solitary trees are observed too; in some cases it has been found to be useful to clear a hill of all trees but one. In very rough work sometimes the tops of prominent hills are used, without any mark



TY COURTER OF MEASUR, COOKE, TROUGHTON

The angles at these trigonometrical points of whatever order, Fig. 3 -- FIVE-INCH MICROMETER are invariably observed with a THEODOLIYE theodolite, and as this is without doubt the most important of all

surveying instruments, it is desirable to give a description of it. The Theodolite.-The theodolite is a surveying instrument consisting of two graduated circles placed at right angles to each other, for the measurement of horizontal and vertical angles. a

results from the use of ordinary steel (not invar) tapes laid or micrometer microscopes. The whole is supported by a pedestal resting on footscrews, which are also employed to level the instrument The size has varied from a minimum with circles 2 1 in in diameter to a maximum with a 36-in horizontal and an 18-in vertical circle, but these very large circles are now obsolete owing to improvements in dividing machines. The largest now in use is 12 m. in diameter.

As an example of a modern theodolite suitable for use in topographical or exploratory surveying, we may take a 5-inch transit theodolite, fitted with micrometer microscopes The accompanying fig. (3) shows such an instrument by Messrs Cooke, Troughton and Simms The instrument rests on a tripod stand, which is not shown in the figure. The levelling base has three screws. The horizontal and vertical reading circles are 5 in in diameter, and are each read, by two microscopes, by estimation to single seconds The telescope, which can be completely rotated in its horizontal bearings, has a magnification of 25 The instrument packs up in two boxes for transport. Excellent work has been done with such a theodolite all over the world. It does not appear desirable to give a more elaborate description, for the use of such an instrument can only be acquired by practice

Triangulation.-This may be carried out either in the form of cham or of a net-work (fig. 4). In a small country even the first-order triangulation might cover the land with a net-work, with sides about 30 miles long; and this was done in the case of the British Isles But in large countries such as India or the United States a very considerable saving of time and money is effected by running chains of triangles, generally north and south, or east and west Second order work may also be either in the form of chains or of a net-work; it would be dependent on the first order work, if that existed. Third order work, which is re-

quired by the detail surveyors, would usually cover the ground completely.



At each station of the triangulation the theodolite is centred over the station mark and one of the distant stations is taken as the Referring Object and the other stations are also observed in turn The first station should read about oo, the base plate being so set, and then the other stations would be observed in

order and the round of angles would close again on the first station If this round were taken with the telescope to the right, the next round would be taken with the telescope to the left. The number of rounds taken will depend on the order of the work, the zero being shifted at each round, or at each alternate round. For rapid work a good system would be First zero, o'o', telescope right; Second zero 225° 1' left Telescope right is sometimes called "Face Right," and telescope left, "Face Left."

The angles having been all booked, the means are taken, and if each angle of a triangle has been observed, it is clear that the sum of the three angles should add up to x80°, plus the spherical excess an excess which is due to the fact that the earth's surface is not plane, but is curved. Spherical excess varies directly as the area of the triangle, and may be taken to amount to 1-32 seconds for every hundred square miles, and other areas in proportion. It is generally neglected in rough work, and the excess or defect of the sum of the three angles of a triangle is, in such work, distributed equally amongst the three angles. Thus, if the sum of the three observed angles amounted to 180° 1′ 30″, each observed angle would be diminished by 30" for use in the computations.

Computations.-Over large areas, and m work which is likely to be extended to great distances, or in which, for some special reason, the geographical positions are required, it is necessary to calculate for each trigonometrical station its latitude and longitude, starting from some station for which these elements are known. But, in the case of small or isolated surveys, such elabo telescope, which turns on axes mounted centrically to the circles, ration is unnecessary, and we can proceed as follows:-Take any and an alidade for each circle, which carnes two or more verniers one station as the origin, and the meridian through that station bearing, at the origin, we shall know the azimuth of each line which radiates from the origin Then if I1 is the length of one of these lines, and if a is the angle which it makes with the initial meridian, then  $l_1 \cos \alpha$  is the north-south co-ordinate, and  $l_1 \sin \alpha$ is the east-west co-ordinate of the end of that line For lines radiating from the end of the line in question, if  $\beta$  be the angle that one of them makes with a line parallel to the initial meridian, then if le be the length of this second line, the co-ordinates of the end of it with reference to the beginning will be l2 cosβ and  $l_2 \sin \beta$ , so that the co-ordinates of any point in the triangulation, with reference to the origin, will be  $l_1 \cos \alpha + l_2 \cos \beta + l_3 \cos \gamma$ Each point in the  $+ \dots$ , and  $l_1 \sin \alpha + l_2 \sin \beta + l_3 \sin \gamma +$ triangulation can now be plotted with reference to the origin and the initial meridian, due regard being paid to the signs of the trigonometrical functions. With these co-ordinates available it is, of course, easy to compute the distance of any one point in the triangulation from any other point.

In using this sample method, we have assumed that the earth's surface is plane; actually it is a spheroidal surface. The errors involved are chiefly in a north-south direction. At sixty miles' distance from the origin the error amounts to  $\frac{1}{1000}$ , and the error increases as the square of the distance, so that at nor milles the error is  $\frac{1}{100}$ , and if we were content with this error as a maximum, we could survey a come less on this system.

Heights.-Points fixed as above described, and plotted on paper at intervals of, say, four or five inches, give a sufficient control for the horizontal work of the detail surveyor, but he will also require a frame-work of heights if he is to contour, or approximately contour, the terrain Heights may be determined in a variety of ways and with several degrees of accuracy, the most accurate method, and at the same time, the slowest and most expensive, is levelling, which will be dealt with later The next method in order of accuracy is trigonometrical determination by vertical angles, taken with a theodolite, and this will now be briefly described. On the same day that the horizontal angles are observed at a trigonometrical station, vertical angles are observed to all the distant marks, and are read on the vertical circle of the theodolite It has been found by experience that vertical refraction is least during the middle of the day, and vertical angles would, therefore, be taken between noon and three. It is best to eliminate refraction as far as possible by observing vertical angles at each of the two stations of which the difference of height is required Then it is easily shown that, if one angle is an elevation, E, and the angle at the other station is a depression, Db, then the dif-

ference of height is  $c\tan\frac{E_a+D_b}{2}$ ; or if both are depressions,—which may often happen with long rays,—the difference of height is  $c\tan\frac{D_b-D_a}{2}$  c being the distance between the two stations. If

only one angle has been observed, it will be necessary to correct this for refraction and curvature, the average amount of this correction may be taken as zoughly about 4½ seconds for every thousand feet of horizontal distance between the stations, and for other distances in proportion Barometers are best used for determining differences of height, and not absolute heights. All heights should, when possible, be based on some determination of mean sea-level, which is now the universally accepted datum.

Levelling—A "Level" is an optical surveying instrument, which, when in adjustment, has its fine of collimation horizontal; that is, the intersection of the cross-wires will cut an object, seen through the telescope, on the same horizontal plane as the optical axis. In using a level there is no need to consider the curvature of the earth, because the distances between the level and the forward and back level-staws are always kept short; in good work such a distance should not exceed go yards. If the distances in question are always kept approximately equal, any error due to faulty collimation will than to disappear. Excellent modern levels are now made which enable the observer to read the bubble without moving from the eye end of the telescope, and the instrument is finally levelled before the reading is taken. Readings at well.

as the initial meridian; then, having observed an azimuth, or true—taken on two staves, usually some ten feet long; each staff gradubearing, at the origin, we shall know the azimuth of each line which—ated in feet and tenths of feet, and hundredths may be estimated.

#### TOPOGRAPHICAL SURVEYS

The British empire affords examples of all possible methods of the survey for, and preparation of, topographical maps.

the survey for, and preparation of, topographical maps.
Great Britain itself is one of the few countries in which all
mapping is combined under one department and in which the
expense of duplicating surveys for different purposes is avoided
The six-nuch plans are used in the field for a special revision,
arranged to secure the correct information for small scale maps
The small scale maps are then drawn for reproduction by heliosincography, each scale serving as a basis for the next in order

Canada supplies excellent examples of topographical mapping and particularly so in photographic method. The one inch maps of areas in the Rocky mountains are made by ground photographic methods. A control of transgulated points is first established from the properties of the photographic party is equipped with theodolites and cameras which tupon the same stands. The cameras are so used that each portion of the ground to be mapped is photographed from two points of view on plates held in the vertical plane. The position of the camera is resected with the theodolite. The plotting is carried out during the winter recess, each photographic view being used as a record of angular measurement both horizontal and vertical. Positions are established by the intersections of rays

The survey of the Orange Free State in the Domnino of South Africa as an example of a plante table survey in country admirably suited to its use. The total area of over 50,000 square miles was mapped in 6 years by a Colonal Survey Section of 2 officers and 4 non-commissioned officers, R.E. There already existed, in parts of the area, chains of the Geodetic Survey of South Africa Based on this triangulation, the officers of the party extended a ruling trangulation of a secondary Internet (ment raingular error of less than 3 seconds). The sides of this triangulation varied from 10 of intersection and interpolation, resulted in a fixed position and height every 4 or 5 miles. Plante tabling was carried out at the scale of intersection and interpolation, resulted in a fixed position and height every 4 or 5 miles. Plante tabling was carried out at the scale of intersection and interpolation from the first position and height every 4 or 5 miles. Plante tabling was carried out at the case of intersection and interpolation from the first position and height every 4 or 5 miles. Plante tabling was carried out at the many continuous conti

An example of a different class of survey in much more difficult country is to be found in the forest regions of the Gold Coast and Sierra Leone. There is little transgulation available, nor would it be possible without heavy expense. The control, mainly astronomical and widely spaced, is provided by a special party equipped with theodolite and wireless receiving set. The detail party traverses along cleared paths with chain and compass between control points. The triangles are then cut up by a number of rope and sound traverses. Along the main traverses lines of rough levelling are run, and aneroid barometers are carried on the minor traverses. Field work is at the two-inch scale and each traverse is adjusted and compiled on a final compilation

Plane Tabling—The plane table is merely a flat board which can be attached to a tripod The board varies in dimensions from 40 in to 18 in. a side, a convenient size being 24×18 inches. The board itself is generally made of wood, somethines fitted with aluminum corners and fittings. Underneath, the board is strapped with metal, and has in the centre a ring with arrangements for statchment to the tripod The tripod, of three girder pattern legs of light wood, can be clamped to the board or left friction tight to allow of rotation. Plane tables designed for large scale surveying often include a ball and socket joint for levelling, and an instrumental slow motion in azimuth. For topographical survey the board and legs are left as simple and light as possible. On the table is mounted drawing paper or some form of celluloid.

The principal accessory to the plane table is the sight vane or alidade, which is merely a ruler with sighting vanes which can be raised or lowered at will. For engineering surveys at a largish scale a telescope with stadia hairs and vertucal circle is added to the alidade. A box compass and some form of clinometer for measuring slopes or vertical angles complete the outfit.

The first step in the field is to set the board. To do so it is

on the ground The alidade is laid on the line a b. and-standing at A .- the planetabler revolves his board until he sees B. through the sight vanes Lines can then be drawn from a towards any other points on the landscape Similar lines from b intersecting those from a. will then fix the positions This intersection is an important factor in plane tabling Even though the topographer may be given many control points fixed by the theodolite, he must amplify that control for the detail surveying he has to do. As a general rule then intersection is used today in providing the minor control for tomorrow The actual mapping is based mainly on the process known as interpolation, resection, or "making the point." This is simply to find, from the positions of three or more control points, the position at which the table is set up There are several methods of resection, the simplest of which will be described briefly.

The board is roughly set and rays are drawn backwards from three control points towards the observer; the alidade being aligned on each in turn, so that it touches its plotted position if the board has been truly set these rays will all pass through a point. If not, the true position of the observer will be nearest to the ray from the true position of the observer will be nearest to the ray from the nearest point, furthest from the ray from the most distant. Again if the three control points he round and outside the observer his position will be within the triangle of error. If the observer is outside his points his position is outside the triangle of error.

At each point so fixed the topographer sketches in the detail immediately around him, on directions drawn along the alidade, and at distances which are measured tachymetrically or by pacing or estimation. Heights are fixed by observing angles of elevation or depression and multiplying their tangents by the distances

In average country a topographer will survey a square mile or so per diem on the one inch scale, but his rate will depend greatly upon his transport Even at such scales as 3 inches to the mile, where the amount of detail to be shown demands intensive surveying rather than fast movement, a bicycle or some other transport is advisable

The scales suitable for plane tabling lie between a quarter inch and three inches to the mile. At larger scales the plane table may still be and often is used, but more as a record of instrumental measurement and less purely graphically.

Traversing.-A traverse consists of measured lengths connected by measured angles. A traverse may end upon itself forming a complete figure, in which case it is called a closed traverse More commonly it starts from one point of the triangulation and ends upon another. In cities, forests, or other areas of little visibility, the whole control may consist of a net-work of traverses.

The lengths or "legs" of the traverse may be measured in many ways. In control traversing invar or steel tapes are used in catenary (as in base measurement) or laid flat; in both cases under tension. For topographical surveying legs are measured with tapes or chains, ropes or rattans, by cyclometer or by pacing. They may also be measured optically with rangefinder, telemeter, subtense bar, or tachymeter. In geographical surveying, distances may be determined by observed differences of latitude on observed azimuths, or estimated from the time taken to travel over them on foot, horse, camel or motor car. Any class of precision may in

fact be obtained, varying in fractional error from 500,000 to 16.

The angles of a traverse may be measured with theodolite or compass, may be obtained graphically on the plane table, or estimated from the direction of a sound, generally in the form of a prearranged call or whistle from a forward observer.

In the topographical survey of a new country various classes of traversing may occur. In the Federated Malay States and in West African Colonies, precise traverses with a linear error of about 50,000 have been used as a framework or control. In the actual detail survey of forest regions minor traverses fill up the gaps between more precise and costly control traverses and afford opportunity of plotting detail. Examples of Topographical Traverses which will explain the procedure are given below.

In a recent three inch to one mile survey in Johore, the trigonometrical control consisted of a number of points assumed as errorless. Between them were run traverses with the compass and chain. The course of the traverse was cut as straight as possible.

only necessary to set a line a b on the board parallel to A B. The observer plotted his bearings and lengths on squared paper at 6 inches to the mile, including the mapping of detail and contours On reaching the closing point the traverse was adjusted graphically to its correct length, reduced to 3 inches to the mile and plotted on the plane table Errors were, in general, of the order of de The triangle of traverses was then cut up by minor traverses running straight and parallel at 200 feet intervals. These traverses were compass and "rattan" (a long creeper, marked to length, and compared each day with a standard chain). The detail and contours were mapped during the course of the traverse which was plotted direct on the plane table and seldom showed need of

As explained above traverses which are graphic in principle are adjusted graphically and proportionally In adjusting instrumental (or booked) traverses the normal rule is to adjust as follows .-

As the arithmetical sum of all x's (or y's) is to any one x (or y's) is the whole error in x's (or y's) to the correction to the corre

An adjustment on these lines gives equal weight to angular and linear measurement and admits the fact that there is, in general, no evidence on which to give preference among (i.e., to weight) the measurements

#### OPTICAL METHODS OF MEASURING DISTANCES

The ontical methods of distance measurement which are here dealt with are those which depend upon the measurement of a length from a small base at one end and the angle subtended by that base at the other. They include a number of alternatives For example the base may be fixed or variable, the subtended angle variable or fixed. The base may be at the observer's end or the far end, may be vertical or horizontal, whilst the angle may be measured by hairs or lines in the focal plane, by a micrometer scale in the focal plane, by repetition measurement on the horizontal arc, or by optical devices actually included in the base apparatus. The earliest form development took was in the use of fixed stadia hairs in the focal plane, reading, according to distance, a variable length on a vertical graduated staff. This method was later called tachymetry, or tacheometry (quick measurement) by the Italian Porro

Tacheometry or tachymetry was first outlined and applied by the English astronomer Gascoigne in 1630. Montanari, a Venetian doctor, constructed and used an instrument of similar principle in 1674. James Watt used it for surveying in the West of Scotland from 1771 onwards, and William Green, a London optician, did much to develop the method by the publication of a description in 1778. (Description and use of an improved Reflecting and Refracting Telescope and Scales for Surveying.) The unequal effect of refraction on the top and bottom lines of sight was understood by Green who called attention to the advantage of a horizontal, as opposed to a vertical, angular measurement. Nevertheless the practical convenience of the vertical staff has made it the most popular. Methods in which the base is variable but horizontal, that is a horizontal tachymetry, are sometimes known by the term telemetry. Methods in which the base is fixed (and generally horizontal) and angles read on the theodolite arcs are known as subtense, whilst the fixed base which includes its own system of angular measurement is commonly called rangefinding. The use of the various terms is, however, and must be, elastic.

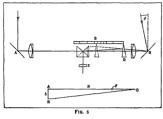
Tachymetry.-- A tachymeter (or tacheometer), in its simplest form, is only a theodolite, or telescopic alidade, provided with two horizontal wires fixed in the diaphragm at equal distances from the axis. These wires, read against a vertical graduated staff at the distant point, measure an intercept "a." The distance between the wires is so arranged that the required length "s" is some fixed multiple "k" of "a" (k usually = 100) although certain corrections may have to be applied.

The theodolite still most commonly used has a biconvex object glass and an eyepiece, and it can be shown that the point at which the subtended angle is constant lies not on the vertical axis but at a distance in front equal to f+c, where f is the focal object glass to the diaphragm.

then s=k, a+(f+c).

(k if not known must be determined by experiment ) Used in this general form for many years, the inconvenience of

the constant computation of (f+c) has led to the use of an "anallatic," or converging, lens between the object glass and the



diaphragm. Due to the Italian Porro the introduction of this lens makes it possible to measure lengths directly from the station as defined by the vertical axis of the instrument. To an increasing extent the internal focussing telescope, translating for focussing, is now replacing the older style, and in it the point of measurement is so close to the vertical axis as to result in consequent errors of an order inferior to many others which are unavoidable. (See bibliography-Henrici.)

The general equation thus becomes s=k a.

The length "s" is however the actual distance between instrument and staff, whereas surveying demands the horizontal and vertical components, and the computation of these will depend on the way in which the staff is held. Normally the staff is held vertical Let  $\theta$  be the angle of elevation, or depression, to the centre of the intercept a. Let d be the horizontal component and h the vertical component. Now the image of a will be reduced, obviously, to equal  $a\cos\theta$ , and

s=kacos0but  $d = s\cos\theta$ . Therefore d=kacos20

and h= ±dtane, or 1 kasin 20.

The rod may however be held perpendicular to the optical axis Where this is intended the staff is equipped with a device which allows the rodman to sight on the instrument. In this case if I be the length from the foot of the stave to its intersection with the produced optical axis-(the sighting point)

> then  $s = kacos\theta \pm sin\theta$ and  $d = \pm Rasin\theta \pm lcos\theta$ .

In the course of a normal tachymetric survey a very large number of points are generally fixed and the trigonometrical computation becomes irksome. There are numerous tables designed to facilitate this computation, and there are also special instrumental fittings for the same purpose. Some continental forms of tachymeter solve the triangle by scaled bars which actually form the triangle whose sides are s, d and h. The Beaman arc is a fitting used often in America. This arc is fitted against the vertical arc of the tachymeter but is independent of it and can be set to any zero. It has two scales which help in the solution of  $\cos\theta$  and of  $\frac{1}{2}\sin 2\theta$ . Some recent models give a direct reading of the horizontal and vertical components. It may be said, generally, that the tachymeter should not be used for distances of over 600 feet, that errors increase proportionally

length at stellar focus and c is the distance of the centre of the the square of the distance) and that they may be expected to reach at least one part in four hundred

Tachymetry is a medium scale method and is particularly suitable to engineering surveys, above or below ground. It is used perhaps more than any other for continental tonographical surveys at scales of 25,000 or 15,000 but is unsuitable alike for the 25 inch mapping of the United Kingdom or the small scale mapping of the Empire overseas. Used on the plane table the tachymeter is useful for traversing in difficult enclosed country or, where the control points can be seen, for measuring distances and heights to points that are immediately round the point of

Telemetry.-The very marked effect of refraction upon the precision of tachymetry has led to the use of staves in the horizontal position. The need for greater precision seems to have been felt particularly desirable for the distance between the cameras used in ground photo surveying

Subtense methods are much used in topographical and military surveys In such cases a theodolite is usually available and a subtense bar or base can be rapidly improvised. The bar or base is arranged horizontal so that the line between stations is perpendicular to it either at its centre point or at one end. The angle is measured by "repetition" on the slow motion screws of upper and lower plates. Thus, sighting on the left hand mark. the telescope is revolved with the top plate slow motion screw to point at the right hand mark. The bottom plate screw is then used to repoint on the left hand mark and the process continued until some 10 to 20 readings have been made. The whole angle is then read and divided by the number of times the measurement has been made. The general equation is

 $d = \frac{b}{-\cot^a}$  if the perpendicular is to centre point

d=b cota if the perpendicular is to end point.

Where d is the horizontal distance, b is the length of bar or base, and a the subtended angle.

The subtense base may be of any convenient size. Sometimes signals have been erected as ends of a subtense base of as much as a quarter of a mile in length the distance between being taped But subtense bars of special design, 10-20 ft, long, are the commonest form of base The end marks are often discs with black lines on a white ground For distances up to 500 yards using a rofoot subtense bar, with disc terminals, errors of the order of may be expected, but with proper precaution, good end marks, and sufficient repetition, a much higher order of precision may be obtained. The advantages of these subtense methods over tachymetry he in their greater range and precision, in the ease with which the base can be improvised, in the freedom from either a special instrument or a special staff of rodmen, and in the direct measurement of the horizontal distance,

Rangefinders.—Some rangefinders are stereoscopic in principle and resemble, in that respect, the stereoscopic plotting machines with their "floating mark" Coincidence methods have the great advantage over stereoscopic that almost everyone can use them. Moreover for this particular purpose a general plastic image is not required Errors involved in the use of the rangefinder, for any given base and magnification, are proportional to the square of the distance and an error of 18 may be taken as normal at a range of 250 yards with a 31 5 inch (8 cm.) magnification 8 model. Models reach 100 feet in base length and 28 in magnification With a 1 metre base and magnification 20 the fractional error is less than at 500 yards. An increasing survey use is being made of this rangefinder. In Canada, Egypt and elsewhere surveyors are finding its advantage over the tachymeter in the independence of rodmen and the increased speed In Canada it has been, and is, used in the control of river and lake traverses on which the surveys, nowadays mainly air photo-surveys, of the northern territories are based. Obviously the rangefinder would prove useful in medium scale plane tabling for the measurement round each resected

Contouring.-The first step in contouring is to measure or to the distance (except in the case of refraction which acts as choose the datum to which the height of all points shall be reand meaned over a long period of time at same tide gauge. With reference to this datum a control of heights is distributed over the country by spirit levelling or by vertical angles measured with the theodolite.

Geodetic levelling would not be available, normally, as a backbone or control for a topographical survey. For this latter purpose secondary levelling with errors not exceeding about 0-03 foot per mile would suffice. These secondary chains, spaced fifty to a hundred miles apart in a grid or net, are generally confined to railways or roads. The intervals would then be filled up with subsidiary orders of levels reaching eventually such errors as o I foot per mile over short lengths Levels of a topographical class are often run with the tachymeter in conjunction with plane

In topographical surveys of new countries it is usual to base contouring on a control of heights determined trigonometrically (by vertical angles with a theodolite). The operations of triangulation and determination of heights are thus combined. Truly simultaneous observation between two points will tend to eliminate refraction In all other cases there is bound to be uncertainty. Observation of vertical angles should be confined to the times of minimum refraction (early in the afternoon), and heights should be carried forward through the shortest sides-since the correction for refraction varies as the square of the distance. Trigonometrical heights show errors of the order of two or three feet in roo miles

In plane-table surveys minor heights are obtained with the Indian pattern clinometer, a small instrument which reads slopes. vertical angles, and natural tangents of the vertical angles. The chnometer (nine inches long) has two vanes. In the rear vane is a sight hole which can be levelled in relation to the zero point of the front vane. If confined to a radius of two miles this clinometer gives excellent results, but at longer ranges errors rapidly increase

The increasing use of the aneroid barometer is due to the convenience of measuring height directly instead of deducing it from distance and slope. A barometer measures the pressure of the air however and before it can be used to measure either absolute or relative heights corrections must be applied to eliminate the effect of (a) Weather, durnal, and area variations, (b) Temperature, (c) Index or other instrumental errors

The first correction is usually applied by comparing the record of a barometer retained in camp with that of the field instrument. The second can be applied directly if the shade temperature is measured at the time of each reading, but thermometer readings must also be taken for the stationary or camp instrument. Under particularly stable conditions it is possible to record the movement due to average diurnal variations and to dispense with the camp instrument, the recording of which is often difficult to arrange In these cases the record graphs should be either corrected for variation in temperature or amplified by a statement of the mean temperature at definite time intervals. There is much to be done still in designing survey barometers with an eye to reducing instrumental errors such as lag, friction of pivots, etc.

The hypsometer (or boiling point apparatus) is of more value to the explorer than the surveyor.

In topographical surveying contours are not generally followed out in detail, but are sketched in upon the control. Strict accuracy in contouring is not perhaps a very important feature of a topo-graphical map. Topographical scales will not show, in any case, enough information for engineering enterprise, whereas a relatively good and reliable picture of the accidents of the ground is of the first order of importance in the development of a new country. The sketching in of the contours is helped by measuring gradients, by noting all points in the observer's level and by spacing contours properly on rivers and streams. There is little difficulty in attaining sensible accuracy in the position of contours in hilly country, but errors of four or five feet in altitude are normal and may be appreciable in flat country.

The vertical interval between contours depends principally upon

the scale of the map although it is also conditioned by the type

ferred It is now common to accept mean sea-level, as measured of country. Thus the same vertical interval could hardly be applied to Switzerland and to Flanders. A good idea as to the proper interval in feet for average country will be obtained by dividing 50 by the scale in inches to the mile. Thus a man on the scale of 1 inch to one mile would have contours at 100 feet intervals

Field Sheets .-- As explained in the article on plane tabling the board is covered with paper, canvas backed, or mounted previously on a thin sheet of aluminum. Some form of celluloid is also used on occasion. This covering is called the Field Sheet On it are plotted the control and the boundary lines of the individual task, and on it the plane tabler subsequently maps. A plane tabler should be "within his points." The area of his work should then be substantially less than that of the board itself in order to allow of plotting control points in the margins, which are also wanted for notes and lists of names On the other hand, a plane tabler starts a new field sheet slowly and gathers pace as he gets to know his control and his country. A good mean figure for the area of work on a board of 18×24 in. is from 60 to 80 sq. inches.

The plane tabler's area should be bounded by definite, ruledin lines It sometimes happens that a river or other topographical obstacle makes it imperative for neighbouring topographers on either side to work to this natural and therefore megular line, but the accuracy of subsequent adjustment suffers. The dividing line should be one across which roads, rivers and other details pass naturally. An overlap between well trained plane tablers is neither necessary nor advisable, nor is it, necessary for them to meet at any stage of their work. The correct conventional signs and colours will have been laid down in advance and each plane tabler will ink in his work as and when he considers it final No colour which is not photographically opaque should be used. It is not generally advisable to map at scales larger than the final map The plane tabler judges more accurately the amount of generalisation necessary if his field sheet is plotted at the map scale and as names are generally written in the margin, there is ample space available in which to show all the required detail.

On conclusion of the survey, the field sheet will be available for checking. Every party should have some proportion of its strength earmarked for revision. After, or during, revision the edges common to the finished field sheets should be compared. Differences on the edges should be small, but occasional errors in orientation ("swing") may arise if there has been difficulty in seeing the control points. Differences should be traced backwards to the nearest resections and for this reason resected points and their heights should be left in pencil on the field sheet until comparisons are finished.

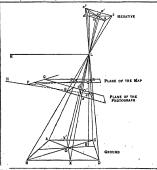
#### SURVEYING FROM AIR PHOTOGRAPHS

A photograph is a perspective view of the ground it represents. In certain cases, though rarely, the ground surface is truly parallel to the plane of the photographic plate. In this case the photograph is a correct plan. Any other relationship of ground (or map) and photographic plane results in a true perspective plan so long as the surface to be mapped is flat, the angle between the two planes being known as the tilt. In this case the map can be wholly reconstructed on perspective lines,

The general case differs from either of the above in that the surface to be mapped is rarely flat, presenting the three ordinary dimensions of nature, whilst, as in the second case, the photographic plane is inclined or tilted to the map plane. There are then two difficulties to surmount, the perspective effect and that of difference of altitude. These two effects act from different points on the plane of the photograph. It is one of the hardest problems of surveying from air photographs to disentangle these two effects and to correct them in the proper way. The photograph is a central perspective of the ground mapped, which is true in so far as lens, shutter, photographic material, temperature changes and rigidity of the camera allow. The perspective centre is the point on, or with reference to, the plate from which directions to points on the ground correspond to those from the camera. Height, however, introduces in the perspective view distortions which radiate from a point in the plane of the photograph vertically below the front notal point of the lens. This pount is commonly known as the Photo Plumb Point. The perspective centre and photo plumb point councide with each other, and with the optical centre, when the two planes (ground and photo) are parallel. In all other cases these three points are distinct from each other and lie on a line perpendicular to the axis of tilt at distances which are functions of the tilt.

As nearly all photographic surveying demands a knowledge of the position of these points the first step is so to calibrate and to adjust the camera that the optical centre corresponds to the promotap lapint (the point at which a perpendicular from the front nodel point meets the plane of the photo). Fiducial marks photographed to the four edges of the plate can then be joined up to give the correct position. It is with reference to this position that the perspective centre and photop lumb point can be jound. The principal distance (between the lens and the principal point) must also be measured. In the remainder of this article it will be assumed that the camera has been properly calibrated and adjusted

calcutated and adjusted. The Single Photograph in Perspective. (a) When the Grand is Flat—II is the representative fraction of the scale, L be a distance on the ground, and I the corresponding distance on the photograph, then for any given small area  $S = \frac{1}{L}$ . But I is conditioned by the tilt and the scale varies accordingly. Where photographs are taken as nearly as possible with a vertical axis then  $S = \frac{1}{L}$  where l is the principal distance (not quite the same thing as the focal length), and H is the height of light. Whether or not photographs are nearly vertical the problems is the same because it has not been found possible hitherto to maintain the axis truly vertical, to record such deviations from the vertical as may occur, or to keep a constant height. In



by country of col. M. M. Macleon, from trads. Oft. Socy., by perhipsion of sect. Fig.  $\phi$ 

every case then the photograph is a perspective view at an unknown till and from an unknown height. The effect of tilt can be eliminated by perspective treatment founded on the coresponding positions (on ground and photograph) of four points. Such treatment may be either graphic or photographic and is generally called rectification.

Graphic methods are seldom applied to the whole photograph. In practice it is easy to find straight lines through points clear on the photograph, and already mapped, which will intersect on, or sufficiently close to, the new point which is to be added.

Perspective figures may also be used If the lines or subdivisions of the perspective figures are sufficiently close, detail may be copied by eye, correcting both for tilt and for scale in the process

Photographic rectification is more suitable for larger aleas if these are really flat I must be remembered however that a sharp image is essential to good plotting and that the ordinary projecting lantern, though it offers freedom of movement for the screen, does not do so for the photograph. This latter movement is, however, necessary to secure a sharp image Space forbids a further analysis of the perspective and optical principles involved (See bibliography). For small scale or exploratory mapping it may be convenient to assume that photography has postic pictures made up of "vertical" photography as postic pictures made up of "vertical" photography as made up of "vertical" photography as made up of "vertical" photography are made on this assumption, although where good maps already exist, mosaics are usually buttu our postions taken from them

Examples of Surveys on the Above Lines: 1 The Topographical Survey of Canada has made excellent quarter inch maps of the lake and river areas of the Laurentian Plateau from highly tilted oblique photographs in which the horizon appears, and serves the purpose of two of the four necessary control points

ii The swamps and forests of the Irrawaddy Delta were mapped by the Survey of India from "verticals" controlled by trangulation and traverse Individual photographs were not rectified but strips of photographs were prepared and rephotographed to the correct scale as given by the control

ni. The Air Survey of Flanders and Picardy in 1916-17 was based on a fresh triangulation, on which an old but farily reliable cadastral survey was assembled. Fresh detail, inclusive of ternches and other military works, was added from vertucal air photographs, each of which was treated as a perspective view within the narrow limits of the cadastral control.

(b) In Ordinary Country and for Contoured Maps — In the bundle of rays which converge to the camera that from the top of a high chimney or hill (unless it be vertically under the camera) will make a larger angle with the vertical than will the ray from the point directly under that chimney or hill top Heights are thus displaced outwards from the plumb point, depressions inwards The only perspective effect which holds good is that of direction from the perspective centre.

In ground photo topography the position, height and tilt of the camera are known. In air photo topography none of these are known, but they can be found from the corresponding positions on ground and photograph of four points properly surveyed in plan and in height.

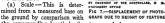
The reconstruction may be graphical, mathematical or mechanical. Graphical methods are not sufficiently precise, whilst a mathematical solution, possible in several ways, is excessivel lengthy. The mechanical solution is that adopted in the machines for stereoscopic measurement which will be mentioned later. All three suffer from the difficulty of securing sustable well defined and sharp images on the plate Precision of measurement on the plate is therefore difficult to attain whilst the comparatively small area of the base (the area included by the four control points), and the comparatively sharp angles at the apex, are difficulties.

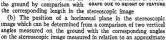
Pairs of Photographs.—A pair exposed from different air stations and covering a common portion of ground gives two directions to each point in the area common to the two photographs. The positions and heights of the points can therefore be completely determined so long as the constants of exposure are known.

The stereoscopic machines for surveying from ground statons act on this general principle but the problem they solve is comparatively easy because the positions of the ground stations can be surveyed directly and the photographs can be taken at measured angles of tilt and in a definite angular relationship to each other. Air stations cannot be surveyed directly Reference must be made from the images on the plates to the points of a ground control, which those images portray, before the stereoscopic image can be plotted on the plane of the map (e.g., mean sealevel), properly oriented, and reduced or enlarged to the appropriate scale. This reference to ground control can be carried out in two ways. Firstly, as in those stereoscopic machines which

follow the general lines of their predecessors designed for ground stereo plotting, each photograph is set, singly, upon a control of four points surveyed on the ground, thus reconstructing the position and tilt of the plate in space When both plates of the pair have been thus placed a final joint setting ensures proper correspondence. The process of setting may take several hours There is however another way which is to set the pair in correspondence, in space, before referring to the ground control The pair is said

to be in correspondence when corresponding directions in space intersect, each pair of points being in correspondence when the rays to them intersect. A perfeci. correspondence between plates is secured when five points are in correspondence and the plates are then set in their correct relative positions to each other and to the base line between the two air stations This is the principal of the Fourcade stereogoniometer. The strip so set or plotted is, however, not on the required plane nor is it necessarily correct in scale and orientation. To secure correct plan the whole must be referred to a ground control which, however, may be comparatively open. We must know-





BY COURT

position of the horizontal which can afterwards be corrected. The data so obtained set the machine for

- (a) The length of the air base
- (b) The angle through which both photographs must be rotated about the air base, in order to re-establish the vertical plane containing the air base.
  - (c) The inclination of the air base to the horizontal.

However the plates of a pair have been set, detail on the relief or stereoscopic image from a pair of set photographs is plotted by the superimposition of the image formed by a pair of artificial "floating marks" which combine stereoscopically to produce that image at a known position in space. The movement of the image relative to the landscape enables the latter to be measured and surveyed in detail. For convenience however in mechanical and optical construction it is usual for the "floating mark" to be fixed and the stereoscopic image of the landscape to be moved. Maps so produced have been mainly cadastral and engineering plans at a large scale. Meanwhile for topographical work at smaller scales methods have been evolved which depend upon the elimination, by good and consistent flying, of any excessive tilt. For all classes of air survey it is most important that navigation in the aeroplane should aim at maintaining an undeviating course both as to direction and height,

Methods for securing straight flight and constant height have not yet been standardized. As a rule each pilot has evolved his own methods for himself, Great skill is often displayed but variations of wind may well cause displacements of track of half a mile in a ten-mile strip. Deviations of 80 to 100 ft. in height are common. This problem, which can only be solved by a judicious mixture of instrumental control and training, remains one of the most important to surmount. If the tilt is small the perspective centre and the photo plumb point approach each other and the principal point. It is possible then to assume that directions from the principal point may hold good both as regards tilt distortion



and height distortion Methods based on this assumption are known as radial methods. The first assumption made is that the air base of any pair is defined in direction by the line joining the photographic images of the two principal points. It would not be possible however to accept as relatively correct on the ground the successive distances measured on the photographs between principal points. It is usual in these methods to allow for an overlap large enough to include the two air bases (forwards and backwards) from the centre of each individual photograph The positions of the fore and back stations can thus be found by a comparison of detail, but such tilt and height distortion as may occur on the lines between them are sufficient to introduce serious errors of length

The scale of the plot is, therefore, obtained by accepting an arbitrary length on the first photograph and by continually fixing points in the overlaps and refixing the principal points from them thus -The base 1-2 on the first photograph is set along any line which will be convenient for subsequent plotting. A line 12 is now drawn to a (on the photograph, image of A on ground) and is accepted as an arbitrary length on the "plot" The second photograph is now set on line 2-1 and moved along

it till the direction from 2 to A cuts the position a on photograph 1. Thus the distance 1a is made the base for all subsequent work From 1 and 2 directions are drawn to b and c (1mages of B and C) which appear on both photographs. As these also appear on the third photograph which is set on the direction 2-3 (between principal points 2 and 3) the position of 3 (principal point of the 3rd photograph) can be resected.

Naturally the construction lines must be drawn on tracing paper, linen or celluloid (the latter is most convenient), the photographs being placed separately and successively under it. Once the positions of the principal points have been plotted all other points of detail may be fixed by the intersection of the photographic directions. A particular development of the radial method, commonly known as the Arundel method, employs a small "topographical" stereoscope in these first stages of plotting The particular feature is the addition over each photograph of glass plates on which are etched diamond shaped grids These grids fuze stereoscopically into a plane which may be moved vertically in relation to the landscape, for contouring, and which are also used to show when the pair is properly in correspondence By this method the orientation of the air base can be established and marked on each photograph. Contouring in the Arundel method is carried out on alternate photographs Each pair is set and examined in the topographical stereoscope on the assumption that they are untilted and exposed from the same altitude. The result-

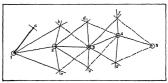


Fig 8

ing stereoscopic image is naturally subject to errors in apparent slopes, the effect of which must be held in check by a fairly close height control. The plane formed by the diamond grids may be made to touch the ground at any place, the extent of movement being recorded on scales. Other heights may then be interpolated and when a sufficient control has been secured contours can be drawn in by eye on the actual photograph. They are subsequently traced in correct position on the celluloid plot.

### MAP REPRODUCTION

The general heading of reproduction covers the various processes of drawing, photography and printing, which come between the survey on the ground and the completed map There is a stage generally carried out by draughtsmen called compilation, which, however, antedates fair drawing and is equivalent to survey. Small scale maps of the less well known parts of the world are made up from material of various sorts and generally of

The next stage is fair drawing. The draughtsman's first task is to plot the graticule and margin of his sheet on the chosen projection. He then plots the control points in proper position and begins to incorporate his material. Whether the latter is compilation, or field sheet, it is probable that the photographer will be called upon to provide bromides at the required scale The next point to decide is the number of colours to employ. If the whole map is drawn on one sheet of paper the photographer will have to divide colour from colour during his preparation of the zinc plates. If each colour is drawn separately then subsequent photography and zincography is made easier, but the fit of one colour upon another, commonly known as the register, will suffer; for, once embarked upon, the various different drawings may expand or contract unequally. The procedure chosen is often a mixture of these two principles.

Sometimes the field sheets are assembled and photographed to be printed in blue and to act as a direct key to the drawing of various colours. Blue is chosen because, in the subsequent photography of the completely drawn colour sheet or plate, blue will not appear on the negative, which will record nothing which has not been inked in. This system is handy, and guards against bad register The use of a complete key of this sort implies that the whole of the material can be collected and photographed into position at one and the same time. In other cases each main colour is drawn on its own tracing paper, the various plates being compared and examined, over each other, at frequent intervals, to prevent the clash or overprinting of the different colours In all such drawing the colours used must be photographically opaque Where main colours are treated separately each is drawn in black. Where all the colours are drawn together a difference must be made as a guide to subsequent separation but the colours employed need not be those of the final map

The main photographic process of preparing the printed record from the finished drawing is heliozincography. In this process the original drawing is photographed, and the glass negative is then laid over a sensitized zinc plate. The negative and zinc are held in close contact in a frame from which the air can be pumped. Light penetrates the lines and names left clear on the negative and hardens the surface below. The remainder of the sensitized surface, protected by the negative, remains soft and can be washed away.

In the heliozincographic process each plate is photographed to the proper dimensions. The great advantage of heliozincography lies, however, in the possibilities of touching up or adding fresh detail actually on the negative. A special staff is employed in large map establishments for this purpose. If all the colours of the final map have been drawn together it is at this stage that separation occurs. As many negatives are made as there are to be main colours. On each negative everything irrelevant to the particular colour in view is duffed out. The glass negatives then become the final records, from which any number of printing plates may be made,

The zinc plates are now given over to the printers. (See Lithog-

REBINO ADDRAY.—C. F. Close and H. St. J. Winterbotham, Test Book of Teoperaphical and Geographical Surveying (1952); W. N. Thomas, Surveying (1952); W. N. Thomas, Surveying (1952); A. R. Hinds, Mays and Survey (1952); S. B. John-Surveying, T. B. M. Wilson, Teoperaphic (1952); A. R. Hinds, Rept and Mays and Surveying (1952). For tacheomorphic, H. M. Wilson, Teoperaphic Surveying (1953). For tacheomorphic, H. M. Proceedings of the Optical Convention, pt. ii. (1954). Fourcade, "The Subtense Measurement," In Proceedings of the Optical Convention, Pt. ii. (1954). Fourcade, "The Subtense Measurement," In Proceedings of Sunday and Convention, Pt. ii. (1954). Fourcade, "The Subtense Measurement," Perman Convention of Convention

ting from An Photocraphi", No. 4, "Mathods of Flying for Air Survey Photography", No. 4, "Simple Methods of Surveying from Air Photographs", No. 4, "Stereoscopic Examination of Air Photographs", No. 4, "Stereoscopic Examination of Air Photographs", No. 5, "The Calibration of Surveying Cameras" (If M Stationery Olic, London), B M Jones and J. C. Graffiths, Aerad Surveying by Raphd Methods (1924) (C. F. A. C., H. St. J. W.)

"SURVILLE, CLOTILDE DE," the supposed author of the Poésses de Clotslde. The generally accepted legend gave the following account of her. Marguerite Éléonore Clotilde de Vallon Challis, dame de Surville, was born in the early years of the 15th century at Vallon In 1421 she married Bérenger de Surville, who was killed at the siege of Orleans in 1428 Her husband's absence at the war inspired her heroic verses and his death her elegiac poems The last of her poems is a chant royal addressed to Charles VIII. In 1803 Charles Vanderbourg published as the Poésies de Clotilde some forty poems dealing with love and war Research showed that the documents, communicated by the marquis de Surville to Vanderbourg were not genuine, and the account of Clotilde herself was proved to be inaccurate.

account or Louiside herselt was proved to de inaccurate.

See A Macé, Un procés d'instince libérare (1870); Austria.

Marquerie Chalis et la légende de Clositic de Survaile (1873), antecide (1874); Austria.

(March 1, 1872) and May 20, 1874), by Paul Cottin in the Bulletin du bibliophite (1894); E. K. Chambers, Literary Forgenes (1891) and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femmes cillères (Turn and further réferences in the Bibliographie de femme

## SURVIVAL: SEE PSYCHICAL RESEARCH

SUS, a province of southern Morocco. It is an east-to-west valley, 125 mi, long, bounded by the Atlantic ocean, High Atlas, Siroua and Anti-Atlas The area is about 12,620 sq.mi. Sus has a Saharan climate slightly mitigated by its nearness to the Atlantic The argana (Argana sideroxylon) is the characteristic tree, it has the appearance of a spiny olive, and forms sparse forest-steppes The waters of the Wad Sus and its affluents allow of some cultivation, helped by irrigation, but one must not exaggerate the agricultural wealth of the region; it is reputed to be rich in mines, especially of copper. The population is about 400,000, grouped at the foot of the mountains and along the Wad; it is Berber in race and speech, and belongs to the Chleuh group The Susis emigrate willingly and are excellent workmen. The port of Sus is Agadir, the Santa-Cruz of Cape Aguer of the Portuguese; situated on the Atlantic to the north of the mouth of the Wad Sus, it includes a citadel and a fishing village. Tarudant, capital of Sus, is a native town of 6,000 inhabitants, of whom 1,000 are Jews.

SUSA (Shúshan, Sús), capital of Susiana (Elam) and chief residence of Darius I and his successors. It lay under the Zagros range at about lat 32°, near the bank of the Karkha (Choaspes) river and close to the Kárún.

(For early history see ELAM)

The site, identified (1850) by W. K. Loftus, has on it four mounds One, rising about 38 metres, holds the citadel. A second to the east represents the palace of Darius I and was excavated by M. Dieulafoy. The enamelled bricks taken from its walls are in the Louvre. A third mound to the south contains the royal Elamite city, while the fourth mound consists of the poorer houses. Excavation of the citadel was begun by I. de Morgan in 1897. It yielded the obelisk of Manistusu, the stele of Naram-Sin, and the Code of Hammurabi (the latter in the winter of 1901-02). (See Babylonia and Assyria.)

The finest pottery came in the lowest strata, 25 metres below the surface, and belongs to two different civilizations both in the Neolithic period. The earlier is characterized by vases of fine red clay, wheel-made, in a few well-defined shapes, but all with very thin, polished sides. The decorations applied in black paint or redbrown ferruginous earth consist of bold geometrical patterns, often combined with spirited studies from nature. The pottery of the second period shows a retrogression, being coarser and porous

Above the early strata come remains of Elamite and early Babylonian civilization, inscribed objects from the latter bearing pictorial characters from which the cuneiform was evolved. The upper portions of the mounds disclosed inscribed Achaemenian monuments, Greek pottery and inscriptions of the 4th century B.C., coins of the kings of Elymais, and Parthian and Sassanian relics. Moslem tradition says that the tomb of the prophet Daniel

bank opposite the supposed spot. Until after the 14th century mountains and traverses the Gettysburg battlefield. the city was a flourishing centre of a district famous for silk, sugar cane and oranges. It is now deserted.

Sugar cane and oranges. As into weeker-level.

BELLOGARIP-W. K. Loftus, Trevels and Researches in Chaldaca
and Susma (1857), M.A. Dieululoy, L'Art entique de la Peres (188485), L'Alexpola de Stuse (1869), L'A. Billurbeck, Sun (1893); J. de
Morgan, Mémoires de la délegation en Peres, vols. ;—tití (from 1869).

H. Frankfort, Sudates in Early Fortlery of the New Est (1924); R. C.
Thompson, in Archaeologus, vol. 1x;; G. le Strange, Lands et the Essiern Caliphate (1965); E. E. Herstled, Archaeologus History of Iran

See also Persia. History.

SUSA, Tunisia: see Sousse. SUSANNAH: see Daniel.

SUSARION, Greek comic poet, a native of Tripodiscus in Megaris. About 580 B.C. he transplanted the Megarian comedy into the Attıc deme of Icana, the cradle also of Greek tragedy and the oldest seat of the worship of Dionysus. According to the Parian Chronicle, there appears to have been a competition on this occasion, in which the prize was a basket of figs and an

amphora of wine.

Susarion's improvements in his native farces did not include a separate actor or a regular plot, but probably consisted in substituting metrical compositions for the old extempore effusions of the chorus. These were intended for recitation, and not committed to writing. Such performances, however, did not suit the taste of the Athenians, and nothing more was heard of them until 80 years after the time of Susarion.

U. von Wilamowitz-Mollendorff (in Hermes, ix) considers the so-called Megarian comedy to have been an invention of the Athenians themselves, intended as a satire on Megarian coarseness and vulgarity. The lines attributed to Susarion (in Meineke, Poetarum comicorum grascorum fragmenta) probably are not

SUSO [Seuse], HEINRICH (c. 1300-1366), German mystic, was born at Überlingen on Lake Constance; he assumed the name of his mother, his father being a Herr von Berg. He was educated for the Church, first at Constance, then at Cologne, where he came under the influence of the greatest of the German mystics. Meister Eckart. He subsequently entered a monastery in Constance, where he subjected himself to the severest ordeals of asceticism. In 1335 he wandered through Swabia as a preacher. and won all hearts by his gentle, persuasive eloquence; the effusive lyricism of his language made him an especial favourite among the nuns. About 1348 he seems to have settled in Ulm, where he died on Jan. 25, 1366.

Suso's first work, Das Büchlein der Wahrheit, was written in Cologne about 1329. Setting out from Eckart's doctrines, he presents the mystic faith from its speculative or theoretical side, whereas in Das Büchlein der ewigen Weisheit, written some vears later in Constance, he discusses the practical aspects of mysticism.

The latter work, which Suso also translated into Latin under the title of Horologium sapientiae, has been called the finest fruit of German mysticism.

of German mysicism.

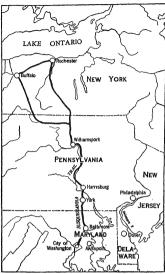
Sun's stroke server of States's Lobes and States and spate in \$15.5 States and States, and spate in \$15.5 States and States, and States, and States, and States, and States, and States, and Dippenherock (1890; 4th ed., 1884); States Desirteds Schriften, by K., Billimoyer (4 vols., 1907). See about 5th education Schriften, by K., Billimoyer (4 vols., 1907). See about for desirteds Mysinic (1888), vol. 81; J. Jager, Hairnick States and Schwaden (1894); and The Life of Blessed H. Stao, by Himself (1912), trans. by T. F. Kono, with Introd. by W. R. Jinger.

SUSPENSION BRIDGE: see BRIDGES.

SUSPENSURA, the architectural term given by Vitruvius (v 10) to the hollow space under the floor of a Roman bath, in which the smoke from the furnace passed to the vertical flues in the wall. (See HYPOCAUST.)

SUSQUEHANNA TRAIL, an American highway from Williamsport, Pa., to Harrisburg, Pa. It connects at either terminal with paved or hard surfaced roads and furnishes a picturesque route connecting Buffalo and Rochester, NY, with Baltimore, Frederick, Md. and Washington, D.C. It passes through farming

lay in the bed of the Karkha river and a mosque was built on the districts in New York and Pennsylvania, crosses the Appalachian



SUSSEX, EARLS OF. The early history of the earldom of Sussex, an English title, is involved in some obscurity. owing to the fact that under the Norman kings titles of earls were often indifferently derived from a county, from its chief town or from the earl's principal residence, although the distinctive mark of an earl was deemed to be his right to "the third penny" of the pleas of a county (see EARL). Thus in the 12th century the same person is sometimes found described as earl of Sussex, sometimes as earl of Chichester and sometimes as earl of Arundel, while the inclusion of the counties of Sussex and Surrey under the jurisdiction of a single sheriff led at one time to further confusion. The difficulty was increased by the crown's admission in 1433 that the possession of the castle of Arundel carried with it the right to the title of earl of Arundel, though a later investigation proved the invalidity of the claim. G. E. Cokayne (Complete Peerage, i, 138, 139) holds that Roger de Montgomery, who received grants from William the Conqueror of a large part of the county of Sussex, including the city of Chichester and the castle and honour of Arundel, besides lands in Shropshire with the castles of Shrewsbury and Montgomery, was the first earl of Sussex. Whatever his titles were, they were forfeited to the crown when his son Robert was attainted in 1102, and the forfeited estates were conferred by Henry I on his second wife Adelicia, who after Henry's death married William de Albini, or d'Aubigny. The latter was created earl of Sussex by King Stephen, and "the third penny" of that county was confirmed to him by an instrument of the reign of Henry II, in which, however, 620 SUSSEX

he is styled earl of Arundel, a designation by which he was more generally known. His grandson William, 3rd earl of Sussex, was one of King John's sureties for the observance of Magna Carta, and in 1243, the earldom reverted to the Crown on the death of Husch de Albim, 5th earl of the line (See Arundel, Earls or)

Ratelyffe Earls.—For nearly two hundred years, from 1347 to 1330, the title of earl of Sussex did not exist in the English peerage In 1329, however, it was conferred on Robert Radchife, Radchyfie or Ratchyfie (c 1438-1542), who had been made Viscount Fitzwalter in 1325 in 1340 Ratchyffe was appointed great chamberlain of England With Edward, the 6th earl (c. 1535-1641), but tile became extinct

Savile Earls—In 1644 Thomas Savile (c 1590-c 1659), son of join Savile, its Baron Savile of Pontefract (1560-1659), was created earl of Sussex Savile opposed Wentworth, afterwards earl of Strafford, the rivalty between the Saviles and the Wentworths being of long standing in the history of Yorkshire. During the Great Rebellon he played a double game, and was imprisoned at different times by both parties His later years were spent in extrement at Howley Hall, where he died about 1650. He was succeeded in the earldom of Sussex by his son James, on whose death without issue in 1671 the title became extinct

It was revived in 1645 in favour of Thomas Lennard, 15th Baron Dacre, whose wife Am (d 1722) was a daughter of the famous duchess of Cleveland by King Charles II, and again became extinct at this nobleman's death in 1715. The title was next conferred in 1770 on Tablos Velvetron, and Viscount de Longueville and 16th Baron Grey de Ruthyn (c. 1692—1731), from whom it descended to his two sons successively, becoming one more extinct on the death of the younger of these, Henry, 3rd earl of Sussex of this creation, in 1790.

Royal Karls.—In 1807 Pfinc Augustus Frederick (1773—1843), the sust has ond George III, was created duke of Sussex. Spending his early years abroad, the prince was married in Rome in 1793 to Ludy Augusta (d. 1850) daughter of John Murray, 4th earl of Dumone. The ceremony was repeated in London and two children were born, but under the Royal Marriage Act of 1773 the Court of Arches declared the union illegal The children took the name of Grate Sussex was a man of themal ideas; he knowwed the abolition of the slave trade, the repeal of the corn laws and the removal time of the slave trade, the repeal of the corn laws and the removal the size of the corn and the size of the

the same time was created cluke of Comangial and Stratheam, See G. E. C., Gomplete Perseq. s. "Sussee," "Serrey," "Arundel," vols. i. and vil. (London, 1889-96). Sir William Diugidis, The Baron-John Strype, Memorials of Themas Commer (1960). Amould of the Referention (1713) and Reclematical Memorials (2 Young, 1721); P.F. Tyler, Reguland under the Regue is Edward VI and Mary (3 vols. \$153)). Calendars of State Papers. Letters and Papers of the Refin of Hemry VIII For the sace and other Savil line see S. K. Gardiner, Hist. War (1804-80). Social Conf. State (1804-80). Social Conf. Social Conf. State (1804-80). Social Conf. Social

SUSEX, THOMAS RADCLYFFE [or RATCLYFFS], 320 EARM of (c \$155-458), lorid-lettenant of Ireland, eldest son of Henry, and earl of Sussex (see Sussex, Earss or), by his first wife, Elizabeth, daughter of Thomas Howard, and duke of Nor-folk, was born about \$153, and after his rither's succession to the eardon in \$154 was styled Viscount Fitzwalter. After serving in the army abroad, he was employed in \$153 in negotiating a marriage between Edward VI. and a daughter of Henry II., king of France His prominence in the kingtom was shown by his unclusion among the signatories to the letters patent of June 76, \$153 on among the signatories to the Cityly Line in the prevention of the company of the c

of Edward VI to promote Protestantism in Ireland, and the "plantation" by English settlers of that part of the country then known as Offaly and Leix But Fitzwalter first of all found it necessary to make an expedition into Ulster Having defeated O'Neill and his allies the MacDonnells, the lord deputy, who by the death of his father in February 1557 became earl of Sussex, returned to Dublin, where he summoned a parliament in June of that year Sussex then took the field against Donough O'Conor, whom he failed to capture, and afterwards against Shane O'Neill, whose lands in Tyrone he ravaged, restoring to their nominal rights the earl of Tyrone and his reputed son Matthew O'Neill, baron of Dungannon (See O'NEILL) In June of the following year Sussex turned his attention to the west, where the head of the O'Biiens had ousted his nephew Conor O'Brien, earl of Thomond, from his possessions, and refused to pay allegiance to the Crown; he forced Limerick to open its gates to him, restored Thomand, and proclaimed The O'Brien a traitor. He took part in the ceremonial of Oueen Elizabeth's coronation in January 1559, and in the following July he returned to Ireland with a fresh commission, now as lord lieutenant, from the new queen, whose policy required him to come to terms if possible with the troublesome leaders of the O'Neills and the MacDonnells Sussex was recalled, at his own request, in 1564 His government of Ircland had not, however, been without fruit Sussex was the first representative of the English Crown who enforced authority to any considerable extent beyond the limits of the Pale

On his return to England, Sussex immediately threw himself into opposition to the earl of Lexester. In 1566 and the following year Elizabeth employed him in negotiations for a marriage with the archduke Charles When this project fell to the ground Sussex returned from Vienna to London in March 1568, and in July he was appointed lord president of the north, in which office he had to deal with the rebellion of the earls of Northumberland and Westmorland in 1569. In 1370 he laid waste the border, maded Scotland, and raided the country round Dumfries, reducing the rebel leaders to complete submission In July 1572 Sussex became lord chamberlain, and he was henceforth in frequent attendance on Queen Elizabeth, both in her progresses through the country and at court, until his death on June 9, 1583.

The earl of Sussex was a patron of literature and of the drama. He was twice marned, first to Elizabeth, daughter of Thomas Wrothesley, earl of Southampton; and secondly to Frances, daughter of Sir William Sidney. His second wife was the foundress of Sidney Sussex College at Cambridge, which she endowed by her will The earl left no children, and at his death his titles passed to his brother Henry

to his brother Henry
See P. F. Tytle, England under the Reigns of Edward VI. and Mary
(2 wobs., 1830)! Richard Bagwell, Irdand under the Tudors (2 wols.,
1830). Richard Bagwell, Irdand under the Tudors (2 wols.,
1830). Charles Henry Cooper, Athenac canaborycenes, vol. 1 (Cambridge,
1858). containing a blography of the earl of Sussex, John Strope,
Ecclesiavistic Memorals (Oxford, 1821); Sir Cuthhert Sharpe, MeEcclesiavistic Memorals (Oxford, 1821); Sir Cuthhert Sharpe, Memark Public Processions of Oxera Ethiology, 1921). Sir WilIslam Dugdals, Pt Baronage of England (1932).

SUSSEX, a southern county of England, bounded north by Surrey, north-east by Kent, south by the English Channel, and west by Hampshire. The area is 1,457 sq miles. The county consists of the central and southern portion of the broad east to west dome of the Wealden anticline, and is very long (78 m) in proportion to its breadth (48 m. at broadest). The dominant feature is the chalk of the South Downs (average height 500 ft, Ditchling Beacon 800 ft.) which cross the county in a westnorth-west to east-south-east direction, ending in bold cliffs at Beachy Head. Westward from this point the chalk forms the south coast, except that at Seaford there are outliers of Read-ing beds and from South Lancing onwards the same beds extend as a thin belt into Hampshire, there to form the Hampshire basin. This belt lies a few miles from the coast, except south of Chichester, where it broadens out and forms the low flat headland of Selsey Bill. East from Beachy Head, Wealden clay and Hastings beds form the coast, but recent deposits round Winchelsea and Rye (members of the Cinque Ports and prominent in

62 I SUSSEX

the sea The South Downs dip gently southward, but form a steep escarpment to the north, where the upper formations of the anticline have been denuded, exposing in succession from south to north, gault and upper greensand, lower greensand, Wealden clay and Hastings beds, with small patches of Purbeck shale, and limestone with beds of gypsum lying west of Battle. The gault and upper greensand form a plam at the foot of the escarpment, bounded north by the elevated ridge of the lower greensand, beyond which the Wealden clay and Hastings beds give rise to hill country known as the Forest Ridges (800 ft near Crowborough), where rise many Sussex rivers Of these, the Rother forms part of the Kent boundary and enters the sea below Rye: the Cuckmere rises near Heathfield (where also natural gas is tound in the Lower, Wealden and Purbeck beds); the Ouse, the Adur and the Arun rise in the district of St. Leonard's forest, flow south and breach the chalk, having respectively as gap towns, Lewes, Steyning and Arundel, and as ports, Newhaven, Shoreham and Littlehampton

The country north of the Downs was formerly covered with forest, but much wood was cut for export to the Low Countries as early as the 14th century, and for the Wealden iron industry. especially in the 17th and 18th centuries. The coast line of Sussex is long and exceedingly varied, and encroachment and erosion have taken place as well as accumulation. Old Winchelsea was submerged in the 13th century, the site of the ancient cathedral of Selsey is a mile out at sea; 5,500 ac, were submerged between 1292 and 1340; early in the 14th century, Pagham harbour was formed by the sudden flooding of 2,700 ac, since reclaimed. The latest movement of the coast is probably one of slight elevation The following changes have taken place at river mouths .- Prior to a great storm on Oct. 12, 1250, the Rother entered the sea 12 m. to the east; until 1570, the outlet of the Ouse was at Seaford, the Adur has frequently shifted its mouth Submerged forests occur offshore. The sheltered coast has given rise to many watering-places --- Brighton, Hastings, Eastbourne, Bexhill, Seaford, Shoreham, Worthing, Littlehampton, Bognor.

History .- Sussex, with its long southern shore, supplying fish

Charlet 1

and salt, and dissected by mouths of clear rivers, with gravellined valleys leading to sunny chalk slopes, was admirably suited to the needs of primitive man, and we have definite traces of him in Palaeolithic times, on the coast, e.g., near Worthing, Eastbourne, Brighton and Chichester, and in the valleys, especially of the Arun and western Rother. In Neolithic times these and similar sites were very important, as kitchen middens, tools, bones of animals, etc., abundantly prove. The Downs were also used. The flint mines of Cissbury are now generally ascribed to a late Neolithic date, though some students have dated them back to earlier times The Bronze age finds (pottery, celts, etc.) show that the coastal regions (Worthing, Wilmington, Eastbourne, where gold bracelets, bronze swords, copper, etc., were found) were again used The importance of Sussex continued, and the Iron age finds, though less numerous, show a high degree of culture, the gold ornaments from Mountfield being especially important Objects of Sussex iron (hammer, plough-share, billhook, etc.) found at Mount Caburn, point to an iron industry in pre-Roman times. The Long Man of Wilmington cut in the chalk is probably also of this period That agriculture was practised by prehistoric man is also proved by the presence of numerous lynchets and rectangular fields still traceable on the chalk slopes Mr. Toms, of Brighton, has gathered evidence to show that the great earthwork at Cissbury is probably of British workmanship in the Roman period, and there are numerous other earthworks in Sussex of early Iron age or Romano-British date. Cissbury and Chanctonbury are in a "Worthing" group, while the Devil's Dyke and many others are in a Brighton group. Mount Caburn and several others are also well known.

In 447 the Saxons, under Ella and his three sons, built up the kingdom of the South Saxons. (See Sussex, Kingdom of.) They took the Roman city of Regnum (Chichester) and drove the British westward, into the forest of Andred. The Roman fortress

mediaeval tiade) and Pevensey have cut these towns off from of Anderida (Pevensey), also fell to the Saxons. According to Bede, Ella was the first Bretwalda After his time the kingdom of Sussex gradually declined and fell under the dominion of Wessex in 823 Saxon remains are found in numerous cemeteries, and scattered burial places along the south slopes of the Downs The cemetery on High Down hill, where weapons, ornaments and vessels of various kinds were found, and the Chanctonbury hoard of coins, are noteworthy A coin of Offa of Mercia, found at Beddingham, recalls the charter of Archbishop Wilfred in 825, in which Offa's connection with the monastery in that place is recorded From 895 Sussex suffered from constant raids by the Danes, till the accession of Canute, after which arose the two great forces of the house of Godwine and of the Normans Godwine was probably a native of Sussex, and by the end of the Confessor's reign a third part of the county was in the hands of his family Norman influence was strong in Sussex before the Conquest, the harbours of Hastings, Rye, Winchelsea and Steyning being in the power of the Norman abbey of Fécamp

Hastings and Pevensey were important under the Normans, being on the most direct route for Normandy William secured communication with London by placing the lands in the hands of such men as his half-brother, the count of Mortain, who held Pevensey, and his son-in-law, William de Warenne, who held Lewes With the exception of lands held by the Church and the Crown, the five rapes of Sussex were held by these and three other Norman tenants-in-chief. William de Braose, the count of Eu, and Roger, earl of Montgomery, who held respectively Bramber, Hastings and Arundel The honour of Battle was afterwards made into a rape by the Conqueror, and provides one of the arguments in favour of the theory of the Norman origin of these unique divisions of the county. The county was divided into five (afterwards six) strips, running north and south, and having each a town of military, commercial and maritime importance.

These were the rapes, and each had its sheriff, in addition to the sheriff of the whole county. Whether the origin of the rapes, as districts, is to be found in the Icelandic territorial division hreppr (rejected in the New English Dictionary), or in the Saxon rap, a rope, or is of Norman origin, as lordships they owed their existence to the Normans. The holdings—which had been scattered under the Saxons, so that one man's holding might be in more than one rape—were now determined, not by the manors in which they lay, but by the borders of the rape Another peculiarity of the division of land in Sussex is that, apparently, each hide of land had eight instead of the usual four virgates

The county boundary was long and somewhat indeterminate on the north, owing to the dense forest of Andredsweald, which was uninhabited till the 11th century Evidence of this is seen in Domesday Book by the survey of Worth and Lodsworth under Surrey, and also by the fact that as late as 1834 the present parishes of North and South Amersham in Sussex were part of Hampshire. At the time of Domesday Sussex contained 60 hundreds, since become 66. These courts were in the hands, either of the Church, or of great lords. The county court was held at Lewes and Shoreham until the Great Inquest, when it was moved to Chichester. After several changes the act of 1504 arranged for it to be held alternately at Lewes and Chichester.

The chief ecclesiastical franchises were those of the archbishoo of Canterbury, of the bishop of Chichester, of the Saxon foundathe of Bosham, and of the votive abbey of Battle, founded by the Conqueror. This abbey possessed, besides land in many other counties, the "Lowy of Battle," a district extending for 3 m, round The see of Chichester was co-extensive with the the abbey. county, and has altered little. It is one of the oldest bishoprics. having been founded by Wilfred at Selsey; the seat was removed to Chichester by William I.

Sussex was constantly the scene of invasions and rebellions, Pevensey and Arundel playing a great part in the latter under the early Norman kings In the barons' wars the county was a centre for the king's forces, Lewes being in the hands of the king's brother-in-law, John de Warenne, earl of Surrey, Pevensey and Hastings in those of his uncle, Peter of Savoy. The forces of the king and of De Montfort met at Lewes, where the famous 622 SUSSEX

battle and "Mise of Lewes" took place. Corrupt administration during the 13th and 14th centuries, constant passage of troops for the French wars and the devastating plagues of the 14th century, were the causes of such rebellions as the Peasants' Rising (1381) and Jack Cade's Rebellion (1450). During Elizabeth's reign there was constant levying of troops for Flanders and the Low Countries, and preparations for defense against Spain. The sympathies of the county were divided during the Civil War, Arundel and Chichester being held for the king, Lewes and the Cinque Ports for the parliament Chichester and Arundel were besieged by Waller, and the Roundheads gained a strong hold on the county, in spite of the loyalty of Sir Edward Ford, sheriff of Sussex A Royalist gathering in the west of the county in 1645 caused preparations for resistance at Chichester. In the same year the "Clubmen" rose and tried to force terms. During the French Revolution, Sussex produced many volunteers. At the outbreak of war with France (1793) a camp was formed at Brighton and at Eastbourne (1803) when the famous Martello towers were erected

In 1200 we have the first extant return of knights of the shire. Drastic reformation was effected by the Redistribution act of 1832, when Bramber, East Grinstead, Seaford, Steyning and Winchelsea were disfranchised after returning two members each, the first being classed among the worst of the "rotten" boroughs. Before 1832 two members each had been returned also by Arundel, Chichester, Hastings, Horsham, Lewes, Midhurst, New Shoreham (with the rape of Bramber) and Rye Arundel, Horsham, Midhurst and Rye were each deprived of a member in 1832. Chichester and Lewes in 1867, and Hastings in 1885. Arundel was disfranchised in 1868, and Chichester, Horsham, Midhurst, New Shoreham and Rye in 1885. In the 18th century the duke of Newcastle was all-powerful in the county, where the Pelham family had been settled from the time of Edward I, the earl of Chichester being the present representative of the family.

Architecture.-Sussex is rich in ancient castles. Lewes and Bramber are in ruins, but Arundel is still the seat of the dukes of Norfolk More famous than these are the massive remains (part Norman, mainly 13th century), of Pevensey, within the walls of Roman Anderida. Other ruins are those of the finely situated Hastings castle; the Norman remains at Knepp near West Grinstead; the remarkably perfect moated fortress of Bodiam (14th century); and Hurstmonceaux Castle (15th-century brick)

Monastic remains are few. The ruins of Bayham abbey near Tunbridge Wells, and of Battle abbey, may be noticed There are numerous churches of great interest and beauty, Of these may be mentioned the cathedral of Chichester, the churches of Shoreham and Rye, and the mother church of Worthing at Broadwater. Construction of pre-Norman date is seen in the churches of Bosham, Sompting and, most notably, Worth. There is very rich Norman work of various dates in the church of St. Nicholas Steyning Several perfect specimens of small Early English churches are found, as at West Tarring, and at Climping, near Littlehampton. Perhaps the most interesting church in the county is the magnificent Decorated fragment at Winchelsea; another noteworthy church of this period is at Etchingham, near the eastern border. The church of St. Denis, Midhurst, is mainly Perpendicular; the large church at Fletching contains the tomb of Gibbon the historian. At Cowfold, southeast of Horsham, is a great Carthusian monastery, founded in 1877.

Dialect.-A large number of Saxon words are retained and pronounced in the old style; thus gate becomes ge-at. The letter a is very broad in all words, as if followed by u, and in fact converts words of one syllable into words of two, as faus (face), tasist (taste), etc. Again, a before double d becomes ar, as arder and larder for adder and ladder; of is like a long i, as spile (spoil), intment (ointment); an e is substituted for a in such words as rag, flag, etc. The French refugees in the 16th and 17th centuries in-

troduced many words which are still in use

Agriculture.- The soil is fertile and 57.2% was under cultivation in 1939. Of this, however, only 134,723 ac, or 25,4%, was arable land. Sussex is still one of the best-wooded counties in

England, oaks are typical of the Weald and the beech of the lighter chalk lands. The Weald, the Downs and the salt marshes provide different types of pasture Weald farms often possess marsh pastures, and transhumance takes place between the two Many cattle are raised (153,483 in 1939), especially in East Sussex, and are sent from the Weald to fatten on the marshes in April and May. Sheep (Southdown and Kent) are important (228,329 in 1939), and lambs raised on the eastern marshes are often sent to the Weald to winter The south slopes of the Downs and the coastal plain at their feet, west of Shoreham, form an early region for lambs, with good arable on which both sheep and lambs can be fattened, the latter for early markets. Sheep-rearing has given rise to several fairs .- Findon (July 12 and Sept. 14); Battle (Sept. 6); Mayfield (May 30 and Nov 13); and Lewes, the most important fair of the year (Sept 25), Large sales are also held, notably at Chichester, in August Dairving is important Shorthorns and Jerseys (for butter) are the chief breeds Fruit and hops are important crops on the heavy lands of East Sussex, root-crops (including sugar beet, the output of which had inreased to 2,775 ac in 1939) and grain (wheat and oats) are grown in both, but especially in West Sussex Milk, poultry, early fruit and flowers are increasingly supplied to London and other markets. The National Trust owned 2,963 ac in Sussex in 1942.

Industries.—The industries are mostly limited to minor ones connected with agriculture (brewing, tanning, etc.), though cement is made to some extent. They were formerly very varied. The furnaces for the Wealden iron industry, which dates back probably to pre-Roman times, were chiefly in Sussex. Clay gave rise to pottery and brick-making Glass-making (with fine Hastings sand) flourished at Chiddingfold (Surrey), and at Westborough Green, Loxwood and Petworth in Sussex, Weaving and fulling were also carried on, Chichester being noted for its cloth The shores abound in shellfish, and both fresh-water and sea fishing are very important; the herring-fisheries and the salt-pans on the

coast are noted in Domesday,

Communications.-The Southern railway runs from London to Hastings, St. Leonards, Bexhill, Eastbourne, to Lewes and Newhaven, to Brighton, to Shoreham, and to Arundel, Chichester and Selsey, with numerous branches and a line along the coast. There are no good harbours, and none of the ports is of first importance, From Newhaven, however, a large trade is ordinarily carried on with France, and daily passenger steamers ply to Dieppe.

Population and Administration.—The earliest statement

as to the population is made by Bede, who describes the county as containing in the year 681 land of 7,000 families; allowing ten to a family (not an unreasonable estimate at that date), the total population would be 70,000. In 1693 the county is stated to have contained 21,537 houses. If seven were allowed to a house at that date, the total population would be 150,759. It is curious, therefore, to observe that in 1801 the population was only 150. 311. The decline of the Sussex iron works probably accounts for the small increase of population during several centuries, although after the massacre of St. Bartholomew upwards of 1,500 Huguenots landed at Rye, and in 1685, after the revocation of the Edict of Nantes, other refugees arrived.

An act of Henry VII (1504) directed that for convenience the county court should be held at Lewes as well as at Chichester, and this apparently gave rise to the division of Sussex into east and west parts, each of which is an administrative county East Sussex has an area of 780.7 sq.mi, and West Sussex 628 sq.mi, with populations estimated in 1938 at 566,680 and 264,900 respectively. Between Sept. 1939 and Feb. 1941 wartime population movements caused a decrease in the population of East Sussex of 12%, this area being close to the path of invading aircraft, but that of West Sussex increased by 5%. East Sussex includes the county boroughs of Brighton, Hastings and Eastbourne, the first two being also parliamentary boroughs, and the municipal boroughs of Bexhill, Hove, Lewes and Rye. In West Sussex the municipal boroughs are Arundel, Chichester (a city), and Worthing The geographical county is almost entirely in the diocese of Chichester. The total number of civil parishes is 271. Sussex is

divided into the following parliamentary divisions. Eastbourne, East Grinstead, Lewes, Rye, Chichester, and Horsham and Worthing, each returning one member. Brighton returns two members, and Hastings, one member.

and Hastungs, one member.

Brancosarur—See T. W. Horsfield, History, Antiquities and
Topography of Sustex (Lewes, 1285), J. Dallaway, History of the
Westen Distunct of Suscetand, 185-243); M. A. Lower, Hustory
of Sustex (Lewes, 1870), Churches of Susceta (Brighton, 1873) and
Collections, W. E. Barker, Downedy Book for Collections, W. E. Barker, Downedy Book for
1876), Sawyer, Sustex Natural History and Folklore (Brighton, 1884),
Susver Dalleet (Brighton, 1884) and Sustex Songrad Maus (Brighton, 1884),
1881), A. J. C. Hare, Sustex (London, 1804); A. Hadrian Allcroft,
Earthwork of Brighand (1905); Vircinal County History, Sustex.

SUSSEX, KINGDOM OF (Sid Seare, ie, the South Saxons), one of the kingdoms of Anglo-Saxon Britan, the boundaries of which choincide in general with those of the modern county of Sussex. According to the tradition given in the Anglo-Saxon Chronicle, it was in 47 that a certain Ella (Aelle) eld the invaders ashore at a place called Cymenes ora and defeated the inhabitants. A further battle at a place called Mearcredesburne is recorded for 485, and in the annal for 49 twee read that Ella and Class has son sacked Anderda (Pevensey) and slew the inhabitants Ella is the first king of the invading race whom Bede describes as exercising supremacy over the southern English

The history of Sussex now becomes a blank until 607 when Ceolwulf of Wessex is found fighting against the South Saxons In 681 Wilfrid of York, on his expulsion from Northumbria by Eggfrith, retired into Sussex, where he remained until 686 converting its pagan inhabitants. According to Bede, Aethelwald, king of Sussex, had been previously baptized in Mercia at the suggestion of Wulfhere, who presented him with the Isle of Wight and the district about the river Meon in Hampshire After Wilfrid's exertions in relieving a famine which occurred in Sussex the king granted to him eighty-seven hides in and near the peninsula of Selsey which, with a lapse until 709 after Wilfrid's retirement, remained the seat of the South Saxon bishopric until the Norman Conquest. Shortly afterwards, however, Aethelwald was slain and his kingdom ravaged by the exiled West Saxon prince Ceadwalla. The latter was eventually expelled by two princes Berhthun and Andhun, who assumed the government of the kingdom. In 686 the South Saxons attacked Hlothhere, king of Kent, in support of his nephew Eadric, but soon afterwards Berhthun was killed and the kingdom subjugated for a time by Ceadwalla, who had now become king of Wessex.

Of the later South Saxon kings we have little knowledge. In 602 a grant is made by a king called Nothelm to his sister, which is witnessed by two other kings called Nunna and "Uuattus" Nunna is probably to be identified with Nun, described in the Chronicle as the kinsman of Ine of Wessex who fought with him against Gerent, king of the West Welsh, in 710. According to Bede, Sussex was subject to Ine for many years. A grant, dated by Birch about 725, is made by Nunna to Eadberht, bishop of Selsey, and to this too "Uuattus" appears as a witness In 722 we find Ine of Wessex at war with the South Saxons, apparently because they were supporting a certain Aldbryht, probably an exile from Wessex. An undated grant is made by Nunna about this time, which is witnessed by a King Aethelberht. After this we hear nothing more until shortly before 765, when a grant of land is made by a king named Aldwulf with two other kings, Aelfwald and Oslac, as witnesses. In 765 and 770 grants are made by a King Osmund, the latter of which is witnessed by Offa of Mercia. Offa also appears as witness to two charters of an Aethelberht, king of the South Saxons, and in 772 he grants land himself in Sussex, with Oswald, dux of the South Saxons, as a witness. It is probable that about this time Offa definitely annexed the kingdom of Sussex, as several persons, Osmund, Aelfwald and Oslac, who had previously used the royal title, now sign with that of dux. In 825 the South Saxons submitted to Ecgberht, and from this time they remained subject to the West Saxon dynasty.

AUTHORITIES.—Anglo-Sazon Chronicle, pp. 449, 477, 485, 491, 607, 722, 725, 823, 827 (ed. Earle and Plummer, Oxford, 1899); Bede, Historia Ecclesiastica, i. r., ii. s. iv. 13, 15, 16, 26, v. 18, 10, 32, 6d. C. Plummer, Oxford, 1896); W. de G. Birch, Cartularium

Saxonicum, Nos 78, 144, 145, 197, 198, 206, 208, 211, 212, 1334 (1885-93). (F. G. M. B)

SUSU, a tall people of French Guinea and Sierra Leone, with pleasant countenances, oval in shape, who tattoo three lines on the breast and beneath the eye. They live in confederate villages under a paramount chief, the houses of one family grouped together. Their material culture is fairly advanced. Marriage is usual between cross counts and between the husband's brother and widow Polysamy, with headship of the first wife, is common. Inheritance is patrinined. The Susu have politicor-elapious confraternities, known as Simo, including as a rule three degrees for men. Their religion is animate but influenced by Islam Susu is also the name of the fresh-water dolphin of the Ganges; it is blind, fish-eating and pale in colour (Gee CEALCA).

See Arcin, La Guinée Française (1907); N. W. Thomas, Report on the Timne-speaking Peoples (1016).

SUTHERLAND, EARLS AND DUKES OF. The first card of Sutherland was a certain William (d. 1742), whose father, Hugh Freskin (d 1204), acquired the district of Sutherland about 1179. Probably about 1230 William was created earl of Sutherland. His descendant William, the 4th earl (d 1370), was a person of some importance in the history of Sootland; he married Margaret (d. 1378), daughter of King Robert Bruce. His descendant John, the 9th earl, died unmarried in 1514.

John's sister Elizabeth (d. 1535) married Adam Gordon (d. 1537), a younger son of George Gordon, and earl of Huntly, and a grandson of King James I, and before 1516 Gordon became earl of Sutherland by right of his wife. He was succeeded by his grandson John (c, 1526-1567), the 2nd earl of his line, who was poisoned at the instigation of George Sinclair, 4th earl of Carthness. His great-grandson John, the 5th earl (1609-1663), was a strong Covenanter, being called by his associates "the good Earl John"; he fought against Montrose at Auldearn, but afterwards he rendered good service to Charles II. John Gordon (c 1660-1733), who became the seventh earl in 1703, supported the revolution of 1688 and was a commissioner for the union of England and Scotland. He was a Scottish representative peer in four parliaments, president of the board of trade and manufactures. and lord-lieutenant of the eight northern counties of Scotland. He was active in putting down the rising of 1715 This earl, who took the name of Sutherland instead of that of Gordon, was succeeded by his grandson William (c. 1708-1750), a representative peer, who helped to suppress the rebellion of 1745 William, the next earl, died without male issue in 1766, his daughter Elizabeth (1765-1839) claiming the peerage. Her title thereto was confirmed by the House of Lords in 1771.

Established in the possession of the title and estates of the earldom, the countess of Sutherland was married in 1785 to George Granville Leveson-Gower (1758-1833), who succeeded his father as 2nd marquess of Stafford in 1803. In addition to the estates of the marquessate of Stafford, Leveson-Gower inherited the Bridgewater Canal and estates from his maternal uncle. Francis Egerton, 2nd duke of Bridgewater, and these properties, together with his wife's estates, which included almost the whole of the county of Sutherland, made him a "leviathan of wealth," as he is called by Charles Greville. In 1833 he was created duke of Sutherland. Leveson-Gower was a member of parliament from 1778 to 1784, and again from 1787 to 1798 and was British ambassador in Paris from 1790 to 1792. From 1799 to 1810 he was joint postmaster-general. He was a collector of paintings, and purchased Stafford House, London He was responsible for the construction of about 450 m. of road and of many bridges, but his policy of removing a large number of his tenants from the interior to the coast aroused bitterness and criticism. However, he reduced rents and brought thousands of acres into cultivation. He died at Dunrobin Castle on July 5, 1813

See Sir Robert Gordon and George Gordon, Genealogical History of the Earldom of Sutherland (Edinburgh, 1813); and also the articles Staffore; and Buckmunham, Earls, Marquessess and Dukes or.

SUTHERLANDSHIRE, county, northern Scotland, bounded north and west by the Atlantic, east by Cathness, southeast by the North Sea and south by the shire of Ross and Cro-

marty Land area, 1,297,914 ac or 2,028 sqmi The western and bridges Attempts were made to repeople some of the glens and northern shores are indented with beautiful bays and sealochs, and terminate at many points in precipices and rugged headlands Almost the whole county is mountainous, the summits are often of finer outline than those of the Grampian heights to the south, and the surface generally consists of wild desolate moorland The highest point is Ben More in Assynt (3,273 ft )

An irregular line from Loch Eriboll on the north coast to the neighbourhood of Cromalt near the southern boundary separates the two rock groups that form the foundation of the major portion of the county. On the western side of this line are ancient gneisses and schists (the Lewisian gneiss), these are penetrated by innumerable basic and acid dikes which generally have a northwest to southeast trend. On the eastern side of the line, occupying the whole of the remaining area except the eastern fringe of the county, is a younger series of metamorphic rocks, the Moine schists. In the northwest Torridonian breccias and sandstones rest unconformably on this gness, and Cambrian rocks upon the Torridonian, the white Cambrian quartzite capping the dark Torridonian rocks on some of the hills forms a striking scenic feature. Granite masses appear in the eastern schists, and patches of Old Red Sandstone form high land near the southeast coast. Evidence of glacial action is widespread

The chief river is the Oykell, which, rising in Coniveall (3,234), a peak of Ben More, flows south and then southeast for 33 mi, to Dornoch firth. Other rivers flowing to Dornoch firth are the Helmsdale (22 mi.), the Brora (28 mi.), preserving in its name (bridge river) the fact that its bridge was once the only important one in the county; and the Fleet (17 mi), the estuary of which was embanked for 1,000 yd. in 1813 by Thomas Telford, whereby rich alluvial land was reclaimed. The Halladale (22 mi), rising in Knockfin on the borders of Caithness enters the sea to the east of Portskerry The district of Assynt is honeycombed with lakes and tarns, but the only large lake is Loch Assynt, 63 mi long, 215 ft, above the sea. The ratio of the area of islands to the total area of the lake is greater than in any other British lake. There are many waterfalls, those of Escuallin, near the head of Glencoul.

are among the finest in Great Britain.

History and Antiquities .- Of the prehistoric inhabitants, there are considerable remains in the form of many brocks (or round towers), Picts' houses, tumuli, carms and hut circles. Dun Dornadilla, in the parish of Durness, 4 mi. south of Loch Hope, is a tower, 150 ft. in circumference, still in good preservation The Noise jarl Thorfinn overran the country in 1034 and the Scandinavian colonists called it, in relation to their settlements in the Orkneys and Shetlands, Sudrland, the "southern land," or Sutherland. After the conquest of the district by the Scottish kings, Sutherland was conferred on Hugh Freskin (a descendant of Freskin of Moravia or Moray), whose son William was created earl of Sutherland in 1228 by Alexander II. On the south shore of Helmsdale creek stand the ruins of the castle in which the 11th earl of Sutherland and his wife were poisoned by his uncle's widow in 1567, with a view to securing the title for her only child, who was next of kin to the earl and his son, Ardvreck castle, now in ruins, at the east end of Loch Assynt, was the prison of the marquis of Montrose after his defeat at Invercarron (1650), whence he was delivered up by Neil Macleod of Assynt for execution at Edinburgh. In the graveyard of the old church of Durness is a monument to Robert Mackay, called Rob Donn (the brown), the Gaelic poet (1714-1778).

Agriculture and Industry.-Only about 12% of the total area was arable land in 1938, the shire ranking lowest in Scotland in this respect. The great mass of the surface is grazing ground and deer forest. The best land adjoins Dornoch firth, where farming is in an advanced condition, but there are fertile patches along the river valleys. At the beginning of the 10th century the first duke of Sutherland (then marquess of Stafford) adopted a policy of wholesale clearance of the crowded crofters of the interior to the coast. The duke incurred great obloquy, but persisted in his policy, which included reduction of rent, reclamation of land, and abolition of the tacksman or middleman He also did much to open up the shire generally by the construction of roads

(Strathnaver, for example) depopulated by the clearances. Crofters still largely predominate, over half the 2,339 holdings in 1938 being 5 ac. or under The average size, 13 ac, is the smallest in Scotland, excepting the Shetland Islands Oats, turnips and swedes, and potatoes are grown The raising of sheep (218,454 in 1938), mostly Cheviot, is the staple business of the county, and cattle are also kept Horses-principally ponies, though Clydes-dales are used on the bigger farms-are kept almost wholly for agricultural purposes. Deer forests belonging to the duke of Sutherland cover a large area

Next to agriculture, the deep-sea fisheries and the salmon fisheries in the rivers are the most important interest. Helmsdale and Golspie are fishing villages. Herrings are the principal catch, but cod, ling and other fishes are also taken. Whisky is distilled at Brora; some woollens are manufactured at Brora and Rogart; coal is mined at Brora, and limestone and sandstone quarried The exceptional facilities offered by the deer forests, moors and the many lochs and rivers attract large numbers of sportsmen, and Dornoch and Lochinver are in repute as holiday resorts The L,MS, railway enters the county at Invershin, goes northward to Lairg, then east to Brora and northeast to Helmsdale, whence it runs northwest to Kildonan, and north to Forsmard, where it shortly afterwards leaves the shire The Glasgow steamers call at Lochinver about every ten days.

Population and Administration.—The population was estimated in 1938 at 15,293 In 1931 Gaelic and English were spoken by 6,770 persons, of whom 24 spoke Gaelic only. The county is the least densely populated in Scotland Several islands lie off the west and north coast, but only Roan (61) and Chorrie (1) are inhabited Dornoch (est. 1938 pop, 676) is the only royal burgh and small burgh. There are six county districts. The shire returns one member to parliament with Caithness, and forms a joint sheriffdom with Ross and Cromarty, with a sheriff-substitute resident at Dornoch The county is under school-board jurisdiction

SUTLEJ, river, India, one of the "Five Rivers" of the Punjab It rises E.S.E. of the Manasarowar lakes in Tibet, at an elevation of about 15,200 ft., threads its way through the gorges of the Himalayas with heights of 20,000 ft. on either side, crosses Bashahr and the Sımla hill states, and enters the British district of Hoshiarpur, Thence it flows through the plains of the Punjab, receives the Beas in Kapurthala state, and joins the Chenab near Madwala From that point the whole river bears the name of Panjnad ("five rivers") until it falls into the Indus near Mithankot after a course of 900 mi.

The Sutlei supplies the Sirhind canal, which draws off its waters at Rupar, 100 mi. above the junction with the Beas; and the Upper and Lower Sutlej systems, which come below the junction. These irrigate altogether some 1,600,000 ac. Extensions include 3 new weirs on the Sutlej and 1 on the Chenab, irrigating over 5,000,000 ac.

SUTRI (anc. Sutrium), an episcopal town of Italy, 4 mi. from the railway station of Capranica, which is 36 mi. from Rome, 955 ft. above sea level Pop. (1936), 2,556 (town), 2,918 (commune). The town is on a hill surrounded by ravines, a narrow neck connecting it with the surrounding country. There are some remains of ancient city walls. The crypt of the cathedral, with twenty columns, is Romanesque, and the campanile dates from 1207. In the cliffs to the south is the rock-cut church of the Madonna del Parto. formerly a Mithraeum; and close by is a rock-hewn amphitheatre, with axes of 55 and 44 yd., now most picturesque Sutri, commanding the Via Cassia, is spoken of by Livy as one of the keys of Etruria, Nepet being the other. It came into the hands of Rome after the fall of Veii. Its importance explains, according to Festus, the proverb Sutrium ire, of one who goes on important business, as it occurs in Plautus.

SUTTEE, the Indian practice of concremation of a widow on the pyre of her deceased husband (Sanskr. sati, "true" wife). Whether the usage existed in Vedic India has been hotly debated World-wide primitive usage compelled a widow to be the wife of her husband's brother or near kinsman or, if he had been of princely standing, to be immolated with his concubines, slaves steeds, stc., at his tomb, to maintain his dignity in the next world. This usage eventually found priestly support in the Handu conception of materimony as a bond eternally renewed when the married pair were reborn in succeeding irves—a concept, hard to reconcile with polygony. In late Hindu myth Sati was Sava's, spouse who, resenting a slight but upon her lord by her father, destroyed herself but was reincarnated as Una, the beautious wife of Swa Here Sati's act is promptled by a very different mortuse, and the tale supports the view that the text of the Rig-Veda was tampered with, to support the Brahmancal light.

According to Diodorus Siculus, Strabo and St. Jerome, Suttee existed in the 4th century so In mediaeval India the practice flourished among the Rapuls—and where Briahman influences were strong. The Sait too began to be worshiped as a Maha Sait or "great and true" wife, commentated by a stone. Yet reformers denounced the usage, as in Malabar. Even the Brahmani-all jurist sometimes deprecated soft, allowing the widow the option of living an ascetic life, with rights of inheritance. The Jans do not practice saif Buddhism probably discouraged it Sichism expressly forbade it, yet on Ranjit Singh's death in 1839, several of his widows were burnt. Outside British juristiction, saif continued in families of high rank until late in the 19th century. In British territory, it was not till 1820 that Lord Wilham Bentinck, with some support from Indian opinion (see Baarma Sanda) was able, despite strong protests, to make it a statutory offence

BIBLIOGRAPHY.—H. Yule and A C Burnell, Hobson-Jobson (ed W. Crooke, 1903) gives full extracts from ancient and modern writers on the practice; J Jolly, Recht und Sitte (Strassburg, 1917)

SUTTER. JOHN AUGUSTUS (1803-1880), American pioneer, was born of Swiss parents at Kandern in the Grand Duchy of Baden on Feb 15, 1803. He came to America in 1834 and purchased land in Missours, but in 1838 went overland to California by way of the Oregon trail Here he was given a grant of 49,000 ac of land on the Sacramento river by the Mexican governor on condition that he would fortify and develop it into a strong Mexican outpost. Sutter became a citizen of Mexico and was appointed "Commissioner of Justice and Representative of the Government on the Frontier of the Rio del Sacramento" He built not only a strong fort and other buildings but a mill. tannery, distillery, blanket factory, blacksmith and other shops, for which he hired skilled workers. He imported Hawaiians and hired Indians to cultivate the land. He traded with the Indians for furs and purchased a schooner and other boats which plied on the Sacramento More land was acquired and he rapidly became wealthy. His settlement, "New Helvetia," became a rendezvous for adventurers, sailors, trappers and hunters and for an increasing number of Americans. His growing strength and independence and, above all, his hospitality to the Americans, made him the object of increasing hostility on the part of the Mexican authorities. In 1846 when the Bear Flag revolt took place and Frémont (q.v.) arrived with American troops, Sutter at first maintained an appearance of fidelity to the Mexican Government However, he made but little objection when Frémont took control of his fort and made use of his property. After California was acquired by the United States and settlement became more rapid Sutter felt the need of a new mill. It was while digging the mill race that the famous discovery of gold in California (1848) was made. Sutter tried to keep the strike a secret, but in vain, and his property was soon overrun by gold seekers from whom he could not protect himself What was worse, the U.S. Supreme Court found the title to 98,000 ac of his land invalid. Much of what was left him was used to reimburse those to whom he had granted subtitles which he was forced to make good. Soon he was bankrupt. From 1871 to the year of his death he petitioned Congress annually for some reimbursement for his services. He died at Washington, D.C., on June 18, 1880, the evening after Congress

had again adjourned without recognition of his claims
See B. Cendrars, Sutter's Gold (1946); T. J. Schoonover, Life and
Times of General J. A. Sutter (1907); "John A. Sutter" in Society of
California Pioneers' Quarterly, vol. v., pp. 39-53, 85-702 (1928).

SUTTNER, BERTHA, BARONESS von (1843-1914), Austrian writer, was born at Prague on July 9, 1843, the daughter of and wool hosiery.

Count Franz Kınsky, Austrian field marshal. Through her mother she was related to the German poet, Theodor Korner She gunte intended in the German poet, Theodor Korner She gunte in the Francis in the State of the Caucaus After 1845 (360–1902), and for marshall the marshall the Caucaus After 1845 she readed Schloss Harman and in Lower Austria. A fertile write, her most famous tales and tracts denounce war, for instance, Due Weglen mider (1889), Krieg und Frieden (1866), Das Maximten Zestater, Zukuntis-Vorleuungen über unsere Zest (1899) and Der Hanger Friedenkonferens (1900) She founded the Austrian Society of Peace-lowers in 1891, and edited the monthly organ of the peace-movement, Die Weglen Neder, established in Dreseden in 1892 In 1905 she was awarded a Nobel prize of £5,000 for her peace prospanda. She died at Vienan of June 21, 1914.

Her Memoiren were published at Stuttgart in 1908. See also H. v. der Mandere, Bertha Suttner (1909)

SUTTON, SIR RICHARD (d. c. 1524), the founder, with William Smyth, bashop of Lincoln, of Braseness college, Oxford, and the first lay founder of any college, was a barrister by profession, and in 1497 became a member of the privy council In 1513 he became a testend of the monastery of Sion, a house of Brigittine nuns at Isleworth. In 1508 Sutton obtained a 92 year lease of Brasenose Hall and Little University Hall for 15 per annum, and from that time until the end of his life was occupied in purchasing estates with which he might endow the new college.

in putchasing estates with which he might endow the new Contege SUTTON, THOMAS (c. 1532—1611), founder of Charterhouse school and hospital, obtained great wealth by the ownership of coal mines in Durham and also by his marriage in 1587 with Elizabeth and the coal of the

SUTTON AND CHEAM, a municipal borough in the Epsom parliamentary division of Surrey, England, 1r mi. S. of London by the Southern railway Pop. (est. 1938) 75,586 Area, 6.8 sq mi. It adjoins the Banstead downs. The manor of Sutton, according to Domesday, belonged to the abboy of Chertsey and continued so until the dissolution of the monasteries by Henry VIII The antition iestablishment of the London county council is there. The town owes its growth to its suitability as a residential area for workers in London, It was morporated in 1931.

SUTTON-IN-ASHFIELD, market town and urban district in Nothinghamshire, England, on the border of Sherwood Forest, on the L.M.S.R. and L.M.E.R., 13 mi. N. of Nothingham. Pop. (est. 1938) 38,510. Area, 16.4 sq.mi. The 13th-century church of St. Mary Magdalene was restored in 1868. There are several colleires in the district and manufactures of cotton, thread, silk and wool hosiery.

SUYÓROV, ALEXANDER VASILIEVICH, COUNT SUVÓROV into the forests. Its trade includes timber and grain. Suwalki RIMNIKSEY, PRINCE ITALYSKY (1729-1800), Russian field mar- was taken by the U.S.S.R. in 1939 and by Germany in 1941. shal, was born at Moscow on Nov. 24, 1729, the descendant of a Swede named Suvor who emigrated to Russia in 1622. He entered the army as a boy, served against the Swedes in Finland and against the Prussians during the Seven Years' War. After repeatedly distinguishing himself in battle he was made a colonel in 1762. He next served in Poland, dispersed the Polish forces under Pulawski, stormed Cracow (1768) and was made a majorgeneral

In his first campaigns against the Turks in 1773-74, and particularly in the battle of Kosludscki in the latter year, he laid

the foundations of his reputation.

From 1787 to 1791 he was again fighting the Turks and won many victories; he was wounded at Kinburn (1787), took part in the siege of Ochakov, and in 1788 won two great victories at Focsani and on the Rimnik. For the latter victory, in which an Austrian corps under Prince Josias of Saxe-Coburg participated, Catherine II made him a count with the name Rimniksky in addition to his own name, and the emperor Joseph II created him a count of the Holy Roman Empire.

On Dec. 22, 1790, Suvórov stormed Ismail in Bessarabia, and the sack and the massacre that followed the capture equals in horror such events as the "Spanish Fury" and the fall of Magde-burg. He was next placed at the head of the army which subdued the Poles, and repeated the triumph, and some of the cruelties, of Ismail at Warsaw. He was now made a field marshal, and was retained in Poland till 1795, when he returned to St. Petersburg. His sovereign and friend Catherine II died in 1706, and her

successor Paul dismissed the veteran in disgrace. But in February 1700 he was summoned by the tsar to take the field again, this

time against the French Revolutionary armies in Italy.

The campaign (see French Revolutionary Wars) opened with a series of victories (Cassano, Trebbia, Novi) which reduced the French government to desperate straits and drove every French soldier from Italy, save for the handful under Moreau, which maintained a foothold in the Maritime Alps and around Genoa, Suvórov himself was made a prince. But the later events of the eventful year went uniformly against the allies. Suvórov's lieutenant Korsákov was defeated by Masséna at Zúrich, and the old field marshal, seeking to make his way over the Swiss passes to the Upper Rhine, had to retreat to the Vorarlberg, where the army, much shattered and almost destitute of horses and artillery, went into winter quarters.

Early in 1800 Suvorov returned to St. Petersburg in disgrace. Paul refused to give him an audience, and, worn out and ill, he died a few days afterwards, on May 18, 1800. But within a year of his death the tsar Alexander I erected a statue to his memory

in the Field of Mars, St. Petersburg,

Suvórov spared his own soldiers as little as he showed mercy to the population of a fallen city. He was a man of great simplicity of manners, and while on a campaign lived as a private soldier. But he had himself passed through all the gradations of military service. His gibes procured him many enemies. He had all the contempt of a man of ability and action for ignorant favourites and ornamental carpet-knights. Dragomirov (q,v.) avowed that his teaching was based on Suvórov's practice. Byron has given Suvórov a place in English literature in certain cantos of Don Juan.

of Don Huan,

See Anthing, Vernuch einer Kriegsgandichte des Grafen Swuoreus

(Gotha, 1796–1799); F. von Smitt, Swuoreus Leben und Heersige

(Villan, 1833–1844) and Swuorous und Poleus Untergang (Leipzig,
1838); Von Reding-Biberegg, Der Zug Suuorous durch die Schwele

(Zürich, 1894); Leitet-Colonel Solding, Swudroft (Condon, 1890);

G. von Fetch, Suuorous Kortespondens, 1799 (Glogau, 1835);

and the standard Russidan hospadika of Polevol (1833; Ger.

trans, Mitsu, 1853); Rybkin (Gloscow, 184) and Vasiliev (Villan,

1860).

1869). SUWALKI, a town of Poland, in the province of Bialystok, 65 m, by rail N.W. of Grodno. Pop. 21,539. The town grew up in the wild borderland between the settlements of the Teutonic Order and the Lithuanians, after the termination of the internecine

SUWARRO or SAGUARO (Cereus giganteus or Carnegiea gigantea), a remarkable tree cactus, 15 to 70 ft. high, called also giant cactus and monument cactus, native to arid districts in southern Arizona, southeastern California and Sonora, Mexico It has a stout, woody, vertically ribbed stem, I to 2 ft. in diameter, sometimes rising unbranched, like a green, fluted column, whence the name monument cactus; more frequently it bears a few large, stout, widely diverging candelabra-like branches, but occasionally it bears numerous branches which rise vertically from near the base like a group of organ pipes. Close to the top of the stem or branches it bears white flowers which are followed by crimson edible fruits. In Arizona, of which it is the floral emblem or state flower, a desert tract containing numerous fine living specimens of the tree was set apart and is now known as Saguaro National Monument. (See Cacrus)

SUYÜTİ [Abū-1 Fadhl'Abd ur-Rahmān ibn Abī Bakr Jalāl ud-Dīn us-Suyūtī] (1445-1505), Arabian encyclopaedic writer, was the son of a Turkish slave woman. His father had been cadi in Suyūt (Upper Egypt) and professor in Cairo The boy's training was taken in hand by a Sufi friend of the father He was precocious, and in 1462 was already a teacher; in 1464 he made the pilgrimage to Mecca, and in 1486 was promoted to a chair in the mosque of Bibars. From 1501 he worked in seclusion at Rauda, an island of the Nile, and there died in 1505. He was one of the

most prolific writers of the East,

A list of his works is given in C. Brockelmann's Gesch. der Arab-ischen Luteratur, in. 144-158 (Berlin, 1902). They deal with almost every branch of Moslem science and literature. Among the best known every branch of Moslem scenec and literature. Among the best known are the High fr Vilins ut-Qurini (on the excepte scenecs of the Koran), published with an analysis by A Sprenger (Calcutta, 1852–1862), published that the Politis ut-Islandia, begun by Jalili ut-Iii ut-Mahalili (1858–1864), and finshed by Suyūti, published offen in the East; and the history of the onliphs, published at Calcutta (1858) and desewhere.

SUZERAINTY. "Suzerain," a term of feudal law, is now used to describe persons or States in positions of superiority to others. Suzerain has been defined as "Qui possède un fief dont d'autres fiefs relèvent" (Littré and Dictionnaire de l'académie française). The term was rare in feudal times in England. But it was used in France to describe a feudal lord, the supreme suzerain being the king.

In modern times the term has come to be used as descriptive of relations, ill-defined and vague, which exist between powerful and dependent States; its very indefiniteness being its recommendation. According to feudal law the vassal owed certain duties to the lord; he promised fidelity and service; and the lord was bound to perform reciprocal duties, not very clearly defined, to the vassal Dominus vassallo conjux et amicus dicitur. The relation between a lord and his vassals, implied in the oath of fealty, has been extended to States of unequal power; it has been found convenient to designate certain States as vassal States, and their superiors as suzerains. Originally and properly applicable to a status recognized by feudalism, the term vassal State has been used to describe the subordinate position of certain States once parts of the Ottoman empire. Such were Egypt and Bulgaria.

M. Gairal (Le Protectorat international) distinguishes suzerainty from protectorate in these respects: (a) suzerainty proceeds from a concession on the part of the suzerain (p 112); (b) the vassal State is bound to perform specific services; and (c) the vassal State has larger powers of action than those belonging to a protected State: (d) there is reciprocity of obligation. According to M. F. Despagnet the term suzerain is applicable to a case in which a State concedes a fief, in virtue of its sovereignty (Essas sur le protectorat international, p. 46), reserving to itself certain

rights as the author of this concession.

W. E. Hall thus defines vassal States: "States under the suzerainty of others are portions of the latter which during a process of gradual disruption or by the grace of the sovereign have acquired certain of the powers of an independent community, such as that of making commercial conventions, or of conferwars between the two. Polish colonists from Masovia penetrated ring their exequatur on foreign consuls. Their position differs from that of the foregoing varieties of States (protectorates, etc.), in that a presumption exists against the possession by them of any given international capacity" (International Law, 4th ed., p. 31).

On the whole, usage seems to favour this distinction: while a protectorate flows from, or is a reduction of, the sovereignty of the protected State, suzeramty is conceived as derived from, and a reduction of, the sovereignty of the dominant State.

As to the power of making treaties, a vassal State cannot, as a rule, conclude them; such power does not exist unless it is specially given. On the other hand, a protected State, unless the contrary is stipulated, retains the power of concluding treaties.

Definitions of suzerainty are of little use. Each instrument in which the word is used must be studied in order to ascertain its significance. Even in feudal times suzerainty might be merely nominal, an instance in point being the suzerainty or over-lordship of the papacy over Naples In some cases it may be said that suzerainty brings no practical advantages and implies no serious obligations. Among the instances in which the term is actually used in treaties are these, the General Treaty, Peace of Paris, 1856 (arts. 21 and 22), recognized the suzerainty of Turkey over the Danubian principalities Moldavia and Wallachia, modifying the "sovereignty" of Turkey recognized by the Treaty of Adrianople The convention of Aug 19, 1858 (Hertslet x 1052) or-ganized the then principalities "under the suzerainty of the sultan" The internal government was to be exercised by a hospodar, who received his investiture from the sultan, the sign of vassalship The autonomy of these vassal States was fully recognized by the Treaty of Berlin of 1878. In the Interpretation Act 1889, s. 18 (5), "suzerainty" is used to describe the authority of the sovereign over native princes.

The word suzerain is used in the Pretoria convention of 1881 between the British Government and the late South African republic. The convention (by its preamble) granted to the inhabitants complete self-government, "subject to the suzeramty of her Majesty," and this suzerainty was reaffirmed in the articles. Even when the convention was being negotiated doubts arose as to its meaning, and legal authorities were divided as to its effect. It was doubtful whether territory could be ceded by the Crown of its own authority; and if the power existed the cession could, it was said, be made only by virtue of clear words. From the articles substituted in the London convention of 1884 for those of 1881, the word "suzerainty" was omitted. Fresh doubts arose as to the effect of this omission; before the outbreak of hostilities in South Africa, the British Government maintained that the preamble of 1881, by which alone any self-government was granted, was still in force, and therefore that the suzerainty-whatever it involved-remained, the Transvaal Government, on the other hand, contended that the suzeramty had been abolished by the substitution of the 1884 convention for that of 1881. (See MANDATE, PROTECTORATE, SOVEREIGNTY, SPHERES OF INFLUENCE, STATE )

Somethican vi, Grand Sol & Statementon, so the rights and duties of Susceilla and Vascal States (1829); G. Jellines, De Leber von den Statemerbundungen (Vienna, 1882); C. Bornhak, Emsettige Abbandgighelsverhöhmtes unter den moderner Statet in G. Jellines hand, Mayer's Staats und volkerrechtliche Abbandlungen Bd. I. Bett y. (1896); A. G. Meniphan, Frait de erfait philic metrentional (1918); R. (1896); A. G. Meniphan, Frait de erfait philic metrentional (1918); R. (1986); A. G. Meniphan, Frait de erfait philic metrentional (1918); R. Racht der Gegenwart Bd. 3. (Tubingen, 1908); M. G. Georganias, Dr. Racht der Gegenwart Bd. 3. (Tubingen, 1908); M. G. Georganias, Dr. La notion de Souverlandet de teon évolution (Lausann, 1911); L. Duguit, Souveraineté de teon évolution (Lausann, 1911); L. Duguit, Souveraineté de teon évolution (Lausann, 1911); L. Duguit, Souveraineté de teon évolution (Lausann, 1911); L. Duguit, Souveraineté de teon évolution (1909); 1809; I. Westlako, 'Angleterre et la république sud-africaine' in Revue de évolt internaciation (1908); A. Leu Magazine and Review, di series, vol. 1818, (1890) p. 413; Journal of the Society of Comparative Legislation, new senses, vol. 1 (1800) p. 4.13.

(1909) provide typical examples. Syabinsky painted portraits of Manes, Smetana, Masaryk and Maetellinck His work also includes etchings, woodcuts, mosacs in the Prague Labeation memori-I (1936-39), and five windows in St. Vitus cathedral, Prague (1926-0)

SVANE [or Sountino], HANS (1606-1668), Danish statesman and theologan was born on March 47, 1606, at Horses, where his father, Hans Riber, was burgomaster. His mother Anne was a darwher of the historian Hans Svaning, whose name, subsequently disced to Svane, he adopted. After seen years' residence ah: 4 Svane became professor of oriental languages at the min style of Copenhagen. In 1646 he turned to theology. He bec: bislop of Sjaelland in 1655. As a theologian he belonged to the severely orthook Lutheran school.

At the reside of 1660 he played an important political role. It was c, Svane's motan (Ort. 8) that the commons agreed to offer 'alcrick III the crown as a hereditary crown. Svane quashed the tunid attempt of the more bleral minded of the deputies to obtain from the king some sort of a constitution. He proposed the erection of a constitution. He proposed the erection of a constitution and poor rollef, anticipating to some extent the modern ministries of education and public worship, which unfortunately was not adopted The privileges which he obtained for the clergy increased the independence of the Danish Church in difficult times. Svane died on July 26, 1640.

See Detlev Gotthard Zwergius, Siellandske clerisie (Copenhagen, 1754) (R. N. B; X.)

SYEDBERG, "THEODOR (THE) (1884) Swedsh, chemist, invented the ultracentritings, a dovice, facilitating the study of colloids and high-molecular substances. Born at Cavleborg county, Swed, on Aug 30, 1884, Swedberg was educated at the University of Uppsala, where he was a professor of physical chemistry, 1972-51. He devoted himself to research in the field of colloidal chemistry, and in 7956 he was awarded the Nobel prize in chemistry "for his work (in colloids) on disperse systems."

SVEHLA, ANTONIN (1873-1032). Czech statesman, was born at Hostuvar, near Prague. He was a founder and (1900) chairman of the Caech Agrarian party. Contact with Thomas Masryk enabled him to complete the preparations for the final coup against Austra on Oct. 28, 1918, when in his capacity as were president of the Prague national committee, together with Soukup and J. Stribirny, he took over the government of the Czechosłowsk state on behalf of the Czechosłowsk state on behalf of the Czechosłowsk antional council, which in the summer of 1918 had been recognized as the Czechosłowsk state on behalf of the Czechosłowsk was the control of the Czechosłowsk was well with the summer of 1918 had been recognized as the Czechosłowsk when he formed a new coalition, reconstituted after the Oct 1925 elections, so as to include the "Big Business party." But on Marth 16, 1965, Swebla resigned. He formed his third administration on Oct. 28, 1926, two German Bohemians being included in his cabinet.

The German bourgeois group in the chamber supported him in a reversion to the four main provinces into which Czechoslovakia was divided before 1920, in preference to the county system then established.

Svehla's health failed in the autumn of 1927, and in Jan. 1929 he resigned.

(See also Czechoslovakia: History.)

SVENDBORG, a seaport of Demmatic, capital of the amticountry of its name, on the island of Fyn. Pop. (1950) 32,569. The narrow Svendborg Sund separates Fyn from the lesser islands of Taasinge (245 ft.) and Turps. Inland there is also elevated ground, the Ovinchysi. The harbour is accessible to vessels drawing 20 ft. Near the town are the ruined castle of grizold, the watering-place Christiansminde, and the orchards of Gammel Hestehave, where wine is produced.

SVENDSEN, JOHANN SEVERIN (1840-1911), Nor-

SVENDSEN, JOHANN SEVERIN (1840-1911) Norwegian composer, was born in Christiania on Sept. 30, 1840. He learned the violin from his father and, after serving in the army and touring with an orchestra, he entered the conservatorium at Lepizg through the aid of the king of Sweden. In 1883 Svendsen was at one time intimate with Wagner, his own music was not influenced by him. His works include two symphonies, a violin concerto, a romance for violin and orchestra, and Norwegian rhapsodies for the orchestra He died in Copenhagen on June 14, 1911

SVERDLOVSK (formerly Ekatermburg), chief town of the Sverdlovsk region of the Russian S F.S R. on the east foothills of the Ural mountains. It is the centre of a gold, platinum, copper and coal-mining district; its population rose from 55,488 in 1897 to 425,544 in 1939 There are copper mines and electric power plants which supply the numerous industrial undertakings, including iron, copper smelting, platinum refining, the manufacture of machinery and linen goods. There is also a jewel cutting and polishing industry, Sverdlovsk emeralds being spe-cially famous. Mining was developed there by Peter the Great in 1721 and the town was named Ekaterinburg in honour of his wife Catherine I. In 1735 a government mint for copper comage was established and later a government engineering works, and an imperial factory for the cutting and polishing of ornamental stones. In 1763 the Siberian highway was diverted to the town from Verkhoturve. This helped the two annual trading fairs, dealing mainly in cattle, cereals, iron, woollen and silk goods, and products from Siberia and central Asia. Later the town became a railway centre and developed rapidly; it is well built, with wide streets. The Cathedral of St Catherine's was completed in 1758. and that of the Epiphany in 1774 Sverdlovsk was a storm centre during the civil wars following the 1917 revolution, and it was captured by the Czech army under Gajda Later the world received news that in July 1918 the Tsar Nicholas II and his family had been executed in a house formerly belonging to a merchant named Ipatiev (ten years later Mrs Anna Tschaikovsky entered a claim that she was the Grand Duchess Anastasia, Nicholas' youngest daughter, who had been spared the fate of her family by two soldiers, one of whom she was obliged to marry; in 1939 she began suit in Berlin to recover money deposited by Nicholas in a German bank, but the case was suspended until after the war).

SVERDRUP, JOHAN (1816–1892), Norwegian statesman, was born at Jarlsberg on July 30, 1816 His father, Jakob Sverdrup, was a land steward, and the founder of the first school of agriculture in Norway. Johan entered the Storthing in 1850. He built up a strong political party, supported by the peasantry, and in 1872, secured a bill for the admission of ministers to the Storthing, which was a step to parliamentary control. King Charles XV. refused his sanction to this bill, and on its third passing in 1880 Oscar II opposed his absolute veto. Sverdrup then proposed the proclamation of the law in defiance of the king's action. The retirement of Frederik Stang removed Sverdrup's chief political opponent from the field. He was aided in his campaign by Björnstjerne Bjornson, and after a series of political crises he became prime minister in June 1884. He soon found himself at issue with Björnson on church matters, although during his term of office no fewer than eighty-nine measures, many of them involving useful reforms, became law, he failed to satisfy the extremists and was driven to rely on the moderate Liberals. He was compelled to retire in 1889, and died on Feb 17, 1892, at Christiania

SWABIA, SUABIA or SUEVIA (Ger. Schwaben), one of the stem-duchies of mediaeval Germany, taking its name from the Suevi, a tribe who inhabited the district in the first century of the Christian era. They were joined by other tribes, and the district was called Alamannia, until about the 11th century, when the form Swabia began to prevail. In 496 the Alamannı were defeated by Clovis and governed by dukes dependent on the Frankish kings. In the 7th century the people were converted to Christianity, bishoprics were founded at Augsburg and Constance, and in the 8th century abbeys at Reichenau and St. Gall. The Alamanni had gradually thrown off the Frankish yoke, but in 730 Charles Martel again reduced them to dependence.

The duchy, bounded by the Rhine, the lake of Constance, the Lech and Franconia, was ruled by the counts of Raetia, one of whom, Burkhard, took the title of duke in 917 and was

became court kapeilmeister at Copenhagen Though Svendsen his death in 926 he was succeeded by Hermann, a Franconian noble, who married his widow. When Hermann died in 948 Otto the Great gave the duchy to his own son Ludolf, who had married Hermann's daughter Ida; but he reduced the ducal privileges and appointed counts palatine to watch the royal interests Ludolf revolted and was deposed, and other dukes followed in quick succession. During these years the Swabians were loyal to the kings of the Saxon house. In 1077, Rudolph, count of Rheinfelden, as duke, was chosen German king in opposition to the emperor Henry IV, but found little support in Swabia, which was given by Henry to his faithful adherent, Frederick I, count of Hohenstaufen Frederick II succeeded his father in 1105, and was followed by Frederick III, afterwards the emperor Frederick I. The earlier Hohenstaufen increased the imperial domain in Swabia, where they received steady support, although ecclesiastical influences were very strong After numerous changes, the chief authority in Swabia in 1268 fell to the counts of Wurttemberg, the margraves of Baden, the counts palatine of Tubingen and the counts of Hohenzollern

SWABIAN LEAGUE, an association of German cities, principally in the old duchy of Swabia. The cities had attained prosperity under the Hohenstaufen emperors, but on the extinction of that house in 1268, they were ill-defended against aggression by succeeding dynasties

In 1331, 22 Swabian cities, including Ulm, Augsburg, Reutlingen and Heilbronn, formed a league at the instance of the emperor Louis the Bavarian, who in return for their support promised not to mortgage any of them to a vassal. The count of Wurttemberg was induced to join in 1340. Under Charles IV the lesser Swabian nobles began to combine against the cities, and formed the Schlegelerbund (from Schlegel, a maul). Civil war ensuing in 1367, the emperor, jealous of the growing power of the cities, endeavoured to set up a league under his own control, for the maintenance of public peace. The defeat of the city league by Eberhard II. of Württemberg in 1372, the murder of the captain of the league, and the breach of his obligations by Charles IV., led to the formation of a new league of 14 Swabian cities led by Ulm in 1376 This league triumphed over the count of Wurttemberg at Reutlingen in 1377, and the emperor having removed his ban, it assumed a permanent character, set up an arbitration court, and was rapidly extended over the Rhineland, Bavaria and Franconia. Its professed aims were the maintenance of the imperial status of the constituent cities, the security against sale or mortgage and against excessive taxation, the protection of property, trade and traffic, and the power to suppress disturbances of the peace. There is no trace of co-operation with the Hanseatic towns

For nearly a century there was no great effort at federation among the Swabian cities, though there were partial and shortlived associations. The growing anarchy in Swabia, where the cities were violently agitated by the constant infringement of their liberties (e.g., the annexation of Regensburg by Bavaria in 1486), induced Frederick III, who required men and money for the Hungarian War, to conciliate the cities by propounding a scheme of pacification and reform. His commissioner, Count Hugo of Werdenberg, met the Swabian estates at Esslingen, and on Feb. 14, 1488, the Great Swabian League was constituted. There were four constituent parties, the archduke Sigismund of Austria, Count Eberhard V. of Wurttemberg, who became the first captain of the league, the knightly league of St. George, and lastly 22 Swabian imperial cities. The league received a formal constitution with a federal council consisting of three colleges of nine councillors each, a captain and a federal court with judicial and executive powers. The armed force which was to police Swabia consisted of 12,000 foot and 1,200 horse, each party contributing one-fourth. The league gained strength by the speedy accession of Augsburg and other Swabian cities, the margraves of Brandenburg-Ansbach, Bayreuth and Baden, the four Rhenish electors, etc., and in 1400 of Maximilian, king of the Romans. whom the league had helped to rescue from the hands of the Netherlanders in 1488. It did not render him the support he recognized as such by King Henry I., the Fowler, in 919. On expected in his foreign policy, but it performed its primary work

of restoring and maintaining order with energy and efficiency. In 1492 it compelled Duke Albert of Bavaria to renounce Regensburg; in 1519 it expelled the turbulent duke, Ulrich of Wurttemberg who had seized Reutlingen, and it sold his duchy to Charles V : and in 1523 it defeated the Franconian knights who had taken up arms with Franz von Sickingen In 1525 Truchsess, the league captain, aided by the forces of Trier and the palatinate, overthrew the rebel peasants of Konigshofen on the Tauber and at Ingolstadt. The league, after several renewals, expired on Feb 2, 1534, its dissolution being due to the Reformation. Futile attempts were made to renew it, in 1535 by the Bavarian chancellor, Eck, and in 1547 by Charles V.

See E Osann, Zur Geschichte des schwäbischen Bundes (Glessen, 1361), K. Klüpfel, Urkunden zur Geschichte des schwabischen Bundes (Stuttgart, 1846-53), "Der schwabische Bund," Hist. Taschenbuch (1883-84).

SWAFFHAM, an urban district in Norfolk, England, 28 mi. W of Norwich by road, in the Southwest Norfolk parliamentary division Pop (1951) 2,863. Area 11.9 sq.mi. It is a market town and agricultural centre with a fruit-canning industry. To the south are vast plantations of the Forestry commission. The cruciform church of St. Peter and St Paul is Perpendicular, with a fine double hammerbeam roof. In the church library is the Black Book of Swaffham, one of the earliest existing church terriers. At Castle Acre, 4 mi N., are the ruins of a Cluniac priory founded shortly after the Conquest by William de Warenne

SWAHILI, Wa-Swahils from Arabic sahil, ruast, a term applied to the inhabitants of the East African coast from Mogadishu to Kılwa and of the islands of Zanzibar, Pemba and Comoro They are a mixture of African and Arab, the African element being based on a local Bantu people with a large admixture of slaves from all over East and Central Africa. Their language, Ki-Swahili, has a purely Bantu grammar and a large Arabic vocabulary.

The Swahili are not a tribe, but a people united by a common language and religion (Islam). Though their culture is largely Islamic, there remain many traces of their African origin and some Indonesian and other non-African elements. The chief Swahili dialects are Ki-Unguja of Zanzibar (now the standard form); Ki-Mvita of Mombasa; and Ki-Amu of Lamu Older forms are Ki-Ngozi and Ki-Kae. There is a large body of Swahili poetry and prose, written in Arabic, comprising secular and religious works.

(G. W. B. H) SWAHILI LANGUAGE. Swahili belongs to the Bantu family of languages (q.v.) and is spoken on the eastern coast of Africa, ranging approximately from Warsheikh, on the Somali coast, to the mouth of the Ruvuma (10° 30' S). It has also obtained wide currency as a trade language, having been carried by Arab caravans to the region of the Great Lakes before the middle of the 19th century and, since then, through European influence, into the Congo basm; and, in a very debased form, it is the vernacular of some Pygmy tribes on the Ituri.

Origin and History of the Language.-Swahili is not the language of any particular tribe; it grew up among the descendants of the Arab settlers on the coast, who intermarried with native women-usually Bantu. The name is derived from the

Arabic Sahil ( الحامل), which means "the coast," the Arab colonists and their descendants being known simply as "the Coast-

Pokomo, the speech of a very interesting Bantu tribe inhabiting the Tana valley, may have formed the groundwork of Swahili. The Pokomo would probably be the first Bantu tribe to meet the Arab colonists. Intercourse between Arabia and the east coast of Africa is as early as the 1st century A.D., when, as we learn from the Periplus of the Erythraean Sea, the people of Muza (in Southern Arabia) "sent thither many large ships, using Arab captains and agents, who are familiar with the natives and intermarry with them

But the earliest known settlement, that is Pate, is said to have been founded A.D. 689.

The Swahili language was first made known to Europeans by Henry Salt, whose Travels (he visited Abyssinia in 1809, by way of the Cape of Good Hope) was published in 1814. He calls it

"Sowauli" and gives a short and very imperfect vocabulary. The first real study of the language was made by Johann Ludwig Krapf, 1810-82, a German who went to East Africa in the service of the Church Missionary Society, reaching Mombasa in 1844-His dictionary, recently revised and supplemented by Archdeacon Binns, is still a standard work; the principal English contributors to the subject are Edward Steere (Bishop of Zanzibar from 1874 to 1882), Arthur C Madan (d. 1920) and the late William Ernest Taylor, for many years a missionary in Kenya Colony

Character of the Language.—Swahili is a Bantu language. Its grammatical structure has been little affected by Arabic influence It includes Arabic words. Contact with outside influences has tended to efface some characteristic Bantu peculiarities and brought about an extensive use of borrowed prepositions and adverbs, which gives it greater elasticity and increases its pos-

sibilities as a literary language.

Swahili has no grammatical gender, but a division of nouns into classes, each with its characteristic pronoun; it inflects nouns by means of prefixes, makes the possessive agree with the thing possessed ("the house of the man" not "the man's house"), and places the object-pronoun between the subject-pronoun and the verb, as if one should say "I him saw," in one word. Though these classes and their concords look formidable, the language is by no means difficult to learn and is quite easy to pronounce.

As the official language of Kenya Colony and Tanganyika Territory, it is indispensable to all civil servants, to settlers, missionaries and business men. It is spoken and understood by many

natives, even where it is not the local vernacular.

Dialects and Literature.—The principal dialects are those of Lamu (northern), Mombasa (central) and Zanzıbar (southern); the last-named being the standard for official use. That of Lamu has preserved many archaisms and comes nearest to that known as "Kingozi," in which the ancient poems, and those more recently imitated from them, are composed. A large body of poetry exists in manuscript, some few specimens having been published in Europe. The metres used are adapted from the Arabic, as closely as the differing rhythm of the two languages permits. Those traditionally attributed to Liongo Fumo may, if authentic, go back to the 12th or 13th century, and their language is certainly very archaic. In prose, almost the only texts available till recently, have been taken down by Europeans from native recitation, but of late years (not to mention translations made by Europeans) native writers have begun to appear, and the Swahili magazine, Mambo Leo published at Dar-es-Salaam, under European editorship, attracts an increasing number of native contributors. There is an immense amount of traditional matter in circulation: folk-tales, some indigenous to the soil, others of Indian, Persian or Arab origin, which, filtered through generations of oral transmission, have acquired a distinctly African colouring. The people, both men and women, have the same facility of improvisation as the Italian peasants. Some songs have a rhythm (probably chanted to the drum) but no metre. Others have both metre and rhyme, often of a very pleasing character. Songs and proverbs -frequently very pithy-have been collected.

"Bibliochapter, "Steer, A Haddook of the Swahill Language as spoken at Zennabar (1871, trequently reprinted); Knapf, A Dickionary of the Swahill Language (1883; revised and augmented edition 1925); A. Wernet, The Bonks Languages (1891, bull); A. and M. Werner, The World Book (1971).

SWALLOW. The name for birds of the passerine family Hirundinidae. With graceful flight, and much twisting and turning. the swallows seek their insect food in the air, and the features that characterize the family are adaptations for this: the long pointed wings, the small feet, the short, broad bill and the wide gape, About 74 species of small to medium-sized birds comprise the family. Their colours are not gaudy, but many species have rufous or glistening white and iridescent deep blue or green in the plumage. The range of the family is almost world-wide. The species breeding far north and south are strongly migratory, and some make long journeys across the equator to reach their winter quarters.

Swallows like company; they gather to feed in favourite spots; great numbers may assemble in the late afternoon to roost together

during the night, and many species nest in colonies Certain species come commonly about human habitations and nest on buildings or in nest boxes prepared for them. Though hardly songsters, their twitterings and chirping notes are pleasant, and this plus their familiar habits and their returning to temperate climates with the spring has given them a friendly place in people's minds and in literature

Their nesting is various: in a hole in a tree or bank, in a burrow dug by themselves in an earthen bank, a saucer-shaped structure on a ledge of rock or a building, or a retort-shaped structure of mud pellets stuck to the side of a cliff or a building. There may be up

to six eggs, pure w 'ite or spotted.

In a restricted sense "the swallow" is used for a familiar species, Hirundo rustica, in England. The name martin (q v ) is used for (A L, Rp) some swallows.

SWALLOW-HOLE, a cavity, forming the entrance to a subterranean stream channel, produced by the solvent action of naturally acidulated water. Such holes are most commonly found in limestone and chalk districts (See CAVE.)

SWAMMERDAM, JAN (1637-80), Dutch naturalist, was born on Feb. 12, 1637, at Amsterdam, the son of an apothecary and naturalist. After a visit to Paris, he took his degree in medicine

at Leyden in 1667.

Neglecting his practice, he became a pioneer of microscopy. He made a comparative study of insect life histories, which he classified according to the type of metamorphosis. He held that his observations supported the preformation theory of embryology. He went into minute details of the internal anatomy of the mayfly and the bee. He observed the cleavage of the frog's egg and the subsequent segmentation and studied the anatomy of tadpole and adult. He described the ovarian follicles of mammals in the same year as Régnier de Graaf (1672). An improved technique of injection aided his study of human anatomy.

Swammerdam discovered the valves of the lymphatics and was the first to describe the red blood corpuscles (1658). By a welldevised experiment he showed that the muscles alter in shape but not in size during contraction; this contradicted the current theory that a material fluid passed down the nerves to cause movement.

He was the first to draw the sporangia of the fern. Deeply religious and somewhat unstable, after a quarrel with his father, he became for a time a disciple of Antoinette Bourignon. He died in Amsterdam on Feb. 15, 1680, after a period of deep spiritual and bodily misery.

spintotal and todary ansesty.

His books, some of them magnificently illustrated, were: Tractatus physico-anatomico-medicus de respiratione usuque pulmonum (Leyden, 1050); Alfquenese verlandatus, you bloeddoose disteption (Uterdit); (1506); Alfracodium naturae seu uteri mulitoris lobrica (Leyden, 1072); in and Sphemerae vou (Amserdam, 1073). H. Boerhaave published a collection of his manuscripts, Biblia naisurae (Leyden, 1737–186). (A. C. C. S.)

SWAMP, a tract of wet, spongy, low-lying land, usually over-grown with vegetation, but too highly saturated with water to be fit for agricultural or pastoral purposes. The term swamp, however, is often indiscriminately applied to various wet, watery or miry places, as a marsh or a bog or, as in Australia, a shallow pond or lake. But as more commonly understood, especially in the United States where the word first came into recorded use (early in colonial days), a swamp is an area of very moist or wet ground, with luxuriant vegetation, and largely free from standing water. It thus differs from a marsh, which is covered for the most part with a thin sheet of water. A swamp differs in a corresponding degree from a bog, which is a very wet, water-logged area. practically without drainage, in which extensive decomposition of vegetable matter is taking place, forming in northern latitudes deposits of peat (q.v.). A marsh or a bog may occur within or may border upon a swamp, with various intermediate stages in each case; hence the frequent interchange in meaning between these terms in popular usage.

The character of the vegetation in swamps varies with the nature of the soil and the extent of drainage. Usually swamps are filled with a dense growth of coarse grasses, trees and shrubs. Swamps are found on the shoreward side of tidal marshes along seacoasts and near inland lakes and ponds with low shores; swamps are common also in the alluvial valleys of rivers and smaller streams

Among swamps possessing marked historical as well as scientific interest are those in the Campagna near Rome, and those found in the Pripet marsh region in western Russia Noteworthy swamp areas in the United States are the Great Dismal swamp in southeastern Virginia, the cypress and the mangrove swamps of the southern states, and the "tule" swamps of the San Joaquin valley in California Vast swampy and boggy areas in northern Canada are known by the Indian name muskeg.

SWAMPSCOTT, a beautiful residential town and summer resort of Essex county, Massachusetts, U.S.; on Massachusetts bay, 13 mi NE of Boston, adjoining Lynn It is served by the

Boston and Maine railroad Pop. (1950), 11,580.

SWAN, SIR JOSEPH WILSON (1828-1914), English physicist and electrician, was born at Sunderland on Oct 31, 1828 After serving his apprenticeship with a druggist in his native town, he became first assistant and later partner in a firm of manufacturing chemists in Newcastle,

Among its operations this firm included the manufacture of photographic plates, and thus Swan was led to one of the advances in photography with which his name is associated—the production of dry plates, which were the outcome of an original observation made by him on the effect of heat in increasing the sensitiveness of a gelatine bromide of silver emulsion In 1862 he patented the first commercially practicable process for carbon printing in photography (See Photography.) In 1879 Swan patented bromide paper.

In 1860, he produced an electric lamp with a carbon filament which was formed by packing pieces of paper or card with charcoal powder in a crucible and subjecting the whole to a high temperature. The carbonized paper thus obtained he mounted in the form of a fine strip in an evacuated glass vessel and connected it with a battery of Grove's cells, which though not strong enough to raise it to complete incandescence, were sufficient to make it red-hot. This was substantially the method adopted by Edison nearly twenty years later.

Subsequently Swan devised a cotton thread "parchmentized" by the action of sulphuric acid, and on Oct 20, 1880, he gave at Newcastle the first public exhibition on a large scale of electric lighting by means of glow lamps. In another method devised by him, collodion was squirted into a coagulating solution and the tough threads thus obtained carbonized by heat. He also devoted attention to apparatus for measuring electric currents, to the improvement of accumulators and to the conditions governing the electrodisposition of metals.

Swan was knighted in 1904. Holding many honours, he died at Warlingham on May 27, 1914.

SWAN, the name for birds of a group that contains the largest waterfowl (family Anatidae). With long necks and short legs, they are most at home on the water, where they feed on aquatic plants. They also eat some grass and grain, though they walk somewhat awkwardly on the land.

There are seven kinds of swan. Five, all white in colour, live in the northern hemisphere; a black necked swan, Cygnus melancoriphus, lives in southern South America, and a black swan,

Chenopis atrata, in Australia.

The common swan of ornamental ponds everywhere is the mute swan, Cygnus olor, native of northern Europe and Asia. It is easily recognized by its pink bill and black knob on its forehead. black swan is also kept as an ornamental bird, and has been introduced and is thriving in New Zealand.

Swans are said to mate for life During the winter they live in flocks, but with the approach of mating time the pairs separate and establish breeding territories which they guard jealously. The eggs, four to six in number, are cared for by the female except with the black swan, the male of which shares nest duties. male is vigorous in its defense of nest and young In captivity it may kill geese and ducks and even be dangerous to children. Some swans utter only a hiss, while others have loud trumpetlike (A T. Rn)

SWAN, HUNTER, AND WIGHAM RICHARDSON, LTD. The "Prince Albert," the first iron vessel ever built on the Tyne, was launched in 1842, from the Neptune works of the firm In 1850, the present Neptune shippard was opened, with a pay-roll of 200 men The Wallsend shippard of the company, owned by C. S Swan and Hunter, was established in 1872, and in 1880 employed 700 men In 1903, C S. Swan and Hunter, Ltd, Wigham Richardson and Co, Ltd, and the Tyne Pontoons and Dry Docks Co., Ltd , became Swan, Hunter and Wigham Richardson, Ltd., and today is associated with Barclay, Curle and Co, Ltd., on the Clyde, and the Glasgow Iron and Steel Co, Ltd., Wishaw The company has 16 shipbuilding beiths on the Tyne, of which the largest are capable of taking vessels up to 1,000 ft in length, Four of these, at the Wallsend shippard, are covered by glass-roofed sheds fitted with electric light, enabling work to proceed in any weather and by day or night. The capacity exceeds 150,000 gross tons a year.

The company builds all classes of naval and mercantile vessels At the Tyne shippard there were under construction (1939) the battleship "Jellicoe," the cruisers "Mauritus" and "Gambia," the destroyers "Janus" and "Khartoum," 4 escort ships, caissons, passenger and cargo ships, oil tank ships, a cable ship, etc., and the large motor passenger and cargo liner "Dominion Monarch" was completed in January 1939 More than 30 floating docks have been built by the company in recent years. One of them was towed through the Straits of Magellan to Peru, a distance of 11.000 miles; another was the immense floating dock for the Singapore naval base, with a lifting capacity of 50,000 tons, which had to be towed out in several parts, barely scraping through the Suez canal The firm built the "Mauretania" (32,000 gross tons; launched in 1906), for the Cunard company, which, while more than once crossing the Atlantic at an average speed of 26 knots, averaged 25½ knots for 27 consecutive voyages During World War I nearly 100 warships, with 230 other vessels, were built by (LCM;X) the company

SWANAGE, a seaport and urban district, Dorset, England. Pop (1938) 5,970. Area 4 3 sq.mi. It has on the so-called Isle of Purbeck, south of Poole harbour. The coast is wild and precipitous; numerous caves occur in the cliffs. The bay affords excellent bathing. Stone from the Purbeck quarries is exported.

SWANSEA, Welsh Abertawe, a municipal, county and parliamentary borough and seaport of Glamorganshire, Wales. Pop.

(1938) 161,100. Area, 37 9 sq mi. The Via Julia from Nidum (Neath) to Loughor probably passed through the north of the borough, where Roman coins were found in 1835 The name Swansea stands for Sweyn's "ey" or mlet, and may have been derived from Sweyn Forkbeard, who certainly visited the Bristol Channel, The earliest known form of the name is Sweynesse, which occurs in a charter granted by William earl of Warwick some time previous to 1184; in King John's charter (1215) it appears as Sweyneshe, and in the town seal, of mediaeval origin, it is given as "Sweyse." The Welsh name, Aber Tawy, first appears in Welsh poems of the beginning of the 13th century. The town grew up round the castle which Henry de Newburgh (or Beaumont) on his conquest of Gower about 1000 built on the west bank of the river. The castle eventually came by marriage to the Somersets and is still held by the dukes of Beaufort, It was finally destroyed by Owen Glendower. In the Civil War the town was royalist till the autumn of 1645 when Colonel Philip Jones was made its governor. The older part of the town, being the whole of the municipal borough previous to 1836, occupies the west bank of the Tawe near its mouth and is now wholly given up to business. Stretching inland to the north along the river for some 3 mi. through Landore to Morriston, and also eastwards along the sea margin towards Neath, is the industrial quarter, while the residential part occupies the sea front and the slopes of the Town hill (580 ft. high) to the west, stretching out to Sketty. The Mumbles or Oystermouth and a large part of the Swansea rural district were included in the borough in 1918. The east side of the river is known as St. Thomas's and Port Tennant.

entirely disappeared; but of the new castle, which was probably intended only as a fortified house, there remain the great and lesser halls, a tower and a so-called keep with the curtain wall connecting them, its chief architectural feature being a fine embattled parapet with an arcade of pointed arches in a style similar to that of the episcopal palaces of St. David's and Lamphey built by Henry Gower (d 1347), hishop of St David's, to whom the building of the new "castle" is also ascribed Possibly some traces of St David's hospital, built by the same prelate in 1331, are still to be seen at Cross Keys inn The parish church of St Mary was entirely rebuilt in 1895-98 Of the earlier work there remain the door of the rood loft (built into a wall), and a few private memorials Within the parish of St. Mary was St. John's, a church once owned by the Knights Hospitallers This church, which was entirely rebuilt in 1820, was renamed St. Matthew in 1880, when a new St. John's was built within its own parish. The Royal Institution of South Wales, founded in 1835, possesses a museum in which the geology, mineralogy, botany, prehistoric and later antiquities of the district are well represented. Its library is rich in historical and scientific works relating to Wales and Welsh industries. The free library and art gallery contains exhibits of local and general Welsh interest. The Glynn Vivian Art gallery was opened in 1915 Near the shore at the west end of the town is the new guildhall, opened in 1934 It is notable as containing Frank Brangwyn's 16 panels depicting the peoples, flowers, fruits and animals of the empire, originally painted for the royal gallery of the house of lords as part of a peers' war memorial. The grammar school was founded in 1682 by Hugh Gore (1613-1691), Bishop of Waterford A college was added to the University of Wales in 1920, with a site in Singleton park (250 ac) The town has about 3,000 ac of open spaces, including Liewelyn park (42 ac). De Braose's charter of 1305 gave the burgesses the right to take from the lord's woods sufficient timber to make four great ships at a time and as many small vessels as they wished Coal was even then worked in the district. Cromwell in his charter of 1655 recognized Swansea as "convenient for shipping and resisting foreign invasions" Its status was only that of a "creek" in the port of Cardiff till 1685, when it was made independent.

From about 1768 to 1850 Swansea had a famous pottery. Beginning with earthenware which twenty years later was improved into "opaque china," it produced from 1814 to 1823

superior, beautifully decorated porcelain.

During the 18th century coal began to be worked at Llansamlet and copper smelting (begun at Swansea in 1717, though at Neath it dated from 1584) assumed large proportions. The coal was conveyed on the backs of mules and later by means of a private canal. Under an act of 1791 harbour trustees cleared the river bed and built a long pier on either side of it. A canal connecting the tidal part of the river Neath with the mouth of the Tawè made in 1789, was in 1824 connected with the Vale of Neath canal by means of an aqueduct across the Neath river, when also a small dock, Port Tennant or Salthouse dock, was made near the east pier, and this continued to be used till 1880. Meanwhile in 1798 the entire coal-producing Swansea valley was connected with the port by a canal 161 mi long (acquired by the G.W.R. in 1872). In 1851 the river was diverted eastward into a new channel (called the New Cut) and its old channel was locked and floated, thereby forming the North dock. (Area 112 acres, and a half tide basin 21 acres, Length of quays 5,500 ft.) The Swansea Valley canal has a connecting lock with this dock, and on the island between the dock and the New Cut are patent fuel works, copper ore yards and other mineral sheds. The South dock, begun in 1847 and opened in 1859, is mainly used for shipping coal and for discharging timber. It has an area of 18½ acres; length of quays 6,550 ft.; depth of water in lock 34 ft. The next development was on the east side of the river where the natural inlet of Fabian's bay, inside the harbour mouth, was utilized for the construction of the Prince of Wales's dock (authorized 1874, opened October 1881, and subsequently extended), area 28 acres; length of quay 6,872 ft. and it is con-The castle, first built by Henry de Newburgh about 1099, has nected with the Tennant canal. The very rapid increase in the demand for anthracitic coal (for the shipment of which Swansen has practically a monopoly) soon necesstated still further accommodation and in July 1904 was begun the King's dock, which lies faither east and has an entrance direct from the bay. By means of the embankment made in connection with it, 400 acres were reclaimed from the sea. King's dock and basin is 71 acres, depth of water, a full, (high tidée), length of quays, 14,050 ft. The Queen's dock, used mainly by the Anglo-Persan Oil Co., is 150 acres with 2,400 of of quays. There are numerous privately owned dry docks. The entire harbour has some 281 acres of deep water in the docks and over 6 miles of quay. The imports include time her, ores (copper, silver, non, etc.), grain, pig 170n, crude oil, etc. The exports are coal, patent fuel, refined oils, coke, tim-plate, etc.

The town (which is often called the metallurgical capital of Wales) is the chief seat of the copper, spelter, tin-plate and patent fuel industries. Copper smelting, which during most of the 19th century was the chief industry, was later replaced by copper retining, but there-fourths of the in-plate manufactured in Great Britain and mneteen-twentieths of the spelter or zinc are made in the Swarsse affect, 86 factories being engaged in the work, Its tube works and manufacture of superphosphates are also very immortant.

From about 1918 Swamesa became an important centre for the distribution of oil, and extensive facilities for its storage and distribution of its storage and refining were provided. It was by reliance on the metallungcal industries and the facilities for dealing with other fuel besides coal that Swamesa escaped in some measure the depression that overtook the purely coal-exporting areas of the south Wales coal field in the late 1900s and 1930s. Trawlers usually land their catches set at the south dock, where there is a well organused falls market. In 1935 a great power station connected with the national grid was occessed.

Administration.—The town claimed to be a borough by prescription, for its only known charters of incorporation are those of Cromwell and James II, which were never acted upon. It probably received its first grant of muncipal privileges from William and earl of Warwick some time before risk4. Cromwell's charter of 1655 changed the title of portreeve into mayor. Four annual fairs were appointed, namely on the 8th of May, and of July, 15th of August and 8th of October—the first being the only new one. These are still held.

From 1535 to 1832, Swansea with other boroughs of Glamorgan sent one member to parliament. In 1658, Cromwell gave Swansea a member of its own but the grant lapsed with the Restoration. In 1832, Swansea, with added parishes, was again granted a member and in 1885 a second member was added. The assizes and quarter sessions for Glamorgan are held at Swansea alternately with Cardiff. The borough has a separate commission of the peace, and a court of quarter sessions. It became a county borough in 1888. In 1932 the "Church in Wales" created a bishorite of Swansea and Brecon.

In Feb. 1941 the whole civilian centre of the town was destroyed

by air raids

"SWANWICK, ANNA (183,5-189,). English writer and philanthropust, was born at Laverpool on June 24, 183, She went in 1839 to Berlin, where she took lessons in German, Greek and Hebrew. In 1843 her first volume of translations, Selections from the Dramas of Goethe and Schiller, appeared, followed by a translation of Schiller's hungfrow one Orleans (1847), and others of Faust, Taxso, Iphigenie and Egmont (1850). In 1878 she published a complete translation of both parts of Faust, which appeared with Retsch's illustrations. In 1865 she published a blank verse translation of Aeschylus's Thieley, and in 1873, a complete edition of Aeschylus's Thieley, and in 1873, a complete chiton of Aeschylus, which appeared with Flaxman's Illustrations. Anna Swanwick was a founder of Queen's and Bedford colleges, and advocated the admission of women to universities. She died in Nov. 1869, 556 ML, Bruce, Armse Semmes (1903).

SWARAJIST. The term sweraj (more properly swarajya from swa-own or self; rajya-rule or government) was originally employed in the ethical sense of control over self—self mastery. Prominence was first given to it in the political arena by Dadabhai Naoroj, who, in his presidential address to the Indian national

congress in Calcutta in Dec. 1906 claimed as the right of India swara; "or self government like that of the United Kingdom or the Colonies," and the word soon gained currency as the equivalent of dominion home rule By a judicial decision of the Calcutta high court (1907, ILR, 34 Calc.), it was held not necessarily to mean "independent government" in the sense of government of the country to the exclusion of the present government "It may mean, as is now well understood, government by the people themselves under the King and under British sovereignty" Its adoption as the label of a particular political party was the outcome of the lengthy and ever-changing agitation set on foot by M K. Gandhi in 1919 That movement commenced as one of passive resistance to the legislation known as the Rowlatt act, which was designed to strengthen the hands of the government in dealing with revolutionary crime, but, utilizing the resentment aroused among Mohammedans by the Turkish peace terms, which crystallized in the Khilafat movement, and the excitement which ran through the country as the result of disturbances in the Punjab and their sequelae, Gandhi, in the succeeding year, launched a campaign of protest under the guise of nonviolent nonco-operation, which was to include the boycott of the courts and government schools, the resignation of titles and government office, and abstention from participation in the forthcoming elections to the new legislative councils under the Reforms scheme. In July 1920 the attainment of swaraj was included among the objects of the nonco-operation movement, and at the meeting of that year it was adopted by the Indian national congress as their avowed aim. But as to the precise meaning of swaraj there existed a vagueness which Gandhi did little to dispel At one time he defined it as parliamentary government, whether within or without the empire; at another as dominion home rule; at a third as the universal employment of the spinning wheel; yet again as the triumph of the Khilafat party. On the other hand, at the first meeting of the legislative assembly in Feb. 1921, in the message from His Majesty the King Emperor, the ideal of swaray was mentioned as the dream for years of patriotic and loyal Indians, while the reforms were cited as the beginnings of swaraj within the empire.

The first elections under the 1979 act Candhi's followers took no part, but an influential section of the congress, acting under the leadership of C. R. Das and Pandit Motlail Mehri, announced on Jan. 1, 1923, the formation of a Congress Khillard Swarijay party, in whose program the capture of the councils and the obstruction of all business in them was the leading immediate item. After protracted dissensions and manoeuvres this section was finally victorious within the congress, and at the elections of Nov. 1923 Swarajist candidates took the field as such and, noticeably as against the Moderates, achieved considerable success, though failing to secure (except in one province) the clear majority for which they had hoped. Throughout the term of the second reformed councils the Swaraj party continued their wrecking tacties, succeeding in two provinces (Bengal and the Central Provinces) in bringing about a temporary suspensional of the control of the cont

sion of the reformed constitution.

Toward the end of that year the party was split by the defections of some of its members, notably in Bombay and the Cartal Provinces, in the direction of "responsive co-operation," including the acceptance of office under government, and in April 1936 an attempt was made to form an Indian national party of responsivists, independents and moderates "to prepare for and accelerate the establishment of swaray or full responsible government in India, such as obtains in the self-governing dommions of the British empire." These differences bore fruit at the third election of the reformed councils at the end of 1936, when the Swaray party definitely lost ground, noticeably in the assembly and in the United Provinces, Punjab and Central Provinces. The Indian national congress (which by that time was practically the Swaraj party) in Dec. 1937 declared for the complete independence of India.

SWASTIKA, a decorative and symbolic omament consisting of a cross with equal arms, to the end of each of which is attached a line running at right angles to it, all these extensions occurring on the same relative side, so that all four extensions have the same rotary direction in relation to the centre. The

swastika is one of the most ancient and widespread of all ornamental forms, appearing in both henripherer. It is generally interpreted as a sun symbol. It occurs in Aegean and archaic Greek pottery and in certain types of fret, found in Egypt and Greece. In some examples it appears as two identical S-curves, intersecting in the middle and set at right angles. Occasionally three arms are found, and the heralick symbol of three running legs set radially, may be a development. Adolf Hiller made the swastika Germany's national symbol. See Dissoit. (T.F. H.)

SWAT, a princely state on the Peshawar border of the North-West Fronier Province of Pakustan, consisting of the valley of the Swat river above its confluence with the Panjkora, which is reached by the Malakand, the Shahkot and other passes from the south It has an area of 4,000 agm and a pop (1951) of 560,000.

The Swat river rises in the Kohistan, near the source of the Gilgit river and is utilized by canals to irrigate about 160,000 ac. A tunnel through the Malakand range taps the river much higher The old name of the river was Suastos, and that of the Panikora was Ghoura, under which names they figure in the history of Alexander's campaign. The upper valley is closely gripped between mountain spurs of the Hindu Kush The valley, narrow though it is, and traversed by the worst conceivable type of hill tracks, is fairly thickly populated The district lies on the direct road to Chitral The Swatis are a clan of Yusafzai Pathans numbering 40,000. They are Suni Mohammedans. The present ruler. the Walt, consolidated his rule throughout the Swat area by both warfare and diplomacy and turned his little kingdom into a model government amid the traditionally turbulent transfrontier areas. The Wali installed a telephone system to his leading villages, with whose headmen he thus confers every morning. He built a model hospital. He tours his kingdom in a modern car over the roads that he has built, but keeps a rifle by his side as a precaution.

SWATOW (also SHAN'TOW), a port in the province of Kwangtung, China, at the mouth of the main branch of the Han river. The population in 1940 was 178,650. Swatow was formerly a small fishing village, and the present town was built to a large extent on reclaimed land. English merchants settled on Double Island, in the river, as early as 1856 and began trading. Swatow is a great emigration port and was the scene of many kidnapping adventures on the part of foreigners in the early days. The region retained a full tribal organization until the latter half of the 19th century. Serious difficulties arose with the T'aip'ing rebellion and foreign interferences. The city is the outlet for Chao-chow, about to mi, up the river, and the centre of a sugar-cane district. Bean cake is manufactured and was also imported from Niuchwang, Shanghai and Hong Kong. Among usual leading exports are tea (after about 1872), sugar and oranges, paper, tobacco, grass cloth (manufactured at Swatow from the so-called Taiwan hemp), lace, drawn thread work embroidery. The imports ordinarily include cereals, peas, beans, kerosene oil and piece goods. The port was opened to foreign trade in 1860. The town, situated at the southern end of Formosa strait, is exposed to fierce typhoons. The

Japanese occupied Swatow in 1939

SWAYTHIANG, SAMUEL MONTAGU, 18T BARON

(183-9-1917), British financier, was born at Liverpool on Dec 21,

1832, of a jewsh family named Samuel. He took by royal

leence the name of Montagu. He rose to be the head of the most

important arbitrage house in London. He was Eiberal M.P. for

the Tower Hamiles from 1835 to 1900; he was a member of the

Gold and Silver commission of 1839-90, being himself a bimel
allist. He was created a baronet in 1849, and raised to the peer
age in 1907. He was a zealous promoter of Jewish interests,

founding the loan fund of the Jewish board of guardians, the

Jewish workingmen's club and several synagogues. Lord Swayth
ling succeeded Sir Julian Goldsmid as chairman of the Russo
Jewish contingnen's club and septed to establish a modern secular

school for Jews at Jerusalem (1875). He died on Jan. 12, 1911,

in London. His son. E. S. Montagwa was secretary for India.

SWAZI. The Swazi are an African tribe of the Embo-Nguni group of Bantu people. They speak a language closely allied to Zulu and Xosa. The political system consists of a hereditary paramount chief (Ngwenyoma) who is the central figure of the tribe in

political, social, military, religious and economic affairs His muther (Nidounhato) occupies a unique position and must be considered in the property of the p

(B. A. N

SWAZILAND, British protectorate in southern Africa, administered by the high commissioner for Bustudiand, the Bedunalland protectorate and Swailand It is a compact country of 6/946 sg mi surrounded on three sides by the Union of South Africa and on the east hemmed in from the sea by Portuguese East Africa, or Mozambique

Physical Geography .-- The territory consists of three fairly well-defined regions of about equal breadth running from north to south. The mountainous high country to the west is a spur of the Drakensberg which reaches altitudes of about 5,000 ft. The average rainfall in this region is 55.6 in, although it varies considerably from year to year and from place to place. This region provides good winter pasturage for sheep and is suitable for afforestation The middle yeld to the east is characterized by wide valleys with less rainfall (average about 36 in.) but suitable for mixed farming. There the tributaries which flow down steep gorges join to form the main river system which drains the territory into the Indian ocean. These rivers, the Komati, the Mbuluzi, the Usutu and the Ngwavuma, traverse the Lubombo flats which comprise the low country. the only considerable area of fairly level ground lying about 500 ft. above sea level and consisting of fertile soil with savannah type vegetation and good pastures. The rainfall is low (average about 20 in.) and badly distributed. The main rivers on their course eastward to the sea in Portuguese territory cut through the Lubombo range.

History.-According to their traditions the Swazi lived origipally in southern Tongaland on the southeastern littoral of South Africa whence they migrated at the beginning of the 19th century to Shiselweni; s.e., the country to the west of the Lubombo range between the Pongolo and Great Usutu rivers. There they remained until 1815 when, being attacked by the Ndwandwe chief, Zwide, the main portion of the tribe under their chief Somhlolo, otherwise Sobhuza I, fled northward to the present site under the Mdzimba mountain near Bremersdorp. Under Somblolo's successor Mswazi, who gave his name to the tribe, they occupied considerable areas in what is now a portion of the Union of South Africa, and conquered and assimilated petty tribes or clans of Sotho origin. After their flight from Zwide the Swazi were occasionally raided by the Zulu and themselves made forays into neighbouring territory. Mswazi made an abortive attempt to check the depredations of the Zulu by seeking the protection of Oueen Victoria through Theophilus (later Sir Theophilus) Shepstone

ophilus (later Sir Theophilus) Shepatone
More formal richations with Europeans were established with the
signing of a treaty by Someuba on behalf of Mawazi in July 1846
which purported to grant to de Hollandshed Zuid Afrikanssche
Nadie a large portion of territory included in the modern districts
Nadie a large portion of territory included in the modern districts
value of the state of the sta

By 1878 white settlers and prospectors had established themselves in considerable numbers in Swaziland, attracted by the fertile and well-watered terrain abounding in game and rich in the promise of minerals. They secured concessions over land, minerals and grazing as well as to exemptions from taxes, to railways, to telegraphs, to mining patents, collection of the revenue and trading.

In 1888 a charter of self-government was granted to the Europeans, and two years later, under a convention between the British government and the South African Republic of the Transvaal, a provisional government, consisting of representatives of the two powers and a representative of the Swazi, was set up with the consent of the latter Three years later the provisional administration came to an end when the British government signed a new convention permitting the South African republic to acquire from the Swazı regent and her council an organic proclamation conferring on the republic rights of jurisdiction, legislation and administration without incorporation into the republic. The Swazi refused to sign the proclamation, but its provisions with some of those in the 1893 convention were embodied in the final convention of 1894 under which the South African republic exercised powers of protection, legislation, jurisdiction and administration in Swaziland subject to the limitations of the convention After the conquest of the Transvaal all the rights and powers of the republic passed to Great Britain, and an order in council under the Foreign Jurisdiction act was issued in June 1903 providing that the gover-nor of the Transvaal should administer Swaziland and conferring on him the right to legislate by proclamation. In 1906 these powers were given to the high commissioner. The main task of this administration was to settle the concessions question, which was achieved in 1907 by the issue of a proclamation under which land and grazing concessions suffered a deduction of one-third of their area for the sole and exclusive use and occupation of the Swazi

Population .- The African population in 1946 was 181,269, an increase of 64.3% since 1921. The European population, which in 1921 was 2,205, had risen to 3,201 in 1946, and in the same neriod the coloured or mixed population rose from 451 to 745 There are European villages at Mbabane, the administrative capital, and Bremersdorp, with European populations of between 500 and 600, and there are smaller villages at Emlembe, Piggs Peak, Goedgegun, Hlatikulu, Mankaiana and Stegi

Religion .- Apart from indigenous religions, Christianity alone is

represented by 23 denominations.

Education.—There were, in the early 1950s, four government Education.—There were, in the early 1950s, four government primary schools for Europeans, one government secondary school and two other secondary schools run by voluntary agencies. The total entolment of European children in 1951 was 705. There were 8 government primary schools for Africans, 8 tubal schools, 3 national schools ment primary schools for Africans, 8 tribal schools, 3 national schools anniatizated from a special fund and 194 mission schools (of which 97 are special manufactured). The food aeroniement 1951 was 18,454. There are government-aided, the total enrolment in 1951 was 18,454. There were specially the total enrolment in 1951 was 3071. These were two government and three mission hospitals in the territory. One of the latter was government-aided. There were also mine

government health centres

Administration.—In the United Kingdom responsibility for the administration of the territory rests with the secretary of state for commonwealth relations. A high commissioner has powers under the order in council of 1903 to administer and legislate for the territory, and he has similar powers in respect of Basutoland and the Bechuanaland protectorate He resides, however, in the Umon of South Africa, where he is also high commissioner for the government of the United Kingdom In Swaziland and directly responsible for its administration Surgious in owacaniau and carecty responsible for its administration is a resident commissioner, who governs subject to the directions of the high commissioner under powers vested in him by proclamation and bits commission. He has a staff of administrative, technical and subordinate officials, and, in respect of European affairs, is assisted by an advisory council, first established in 1921, of ten elected Europeans. A advisory council, first established in 1921, of ten elected Europeans system of administration was set up in 1950 by proclamation which provided for the administration of the Swazi by their paramount and other chiefs together with their councils in close conformity with

provided nor the seminationaries or the Swat by their parameters are the control in the control in close conformity with tention of the control in the contr the end of the 19th century by the then paramount chief Mbandeni.

Livestock raising is practised by Europeans and nearly all Swari.

In 1951 there were 327,964 African-owned cattle, 7,536 owned by coloured persons and 73,733 by Europeans.

The staple diet of the Swazi is maize. They also grow sorghums which are usually converted into beer. Other crops are peanuts, tobacco, beans and lice Tung trees do well, as do citrus, avocados and other subtropical fruits

subtropical routs
The principal exports are asbestos, live cattle, cotton, hides and
skins, butter, metallic tin and wattle bark Gold is mined on a small
scale and some barytes is produced. There are large unexploited coal
fields in the low veld
Communication.—There are no railways in the territory, but

510 mi of bus services are operated by the South African Railways administration

Finance.—A Swazi national treasury was established to handle the finances of the newly created native administration in 1950.

The main heads of taxation for 1050-51 were income tax (levied on non-Africans only) £234,205, customs and excise £68,657 (under an agreement with the Union of South Africa Swaziland receives a 0 149% share of the total collection of the Union), native tax £56,111, base metal royalties (chiefly from asbestos production) £29,207, total

page metal royalties (casely from assessos production) 1:29,397, total particular of the page of the page of the page of the Swari Antican Articlosacy: Rush Among the Swari Gafford, 1947). B A Marwick, The Swari An Ethnographic Account of the Naturus of the Swaniand Protectorate (Cambridge, 1940); annual reports on Swaziland in Colonial Reports series (B.A.M.)

SWEARING. The common use of the word is for the uttering of profane oaths or curses. In English law, while blasphemy (q v.) was at common law an indictable offense, cursing or swearing was left to the ecclesiastical courts. The Profane Oaths act, 1745, inflicted a sliding scale of fines for the use of profane oaths according to the rank of the offender. is, for a common labourer, soldier or seaman, 25 for everyone below the rank of gentleman and 5s for those of or above that rank, procedure under this act is regulated by the Summary Turisdiction acts By the Town Police Clauses act, 1847, the use of profane or obscene language is an offense punishable on summary conviction by a fine not exceeding 40s or imprisonment not exceeding 14 days. The offense must be committed in a street. In the United States, blasphemy is a crime under either the common law or the statutes of substantially all of the states.

SWEATER, a jacket or short coat of a woollen material, usually knitted, and sometimes called a jersey, because it was worn by the sailors of the Island of Jersey The first sweaters were heavy, dark-blue jackets, which were pulled on over the head, and were worn by the participants in athletic contests before

and after games, to prevent cold.

SWEATING SICKNESS. A remarkable form of disease not known in England before, it attracted attention at the beginning of the reign of Henry VII It was known indeed a few days after the landing of Henry at Milford Haven on Aug 7, 1485, as there is clear evidence of its being spoken of before the battle of Bosworth on Aug 22. Soon after the arrival of Henry in London on Aug. 28 it broke out in the capital and caused great mortality. This alarming malady soon became known as the sweating sickness. It was regarded as being quite distinct from the plague, the pestilential fever or other epidemics previously known, not only by the special symptom which gave it its name. but also by its extremely rapid and fatal course.

After 1485 nothing more was heard of it until 1507, when the second outbreak occurred, which was much less fatal than the first. In 1517 there was a third and much more severe epidemic. In Oxford and Cambridge it was very fatal, as well as in other towns, where in some cases half the population were said to have perished There was evidence that the disease had spread to Calais and Antwerp, but with these exceptions it was confined to England

In 1528 the disease recurred for the fourth time and with great severity. It first showed itself in London at the end of May, and speedily spread over the whole of England, though not into Scotland or Ireland. In London the mortality was very great; the court was broken up, and Henry VIII left London, frequently changing his residence. The most remarkable fact about this epidemic is that it spread over the continent, suddenly appearing at Hamburg. and spreading so rapidly that in a few weeks more than a thousand persons died. Thus was the terrible sweating sickness started on a destructive course, during which it caused fearful mortality throughout eastern Europe. France, Italy and the southern countries were spared. It spread much in the same way as cholera,

passing, in one direction, from north to south, arrwing at Switzerland in December, in another northward to Demante, Sweden and Norway, also estiward to Lithuania, Poland and Riussia, and westward to Flanders and Holland, unless indeed the epidemic, which appeared simultaneously at Antiwerp and Amsterdam on the morning of Sept. 28, came from England direct. In each place which it affected it prevaled for a short time only—generally not more than a fortinght. By the end of the year it had entirely disappeared, except in eastern Switzerland, where it ingered into the next year, and the terrible "English sweat" has never appeared again, at least in the same form, on the continent

England was, however, destined to suffer from one more outbreak of the disease, which occurred in 1551, and with regard to this we have the advantage of an account by an eyewitness, the

physician John Kaye or Caius

The disease began suddenly with a sense of apprehension, followed by cold shivers (sometimes very violent), giddiness, headache and severe pains in the neck, shoulders and limbs, with great prostration. After the cold stage, which might last from half-an-hour to three hours, followed the stage of heat and sweating The characteristic sweat broke out suddenly, and, as it seemed to those accustomed to the disease, without any With the sweat, or after that was poured out, obvious cause came a sense of heat, and with this headache and delirium, rapid pulse and intense thirst Palpitation and pain in the heart were frequent symptoms. No eruption of any kind on the skin was generally observed, Caius makes no allusion to such a symptom. In the later stages there was either general prostration and collapse, or an irresistible tendency to sleep, which was thought to be fatal if the patient were permitted to give way to it The malady was remarkably rapid in its course, being sometimes fatal even in two or three hours, and some patients died in less than that time. Those who survived for 24 hours were considered safe

The disease, unlike the plague, was not especially fatal to the poor, but rather, as Caus affirmed, attacked the riches soft and those who were free livers according to the custom of England in those days "They which had this sweat sore with peril of death were either men of wealth, ease or welfare, or of the poorer sort, such as were idle persons, good ale drinkers and tuverne haunters."

Causes.—Some attributed the disease to the English climate, its mosture and its fogs, or to the intemperate habits of the English people, and to the frightful want of cleanliness in their houses and surroundings which was noticed by Erasmus in a well-known passage, and about which Caius was equally explicit. But it must be concluded that climate, season and manner of life were not adequate, either separately or collectively, to produce the disease, though each may have acted sometimes as a predisposing cause. The sweating suckness was in fact, to use modern language, a specific infective disease in the same sense as plague, typhus, scarlet fever or malara.

The only modern disease tesembing sweating sickness is that known as mitary four "Gischweisfriest," sixtet mulitate" or the "Ficardy sweat"), a malady which has been observed in France, Italy and southern Germany, but not in the United Kingdom. It occurs in limited epidemics, not lasting more than a week or two (at least in an intense form). The attack last longer than the sweating sickness, is accompanied by eruption of vesicles and is not usually fatal. The first clearly described epidemic was in 1713 (though probably it easted before) and the last in 361. Better these dates about 175 epidemic laws been counted in 361.

France alone
Billiedoraphyr.—For history see Bacon's Life of Henry III. and
the chronicles of Graiton, Holinsbed, Baker, Rayban, 1999.

Billiedoraphyr.—For history see Bacon's Life of Henry III. and
the chronicles of Graiton, Holinsbed, Baker, Rayban, 1999.

A Boke or Counsell Against the Disease Commonly Colled the Superior
to Supering Sickness (London, 1551); and in Latin De Superior
to Supering Sickness (London, 1551); and in Latin De Superior
to Sickness (London, 1551); and in Latin De systems
of the Middle Ages (Syd. Soc., 1844). This also contains Hecker's
Adalable treaties on the English sweet, published in German (Section
History (Berlin, 1864). Grauper's Soriptors de sudore origileo (Jens.
Bircalo (Berlin, 1864). Grauper's Soriptors de sudore origileo (Jens.
1847) contains nearly all the original documents, including the two
treaties of Calus See also Hirsch, Handbook of Georgishical and
Historical Fabiology, tans by Cenghion (New 194, Sec., 1885).

SWEATING SYSTEM, a term used to describe oppressive industrial conditions in certain trades. The word sweater was used in England as early as 1850 to describe an employer or middleman who exacted monotonous work at very low wages. Charles Kingsley in his novel Alton Locke (1850) and his political pamphilets directed attention to London "sweaters"; and Henry Mayhew in 1851 talked of "the sweating system".

The system can be traced in certain trades in most countries both misde and outside Europe. It is closely associated with contracting Individual workers or groups of workers contract to do a certain pilo for a certain pilo Economic step they carry out this contract themselves, in other cases they left it out again to subcontractors at lower prices. Contracting makes possible labour exploitation, often of women and children; and it produces erratic employment. When trade is brisk extremely long hours are worked in seriously overcrowded works own or dwelling houses. When it may be a subsection of the state of the contraction of the state of the contraction of the contract

Contracting and subcontracting are common in the garment manufacturing industry. In the right century outwork existed in other industries, such as boot-and-shoe manufacture and soap-making. Although legislation had by the middle of the 20th century either eliminated or carefully controlled sweating in most highly developed countries, the system was still operating in many Assauce countries where larger numbers of people were engaged in home work than in industrial establishments.

Conditions tend to be worse in large cities, where sweatshops are hidden away in slum areas. They are aggravated by millium of cheep labour from outside. To the native poor engaged in tailoring in li London in the 1880s was added a large minigant labour cof of unskilled foreigners. In the United States the tireless search for cheen labour encouraged such immirration until 1017.

The first large-scale official inquiry into the sweating system was carried out by a select committee of the house of lords in England Its report, published in 1890, described conditions in tailoring, bootmaking, furriery, shirt making, mantle making, cabinetmaking, cutlery and hardware manufacture, chanmaking and nail making, saddlery and hardware manufacture, chanmaking and nail making, saddlery and hardware manufacture, chanmaking and mall making, and deck labour. It daimed that sweating involved (1) a rate line of the state of t

Like Inquiry of the select commutee did not bear fruit immediately. It was not until 1900 that the Trade Boards act set up boards to fix minimum wages in specified industries such as mechane-made lace manufacture and chummadang. In 1918 the scope of the act was extended to cover any trade where the ministry of labour considered that machinery for the effective regulations of wages was inadequate. Government interference was important, chiefly because it permitted the development of collective bargaining. By 1939, though many workers still received low wages, these were no longer any swated trades in Great Britain

In the United States most of the pressure to eliminate sweating was applied by organused labour. A number of acts, culmmating in 1882, prohibited Chanese immigration. The first minimum-wage law was passed in Massachusstism 1172 Numerous state laws improving factory and outwork conditions followed, and by 1039 practically all states had limited the hours of labour for women, and several had introduced legislation prohibiting might

Four main factors contributed in other countries as well as in Great Bratian and in the Unated States to the control of sweated industries: (1) social idealism; (2) the pressure of trade unions; (3) the extension of the franchise and the growth of abour parties; and (4) the growing economies of factory production and the increased interest in human relations in industry. In 1928 the International Labour organization carried a recommendation concerning minimum-wage fixing that gave home workers and others subject to contracting and subcontracting some measure of protec-

tion; and further action was mooted after World War II.

#### UNITED STATES

The sweating system grew in the United States during the Civil War, when soldiers' wives were employed to make uniforms with the relatively newly developed sewing machines. Its advance was slow, however, until the 1880s, when immigrants from eastern and southern Europe provided a large source of cheap labour At that time the conditions necessary for a sweating system existed, a mass of unskilled, unorganized poverty-stricken men, women and children incapable of resisting the economic pressure to compete for work-women against their husbands, children against their parents: power-using factories or shops, where materials could be prepared for simple processes done in smaller shops or in the homes of workers or both; and mechanized transportation to and from the sweatshops and tenement dwellings, eliminating the long journeys on foot by heavily laden men, women and children. Motor trucks and the parcel post contributed to widen enormously the area within which the sweating system could be carried on

As the first sample foot-powered sewing machines brought the sweating system to the soldiers' families, so the ceaseless evolution of the power-driven machines, first steam, later electric, served to concentrate the production of garments in vast skyscrapers near railway stations to which the employees travelled from their widely dispersed homes. That concentration facilitated labour organiza-

tion within the garment industry.

Sweatung-system evils also prevailed in other U.S. Industries based on small workshops, homework and cheap labour, such as the making of cigais and artificial flowers. Inside and outside the garment industry the unions strove ceaselessly against sweating. In 1889 the tobacco workers obtained the passage of a New York statute forbidding all manufacture of tobacco in any tenement house, but it was held unconstitutional by the New York court of appeals and homework was prolonged for a number of years. The US department of labour and various organizations, such as the National Consumers' league, also participated in the movement against the sweating system, and by the 1930s the conditions which had made it possible in the clothing industry had been virtually eliminated

Beginning in 1912 in Massachusetts, a number of states passed have creating minimum wage boards or commissions. The U.S. supreme court, however, in Adhins v. Children's Hospital (63 U.S. 525, 1934) held that a U.S. statute authorating a wage board in the District of Columbia to fix minimum wages of women and minors violated the guarantees of the due process clause of the fifth amendment of the U.S. constitution, since freedom to contact between the employer and employee was impaired. The tract between the employer and employee was impaired. The Coatt Hatel Co. v. Perrith (100 U.S. 370) decision. Many states passed minimum wage laws, and in 1938 a Federal Fair Labor Standards act covering industries engaged in interstate commerce was enacted.

SWEDEN (SURKER), a kingdom of northern Europe, occupying a part of the Scandinavian peninsula. The length is about 990 mi, the extreme breadth (maintaind) about 290 mi, and the total area, inclusive of inland waters, of which the four great southern lakes comples 3,953 cqmi, is estimated at 173,435 sqmi. I. A. Streibitsky estimated the boundary at 6,100 mi; 4,1737 mi, are coastal, the Nowegeian frontier is 1,250 mi and the Finnish

333 ml.

Physical Features.—The backbone of Sweden is an ancient mountain range of which the crest line forms the Norwegian boundary. The three man territorial divisions of Sweden are Nortland, Swealand and Gotaland. The country may be described in four mam physical divisions: the northern mountains and lake region district, covering all Norrland and the western part of Svealand, the divisional of contral Sweden; the Smilandi highlands, in the south and southeast; and the plains of Skane, occupying the extreme south of the penishal. The first district is much the largest and highest and contains the finest scenery. The greatest hegists lie along the boundary, and several exceed Gooo ft. Kebheights lie along the boundary, and several exceed Gooo ft. Kebheights lie along the boundary, and several exceed Gooo ft. Kebheights lie along the boundary, and several exceed Gooo ft. Kebheights lie along the boundary, and several exceed Gooo ft. Kebheights lie along the boundary, and several exceed Gooo ft. Keb-

nekaise (6,965 ft ) in northern Lapland, the highest point in Sweden, is a bold, somewhat isolated summit Slightly south, beyond the Lule alv, is a lofty mass in which Sarektjakko, the second highest summit, is situated. Still farther south is the betterknown Sulitjelma (6,279 ft ); beyond is a progressive decrease in height southward until Areskutan (4,656 ft.) is reached. Near the southern flanks of Areskutan the railway from Trondheim, Nor., crosses into Sweden. South of the railway the highland line passes into Norway, but before doing so the mass rises into such heights as Helagsfjall (5,892 ft ). There the snow line, which is about 3,000 ft in the north, rises to 5,500 ft. The numerous rivers are linked with long, narrow, high-level (900-1,300 ft) lakes, due mainly to dams of moraine. Among European countries only Finland exceeds Sweden in the number of its lakes. In Sweden the 96,000 lakes cover about 9% of the country, but the largest he in the central lowlands. The northern rivers run through forests and enter the sea usually through long estuaries. The Torne, which, with its tributary the Muonio, forms the boundary with Finland, has a length of 354 mi and drains Tornetrask (124 sq mi.). Along and near to the shores of the lake the railway from Gallivare runs to Narvik, Nor. The Kalıx (269 m1), with numerous rapids, is paralleled by the Lule, whose main stream is 193 mi. One of its branches, the Stora Lule, drains the Langasjaur and Luletrask, which together have a length exceeding 50 mi but a total area of only 87 sq mi At the head of the Langasiaur is the Stora Sjofall (Great Lake falls; Lapp, Atna Muorki Kartje), 130 ft. In the southern mountain valleys of the region there are several beautiful falls, such as the Tannfors, not far from Areskutan. Still farther south of the Lule are the Pite river (228 mi) and the Skellefte (255 mi); the latter drains Horna van and Stora van (total area 163 sq mi.). Horna van is a straight and sombre trough, but Stora van and the intervening Uddiaur are broad and picturesquely studded with numerous islets The Ume (291 mi) with its tributary the Vindel, of almost equal length, drains several lakes, including Stor Uman (63 sq mi.). The further principal rivers of this region are the Angerman (270 mi.) with the magnificent Hallingsa fall within its drainage area, Indal (261 mi.) and Ljusnan (267 mi.). The Dal (320 mi.) embraces Lake Siljan (110 sq mi.). The Klar has its upper waters—the Faemund-in Norway and reaches Lake Vaner after a course of 228 mi. The Torne has a dramage area of nearly 15,500 sq mi , but the Angerman has the largest basin (more than 12,300 sq.mi.) of any river entirely in Sweden; the average for the other large

northern streams is less than 8,000 sq.mi.
The lowlands resemble the coastal belt. There are fertile plains
of clay, with innumerable lakes, including Vaner (Vener), Vatter
(Vetter), Malar and Hjalmar, with areas respectively 2,145, 733,
440 and 189 sq.mi.; the Vaner is the largest lake in western Europe.
The scenery of the lake distruct is quietly beautiful.

Granulite, also called curite and hallefinita, is the most important of the Archaean formations and contains all the metalliferous deposits of Sweden. The rock is a very compact and fine-grained mixture of feldspar, quartz and mica, often grading into mica schist, quurattie and gueiss. The Cambrian and Ordovician strata occur in isolated patches. The deposits in most places are very little disturbed and form horizontal or slightly inclined layers. South of Vaner they are capped by thick beds of cruptive disbase Conspicuous local features are the eskers or gravel ridges (asar), 100 to 200 ft. in helght, in direction north-northwest. Their practical value lies in their excellent water supply and gravel.

South of the central lowlands the Smaland highlands lie in the heart of Gotaland and are a detached part of highland Sweden. They lie roughly south of Vatter and reach the southwest coast. The general elevation of this region exceeds 300 ft. and in the eastern part 600 ft.; the principal heights are Tomtebacken (7,237 ft.) and Galtasen (7,185 feet). There is much conferous forest, but agriculture is profitable. The Smaland highlands abut southward upon the plains of Skane. Newer rocks of Cretaceous and Jurassic Ages, together with Recent marine deposits, have yielded level plains, with rich open meadows and cultivated lands, the monotony of which is in some parts relieved by beech woods. The Triansic formation (Ranett') in the northern part of Malmohus consists of

sandstones and clay beds with coal

On the whole the rivers of south Sweden are few and short. Lake Vaner is drained to the Kattegat (Cattegat) by the short Gota river, on which, near the lake, are the celebrated falls of Trollhattan.

Coast.—The coast of Sweden, though not indented with so many or so deep fixed as that of Norway, yet resembles it in having a fringe of islands which, throughout large parts of its length, shelters the coast of the mainland from the open sea. This skargard is interrupted only round the southern shore off Skane.

The island belt is widest (45 m) of the city of Stockholm (noted for its beautiful sea approach). Farther north, only the narrow Alands Hav lies between the Swedsh coast and the yest Aland archipelage, which extends to Finland. The thergord islands as a whole are rugged and picturesque, in the Baltic several are well wooded, but the majority, particularly in the Gulf of Bothma, are bare or heath-clad. For the large islands Oland and Gotland see securate articles.

Climate.—Several factors contribute toward variations of climate in Sweden's several regions. The land runs through more than 132° of latitude; about 15% of its area is within the Arctic circle; the boundary mountains are sufficiently high to be much colder than the adjacent coastal lands, but are not high enough to shut out entirely the warming effects of those drifts of wind and water from the southwest which give Norway is remarkable chmate, the eastern and southern borders are washed by the sea: the piercing winter winds from the great Russian pool of cooled atmosphere can sweep westward over the Swedish lowlands or can reach the mountain tops which, on the whole, offer but moderate gradients for ascents February is the coldest month and has a mean temperature of below 32° F. over Sweden Stockholm averages 25.7°, Goteborg 30 4°, Haparanda 10.6°, but the coldest region is in the heart of Lapland, there the average for Karesuando is 5.2°. In some northern parts frost occurs in every month of the year, and at Karesuando only five months have a mean temperature above freezing point. July is generally the warmest month. Goteborg has a July mean of 62 2°, Stockholm 62°, Haparanda 59° and Karesuando 54 2°. The summer is short but high maximums are sometimes recorded, e g, 88° at Karasjok in Lapland

The relative length of the seasons shows contrasts resembling those of temperature At Karesuando the last day-frost of spring occurs on an average on June 15 and the first of autumn on Aug. 27. while at Stockholm four and a half months, and at Hyen in the sound more than six months are frostless. Ice forms in October in the north and breaks up in May or June, while in the midlands and south the corresponding months are late November and April. The ice covering of the lakes ranges from 100 days annually in the south to around 200 days in the north, though local increases of the ice period occur in the upper Smaland highlands. Drifting sea ice generally appears in the Kattegat in January, but the sound becomes obstructed later largely by drift ice from the Baltic. In exceptional winters (e.g., 1941, 1942) the sound may be com-pletely frozen over. Ice conditions in the Baltic vary considerably from year to year but usually navigation in the southern part of the Gulf of Bothnia is impeded from the end of November to the beginning of May; in the north the gulf is covered with ice from November to mid-May, and among the islands it may linger until

The length of the Swedish summer day varies between wide limits At Karesundon in 85° 86′ 11, lat the unit so continuously above the honzon from May 86 to July 18; at Haparanda it may be seen for 32 hours and at Land for 17½ hours at the summer solstice. Refraction increases the average length of the day by 30 min. in the north and by 15 min, in the south. More important is the effect of twilght, which results in daylight's lasting without interruption from June 50 to 72 as far south as Harmosand (65° 38° N.)

The average annual rainfall for Sweden increases, on the whole, from north to south, reaching a maximum toward the southwest. Thus the average in the north of Nornland is 16.5 in. and in the south it is 2.3, in. At Borns, midway between the south end of Lake Vatter and the Kattegat, the average is 35 in. 'The minimum et Karesuando is 12.3 in. The pend of maximum is generally the

Sto. 12

later half of the summer and the minimum Pebruary and March. The proportion of total precipitation which falls as now range from 56% in Lapland to 9% in Skane. Show lies 47 days on average on the planes of Skane, while in the noth it like from 140 to 100 days. The Swedish glacers cover about 135 sq mi. They occur in the northern highlands about Kebnekase, Sarekijakko and Sultjelma. The most southerly is on the slopes of Helagsfjall in lat. 65 \* 54.

Vegetation.—The extensive range of latitude and altitude produces many local vegetation differences. Four main regions can be distinguished, but they tend to grade into one anothes near their adjacent fringes. In descending order of altitude and, largely of latitude also are; (r) alpine regions, (2) a zone of birch woods, (3) a conferency forest region and (4) a bechwood region.

(3) a conterous lorest region and (4) a becknowed region. The alpine region occupies only the upper lanks of the spinal mountain range, at an altitude above 1,600 ft in the north and above 3,000 ft, in the south. The lower belt of this region consists of thickets formed by several species of shrubkle willows and dwarf brich, as well as of dwarf shrub communities and meadows With increasing altitude the dwarf shrub communities and meadows With increasing altitude the dwarf shrub communities and meadows With increasing altitude the dwarf shrub communities and a accompanied by grass heath types. The vegetation of calcareous ground of smuch richer in species than that of sluceous ground and comprises Lapps' rhododendron, tree nymph (Druaz) article poppy (rare), several characteristic species of sedges, saxifrages, whitlow grasses, etc. The higher tops of the mountains are characterised by a few flowering plants scattered in carpets of mosses and lichens, alternating with almost or, at the highest altitudes, even entirely naked soil.

The brich forests are much more extensive in the north, where they form a sublaine belt, separating the confierous forest renor from the alpine region. The dominant tree is the brich Betule lorateos, which grows together with rowan, brid cherry, some illows and aspen (which rarely attains tree size). The undergrowth is rich in herbis; e.g., wood crane's-bill, globellower, goldenrod, etc. In dry situations, on gravel, it is poorer, there behens, especially reindere "moss" and Nephroma arctice, are dominant.

The coniferous forests are the most extensive and cover nearly all the country northeast of Lake Vaner. The important tree on the direct and higher ground is the Scotch pane (Prints sylvestris), with cowherry in the undergrowth. More fertile soils are occupied by spruce (Pieca abies), having bilberry in the undergrowth. The conifers extend from sea level to 2,500 or 3,000 ft; and though the pine and spruce predominate yet there is a sprinkling of low-land birches, rowans and aspen in the north, while large numbers of such deciduous trees as oaks, ash, limes, maples and elms are found in the south, especially on fertile soil. These latter trees seldom extend beyond; 500 ft, above sea level, and the oak ceases about Lat. 6: 5° N. (coastal).

The beach forests (with occasional oak) are restricted to Skane. They are tending to be reduced by extended land cultivation. The flowering plants of southern and middle Sweden are largely imagnats since the last glacal epoch, and the number of species shows a decrease inorthward. Many plants in northern Sweden are considered to be glacal survivors.

Fauna.-The effects of the great latitudinal range of Sweden are also shown in the case of fauna. Some animals, such as the hare, vanous shrews, the ermine, the weasel, the squirrel, the fox and the elk, are common to the entire country. Formerly bounties were paid for the extermination of the larger animals, which were thus greatly reduced in number. The bear is now protected and, with the wolf, glutton or wolverine and lynx, is becoming restricted to the more solitary depths of the northern forests. The wild reindeer is extinct, but large domesticated herds form practically the sole source of livelihood of the Lapps. The elk is the most valuable game animal, but badgers, which exist in large numbers in the midland plains, otters and the rare pine martens of the coniferous forests are hunted for their skins. The roe deer is spread over the southern and central parts of the country with a tendency to spread northward. The arctic fox and the lemming are mountain animals the former being confined to the highlands of the north. When the lemmings make their nonperiodical migrations to the lowlands their vast hordes are the prey of bird, wild and domesticated animals. The common porpoise is the only cetacean occurring in the Baltic, and with the gray seal it is held to

be responsible for much damage to fisheries

Bird life 15 very abundant, especially in spring and summer; several types such as the teal, snipe, golden plover and wagtail are found throughout the country. In the northern mountains the ptarmigan is common; ducks and other waterfowl frequent the lakes both there and in the south, the golden eagle, certain buzzards, owls and the small Lapland bunting are found. In the coniferous forests, grouse, capercailzie and woodcock have long been the principal game birds but are now less common, the crane lives in marshy clearings, birds of prey, crows and many other passerines range over a wide area. In the midlands partridges and doves are fairly common. On the coast large numbers of gulls and terns are found, also the eider duck and the rare sea eagle There are very few reptiles or amphibians and the viper is the only poisonous species of snake. The rivers and lakes are generally well stocked with fish, such as salmon, trout, char, pike and perch. Both fresh-water and sea fisheries are important, especially on the west coast, where herring, cod, flatfish, mackerel and sprat are caught Great numbers of a small herring called stromming are fished in the Baltic together with cod, eel, salmon and flatfish the brackish waters of the east coast salt-water and fresh-water forms are found. The crayfish occurs in many places in central and southern Sweden. Pearls are at times found in a fresh-water mussel, and oysters are cultivated to a small extent on the west coast. Among the lower marine animals a few types of arctic origin are found, not only in the Baltic but even in lakes Vaner and Vatter, having survived the changes consequent on the separation of the Baltic sea and the Arctic ocean.

Insect fauna is 11ch, even in the north. In summer in the northem lowlands the gadfly is common enough to cause annoyance to the rendeer, which it drives to the upper pastures and snow fields See M. Zimmerman, Les Estais reandanters (Paris, 1913), vol. ili of Geographie sumwerselle, ed. bp. P. Vidal de la Blache and L. Gallois, C. A. M. Lindman, Svensk Fanerogamflora, 2nd ed. (Stockholm, 1926).

### HISTORY

The first historical notice relating to Sweden is found in Tacitus, Germane, ch. 44, in which we find the name of the chief people of the pennsula, the Swedes proper, Sulones (Old Norse, Svar; Swedish, Svear; Anglo-Saxon, Sweon), who eventually gave their name to the whole country. According to Tacitus they were governed by a king, whose power was absolute, and possessed a strong fleet which secured them from hostile incursions. Their original territories lay on both sides of Lake Makar, in the provinces later known as Uppland, Sodermanland and Vastmanland. Other early Roman writers, Mela and Plimy, mention the country. (See SCAN-DINAYLS CHILLAZION.)

The people next in importance to the Suiones in the peninsula (Swed., Golarz, ON., Goutart, A. S., Geatsa) are first mentioned by Plolemy (under the form "Goutar" for Gautoi). He puts them in the southern part of the country. Gotaland consisted of Vastergotland and Ostergotland divided from one another by Lake Vatter, together with Smaland. In early times Vastergotland seems to have been the most important; Varmland, the district to the nonth of Lake Vaner, and the whole of the country to the north of Sweland seem to have been of small importance. Jamtland was always considered a part of Norway. After the time of Plolemy we hear no more of Sweden until the 6th century, when a surprisingly full account of its peoples is given by the Golibi historian Jordanes. He speaks of trade in furs of arctic animals which were sold by merchant to merchant to merchand Rome.

For the same period information is to be found in the Anglo-Saxm poem Bewulf. The hero himself belonged to the Geatas (i.e., in all probability, Gotar), his mother being the daughter of their king Hrethell. Hactiven, Hrethel's son, is said to have perished in a disastrous battle against the Svear, but his fall was avenged by his brother Hygelac in a subsequent engagement in which the Swedish king Ongentheow was killed. This Hygelac is clearly identical with that Chochiliacus wrongly described as a

Danish king by Gregory of Tours (iii, 2) who died in battle with the Franks under Theodheeth about a D 300. About the time of Hygelac's death strife broke out in the royal family of the Swen, between Onels, the son and successor of Ongenthow, and Eanaumd and Eadgils, the sons of his brother Ohthere The latter fled for protection to the Gotar and the war which ensued cost the lives of Eanmund and of Heardred, the son and successor of Hygelac. According to the poem, Beowulf himself became king of the Gotar, but Beowulf's later history has a mythical character, and for three centuries after this time there is no reference to Swedshi affairs in English or other foreign authorities. The kingdom of the Gotar probably ended soon after the 6th century

At a later time the kings of Norway claimed descent from the ancient royal house of the Svear, and their traditions, though in great part mythical, prove at least its high antiquity. They trace its origin to the god Frey, son of Norör, who is said to have founded Upsala, the ancient capital of Sweden Among his descendants Athlis, the Eadgils of Beowulf, is a prominent figure, in general, the account given of him agrees with Beowulf.

Barly Kings.—Four generatons after Ahlile' time a king named Ingaldr was overthrown by a prince from Stane, called Ivarr Viötäömi His son Olafr Tretelgia withdrew to Varmland, which he brought into a state of cultivation, though he was subsequently sacrificed by his subjects in a time of famine. The sons of Olafr Tretelgia moved westward into Norway, and if we may trust later traditions Sweden passed out of their family The subsequent kings of Sweden are said to have been descended from Ivarr Viötäömi About 83 och emissionary bishop Ansgar made his way to Birca on Lake Malar. For more than a century after Ansgar's death no serious mission seems to have been attempted

During the 9th century extensive Scandinavian settlements were made on the east side of the Baltic. The famous expeditions of Rurik and Askold which resulted in the origin of the Russan monarchy appear to have taken place toward the middle of the century, but it is not possible to connect these names with any families known from Swedsh tradition. Many names in Russian chron.

icles seem to be Swedish.

The continuous history of Sweden begins in the early 10th century, when a king named Eric son of Emund was reigning at Uppsala. Before the end of the century his descendant Olaf Skottkonung had created what for the moment was the strongest kingdom in the north Under him Christianity was established in Sweden As a leading ally in a coalition which included Sweyn, king of Denmark, and Eric, jarl of Lade, he overthrew Olaf I Tryggvesson, king of Norway, and annexed for a time part of Trondheim and the district now called Bohuslan, which he handed over to Sweyn Jarl, brother of Eric Jarl, as a marriage portion for his daughter Holm-Several years later another Norwegian prince, Olaf II Haraldsson the Fat, returning to Norway as king, put an end to the Swedish and Danish supremacy and in 1015 forced Sweyn Jarl to leave the country An attempt to arrange an alliance between Olaf Skottkonung and Olaf Haraldsson (who married a Swedish princess) was unsuccessful, and their relations were still strained when the former died, probably in the winter of 1021-22.

Anund, his son, early in his reign allied himself with Olaf Haraldsson against Canute of Denmark, who had demanded the restitution of the rights possessed in Norway by his father, Sweyn. The allies took advantage of the Danish king's absence to harry his land. On his return an indecisive battle was fought at Helgi A, and Anund returned to Sweden Olaf was driven from Norway by the Danes, but in 1030 he raised a small army in Sweden only to meet his death at the battle of Stiklestad Anund, who died about 1050, according to Adam of Bremen, was succeeded by his brother Emund the Old, who had been previously passed over because his mother was unfree, the daughter of a Slav prince captured in war. This king had become a Christian, but soon quarrelled with Adalbert, archbishop of Bremen, and endeavoured to secure the independence of the Swedish church, which was not obtained for another century. Under Emund there was a rectification of boundaries which assigned Blekinge to Denmark.

With Emund's death in 1060, the old family of Swedish kings died out. He was succeeded by his son-in-law Steinkel, a noble of Vastergotland, who was warmly attached to the Christian religion, though he refused to destroy the old sanctuary of iods at Uppsala During his regin grants of land in Varmland made by the king to the Norse jarl Haakon Ivarsson led to a successful invasion of Gostaland by Harald III Hardraade of Norway Steinkel also had disputes with Denmark. His death in 1006 was followed by a civil war, and for the next 15 years the history of Sweden is very obscure In 1081 we find the sons of Steinkel, ling eand Haistan, regging Inge's attachment to Christianity caused him to be expelled after a short time by his brother-in-law Sweyn or Blotsweyn, so called from his revaval of the old scarifices, described by Adam of Bremen Sweyn retained the kingship for only three years before line returned and slew him.

Organization of the Kingdom.-Under Blotsweyn's grandson, King Sverker (1134-55), who permanently amalgamated the Swedes and Goths (each of the two nations supplying the common king alternately for the next 100 years), Sweden began to feel the advantage of a centralized monarchical government Eric IX (1150-60) organized the Swedish church on the model prevalent elsewhere and undertook a crusade against the heathen Finlanders, which marks the beginning of Sweden's overseas dominion Under Charles VII, the archbishopric of Uppsala was founded (1164). But the greatest mediaeval statesman of Sweden was Birger Tarl. of the powerful Folkungar family. He practically ruled the land from 1248 to 1266 He founded Stockholm, but he is best known as a legislator who prepared the way for the abolition of serfdom. The increased dignity which the royal power owed to Birger was still further extended by King Magnus Ladulas (1275-90). Both these rulers adopted the dangerous expedient of creating a number of almost independent duchies in Sweden, but the danger of weakening the realm by partition was averted, though not without violent complications. In 1319 the severed portions of Sweden were once more reunited. Meanwhile the political development of the state was steadily proceeding. The formation of separate orders, or estates, was pronounced by Magnus Ladulas, who extended the privileges of the clergy and founded a hereditary nobility (Ordinance of Alsno, 1280) In connection with this institution we now hear of a heavily armed cavalry as the kernel of the national army. The knights too became distinguishable from the higher nobility To this period belongs the rise of a prominent burgess class, as the towns began to acquire charters. At the end of the 13th century and the beginning of the 14th provincial codes of laws appeared and the king and his council executed legislative

Union of Kalmar, 1397,--The first union between Sweden and Norway occurred in 1319, when the three-year-old Magnus, son of the Swedish royal duke Eric and of the Norwegian princess Ingeborg, who had inherited the throne of Norway from his grandfather Haakon V, was in the same year elected king of Sweden (Convention of Oslo). A long minority weakened the royal influence in both countries, and Magnus lost both his kingdoms before his death. The Swedes, irritated by his misrule, superseded him by his nephew Albert of Mecklenburg (1365). In Sweden, however, Magnus' partialities and necessities had led directly to the rise of a powerful landed aristocracy and, indirectly, to the growth of popular liberties. Forced by the unruliness of the magnates to lean upon the middle classes, Magnus summoned in 1359 a primitive form of the riksdag, on which occasion representatives from the towns were invited to appear along with the nobles and clergy. His successor, Albert, was forced to go a step farther and, in 1371, to take the first coronation oath.

The Swedish nobles, however, remained dissatisfied with the rule of Albert of Mecklenburg. In 1388, therefore, they called in Margaret (q.0.), Valdemar IV Alterdag's daughter and successor on the Danish throne, who became queen of Sweden also in 1389, Norway was already united with Denmark, and Margaret's plan was to bring all the three kingdoms together into a single union under Denmark. An act of union was drawn up at Kalmar in 1397 but was not proceeded with as the queen was dissatisfied with some of its clauses. At the same time her relative Eric of Pomerania was elected future king of the three kingdoms Alter Margaret's death in 1412 be assumed the government and proceeded to try

to change Sweden into a vassal country with the help of a system of Danish bailiffs. The consequent oppression became so hard that the Swedish peasants rose in 1434 under the leadership of Engelbrekt Engelbrektsson, a noble from Bergslagen. The national movement spread swiftly and the Danish strongholds were conquered In the course of this fight for freedom Engelbrekt called together at Arboga, in Jan. 1435, the first riksdag in which nobles, priests, burghers and peasants were all represented. In 1436 Engelbiekt was murdered. For several decades a party in fayour of the union, made up of the more important nobles and the clericals, with Danish support, proceeded to contend against a national democratic party under native leaders taken from the nobles. Danish kings were on several occasions recognized as rightful sovereigns also of Sweden, among them, for instance, Christopher of Bavaria (1440-48), in whose reign there was enacted in 1442 a new general law which, with additions, held good until 1734, and Christian I (1457-64) In between, a Swedish nobleman, Karl Knutsson, was recognized king (as Charles VIII) during the years 1448-57, 1464-65 and 1467-70, being twice expelled and twice reinstated. During the years that followed no native-born sovereigns were set up against the Danish kings, but the national party was under the leadership of riksforestandare, or regents, in the persons of members of the Sture family. After riks forestandare Sten Sture the Elder (1470-97) came the Danish king Hans (1497-1501), then Sten Sture again, (1501-03), and then Svante Sture (1504-12) and Step Sture the Younger (1512-20). The times were troubled and there were continual struggles with the Danes. Many Germans lived in the towns. After a Swedish victory over the Danes at Brunkeberg in 1471 an old ordinance by which the Germans should have half the seats in the town councils was abolished. The country now became impoverished, but the national feeling grew stronger than ever, concurrently with a hatred of Denmark caused by Danish intrigues against Sweden. After 1512 the aristocracy, led by Erik Trolle, sought reconciliation with Denmark Things came to a climax when the Danish king Christian II conquered the country; and in 1520 Archbishop Gustaf Trolle, Erik's son, had the foremost men of the national party in Stockholm executed (the "Stockholm blood bath") Among noteworthy events in this period may be mentioned the founding of Sweden's first university in Uppsala in 1477.

Gustavus I Vasa.—The Standinavian union was represented by the Damsh king hvmg in Copenhagen. Denmark and Norway held the south, and foreign trade lay in the hands of the Hanseatic league. Sweden was a land of peasants, divided by provinces and inspired by all the local patriotism that troublous times evoke. Uppsala university had deteriorated, and the affars of the Catholic Church had long been neglected by the Holy See

A young Swedish nobleman, Gustavus (Gustat) Enksson Vass, who had been treacherously carried off to Demmark as hostage and prisoner, in 7579 made his secape to Lübeck, where he won good friends. At the end of May 1520 he landed again in Sweden near Kalmar and quickly learned of the massacre in Stockholm, in which his father and brother-in-aw had persibed. He made his way up to Dalecarlis, where he raised his first peasant troops. He had neither arms nor money, but one province after another came to be supply to the complete of the compl

But it was not easy to guard what had been won. Lütheck had seemed for itself a monopoly of Sweden's foreign trade as well as exemption from tolls and bonds for very considerable sums in payment for services rendered. Drastic taxation had to be imposed, and the churches and monasteries also were requisitioned for help. Archbishop Gustaf Trolle was a fugitive, and the Swedish church found itself in a state of dissolution. Gustavus Vasa's first appeals to the pope were for bishops of Swedish birth, a new archbishop and church reformation. No favourable response came from Rome, and in these circumstances the king was influenced by Lutheras The New Testament was translated into Swedish. At the ribsdag help in Vasters in 1,027 the church settlement decreed

that the bishops had to hand over their castles to the king, and the chapters and canons, moreover, their superfluous incomes; that Peter's pence should no longer be paid to the pope; and that the pope's authority should not be invoked for the election of bishops. The year afterward the king was crowned in the cathedral of

Uppsala,

Gustavus Vasa had to defend the interests of the kingdom against the individual claims of the provinces. The peasants had become disturbed by the novelties of the Reformation, and an adventurer came upon the scene, declaring he was Sten Sture's son, Disturbances broke out but the king put them down with severity. Christian II had been driven out of Denmark also, and this produced a rapprochement between Sweden and Denmark Finally Christian was incarcerated in a Danish prison in 1532. Mean-In 1531 while, Lübeck's privileges had come to be intolerable. every church was called upon to hand over its largest bell to supply means for meeting the Lübeck habilities Lubeck declared war on Denmark and Sweden; with the help of German allies its forces took Copenhagen and Malmo. They could not hold out, however, and in 1536 peace was declared. In the following year a treaty was framed between Sweden and Lubeck regarding certain exemptions from tolls but without trade monopoly. Sweden's debts were declared to be settled.

King Gustavus had now to organize administration He heard talk about Roman law as the bass of all law. He consequently called in a great number of Germans, so that the years 1538-44 came to be known as the "German period", but the Germans were for the most part adventurers and the results were not satisfactory. The newcomers caused the king to distrust his earlher helpers. There was a dangerous outbreak in Smaland, led by a peasant, Null Dacke, who was killed in 1543. The influence of the Germans then cased, and Gustavus ruled alone He devoted great attention to mining, trade and agriculture An influential landed nobility was restrained At the riksdag meeting of 1560 the king presented his testament. He died on Spet 1.9 of that year, aged 46, second his devanement. He died on Spet 1.9 of that year, aged 48,

He was the founder of the new Sweden.

Eric XIV.—Custavus Vass' eddest son succeeded. Scholarly, display-loving, wayward, he ruled well at first but became insane. Gustavus had bestowed on his other sons dukedoms which entailed discords between them. On the occasion of his coronation Eric created the ranks of counts and barons, but he was mistrustful of the nobles, upon whom he imposed great exactions. He entered into negotiations for marriage with Queen Elizabeth I and afterward with Mary Stuart, as well as with two princesses on the continent, but met with refusals. Toward the close of his regni he married his low-born mistress, a good-hearted woman, Kann Mansodtter.

When the Teutonic Knights of Estonia and Livonia cassed to be, the town of Tallian and the neighbouring region went over of the own accord to Sweden. This was the first step toward a Swedish sovereignty over the Baltre south of the Bay of Finland. The situation pointed ominously to coming conflicts, for Russia took Narva, the Danish duke Magmus took Osel and Poland took a large

portion of the Teutonic Knights' country.

A break with Poland resulted in internal dissensions, as Eric's brother John, who was duke of Finland, married Catherine, the sister of the Polish king Sigismund II, and as security for a loan to his brother-in-law got some Polish castles in Livonia. A brief civil war took place. Eric's troops took Abo, and John and Catherine were put in prison, after being tried and sentenced by the riksdag. Negotiations were entered into with Ivan IV the Terrible in Russia and ended with a proposal for a treaty containing the condition-a blot upon Eric's name-that Duke John's wife should be handed over to the tsar, evidently to be used as a means of enforcing concessions from the Polish king. The shameful clause may be ascribed to Eric's madness, and it was never enforced. A severe conflict ensued with Denmark, which wished to have the union preserved and kept Sweden's "three crowns" in its coat of arms. Eric wanted to break the cordon in the south and would not recognize Denmark's claims to supremacy over the Baltic He ostentatiously added the Danish and Norwegian kingdoms' arms to his own. Other disputes followed, and war resulted

in 1563. The Swedish fleet won victories but the Danes had the mastery in the war on land, which was waged on both sides with grim ferocity. Lubeck and Poland allied themselves with Denmark. In 1569 Erick insurity became manifest. He had some of the foremost nobles imprisoned, murdered one of them himself and had others of them assassinated. He became penitent and set free Duke John, who, in alliance with his younger brother Charles and the nobles, dethroned and imprisoned Etic in 1568. He ducid in prison in 1579.

John III .- John, an amiable man, learned in theology but irresolute and weak, was acclaimed king. The Danish war died a natural death through the economic attrition of both powers and in Dec 1570 peace was declared at Stettin through Polish and French mediation, the frontiers remained the same as before the war Gotland was allotted to Denmark: Alvsborg on the west coast was to be surrendered by Sweden with a large sum of money, the question of the three crowns was left for later decision, but in the meantime Denmark was free to incorporate them in its arms, the Danish and Norwegian arms were to be taken out of the Swedish coat of arms. Sweden's gain consisted in the fact that from this time forward it was to be considered Denmark's equal as a Baltic state Between Sweden and Poland good relations sprang up at once, but war broke out with Russia, waged with changing fortunes and occasionally interrupted by armistices As a result the whole of Estonia, with Narva, was incorporated with Sweden.

The great religious struggle in Europe was followed with interest by John, who sought to take up a mediative role and entered into negotiations with the pone Both panal and Spanish envoys came to Sweden, and it looked as though the king would go over to the Catholic Church, but when the pope refused to accept his offer of mediation he changed his tone and entered into definite opposition to Rome. He had previously given out a liturgy which evoked general displeasure in Sweden by its approach to the Catholic form of religious services; taken as a whole, his religious measures caused great unrest His son Sigismund adopted the Catholic faith and was elected king of Poland in 1587. The internal administration of the country was marked by continual lack of funds (despite high taxation) and at the same time by extravagance over new buildings. Falls in the currency made the financial situation worse. The nobles were rewarded by special privileges for their part in the overthrow of Eric-a departure from the more democratic policy of Gustavus and Eric. The nobles now showed a tendency to aggrandize their powers, but the peasants never became serfs and the riksdag of the four estates continued to be called together. There were serious complications when John died

in 1592.

Charles IX.—The crown went to Sigismund, who was scantily gifted, obstinate and a devoted servant of the Cathole Church; list uncle Charles on the other hand was a practical man of affairs, passionate and hard. The evangelical learning had taken still stronger root, and at a church meeting in Uppsala in 1593 it was decided to abide by the Holy Scriptures, the three great symbols and the unmodified Augsburg Confession. Silgismund was forced to agree. On the day previously, however, he had protested to the papal nuncio against the undertaking, and he considered himself entitled to disregard it. He returned to Foland in 1594. Duke Charles and the council soon fill out, with the result that the Charles and the council soon fill out, with the result that the Sigismund landed with a small Polish army, but he suffered default in 1590 to declare him delhoned. Charles took a sangunary revense. The cantive members of the countly were excent.

Duke Charles was not crowned until 1607. He simed at a monarchical-democratic conception of government. During the years 1501—93 the riksdag or other estates were convened 15 times; during Charles's much briefer reign, 1594—1611, they were called together 16 times. New church dissensions were caused by the fact that Charles cherashed Chiumstic ideas while the clergy and the people expressed themselves more and more strongly in favour of evangelical tenets. By the peace with Russia concluded at Teusina in 2595 Sweden's ownership of Estoma and Narva had been recognized, but the troubles in Russia evoked new conflicts.

EDEN 641

Swedish troops matched into Moscow, and the Russian crown war offered to one of Charles's sons Novgorod was conquered War with Poland was waged in Livonia, where the Poles won certain advantages without being able to turn them to account Beccuse of Charles's endeavour to extend the region of Finnmark up to the arctic under the rule of Sweden, and from other causes, war brooke out with Demmark in 1611 and Kalmar was taken by the Danes, When Charles died in 1611 he left to his son, Gustavus Adolphus, an inheritance of three unfinished wars.

Gustavus II Adolphus.—Gustavus Adolphus, born in 1504, was declared of age on his faither's death. He had been given a thorough classical education and spoke Latin and several modern languages. He was an organizer of great capacity both n military and in internal administration. His personal influence was attributable to a strong and good character and a clear and faraghted vision. In all his work he had assistance of extraordinary value from his chancellor of state Count Ared Densityers (1987).

The Danes were successful in the war and took the harbours on the west coast. Through the mediation of King James I of England peace was concluded in 1613. The peace conditions were hard. Alvsborg was to be handed back to Sweden in return for a purpent of 1,000,000 dalers within sax years; the Finnmark region was given to Denmark-Norway, and the right of the Dansh king to use the Swedish three crowns in his coast of arms was reconnized.

Sweden next desired peace and a fixed frontier with Russia. The war was continued until the conclusion of peace at Stolbova -also with King James's mediation-in 1617. Sweden won eastern Karelia and Ingermanland, whereby land connection was obtained between Finland and Estonia, but gave up Novgorod. During and after these wars a great task of organization was carried out in Sweden. The council acquired a stronger position as the fices were set up after the French-Burgundian model; a method of judicial procedure was instituted and courts of appeal were established The nobility was incorporated in the social system as officials of the government, and much was done to improve local administration. The king promised not to begin war or conclude peace or make a treaty with other powers without the sanction of the riksdag. The ransom of Alvsborg made heavy taxes necessary, and even so the town of Amsterdam had to help with a loan. The financing of the state and the raising of the loan were based in a high degree on the copper ore in the Falu mines. In Jan 1619 the ransom sum was paid and Alvsborg was returned to Sweden. Gustavus Adolphus endeavoured to promote commerce. New towns were founded, of which Goteborg on the west coast was the most prominent (1621). A source of future difficulties lay in the privileges of the nobles Their graduated freedom from taxes the reward of the servants of the state-was to diminish thereby the state's revenue from taxation; this danger, however, did not present itself until later. The nobility secured the stability which it needed through the founding of the riddarhus, or house of the nobles, in 1626, in which records were inscribed of the noble families. Higher education was furthered. The University of Uppsala got from the king in 1624 a great donation of lands. Great attention was given to the equipment of the army and navy. Relations with Poland were settled by armistices until the year 1617, when negotiations led to no result. Sigismund had never abandoned his claim to the Swedish crown and therein lay a menace for the future. Open war began again and Gustavus Adolphus took personal part in it. Livonia and Riga were conquered, and for several years the Swedes carried the war into Polish Prussia. Through the mediation of Brandenburg, France and England, a six years' truce was agreed to at Altmark in Sept. 1629; some Prussian seaports continued to be Swedish possessions, the Swedes retaining the right to levy tolls.

Meanwhile the great conflict that was to be known as the Thirty Years' War  $(q, \nu)$  had started within the German kingdom, and Sigismund's efforts were meancing to the religious peace of Sweden. The emperor's troops were sent to Prussia to help Poland. The royal houses of Sweden and Denmark were related to German princes who asked for help. Catholic France sought to check the emperor's mcreasing influence and negotiated with Sweden

and Denmark; the English government was working to the same end Christian IV of Denmark entered into the war but was completely defeated, and Wallenstein's imperial army took up its position on the Baltic. Wallenstein was made duke of Mecklenburg and imperial admiral over the Atlantic ocean and the Baltic; an imperial fleet was to be built. When Stralsund was threatened, Gustavus Adolphus sent help (1628), and after long and many deliberations with the council and the riksdag he made his way with 13,000 men to Pomerania in June 1630; he preferred to have Germany as his theatre of war rather than to await an attack in Sweden. When success attended his invasion of the country, France concluded a subsidiary treaty with him at Barwalde in Jan. 1631. The evangelical princes of Germany took up a dubious attitude at first, and the Swedes were blamed when they did not succeed in reheving the town of Magdeburg, which was taken by the imperial general Tilly. After various negotiations, a decisive victory was won at Breitenfeld in Sept. 1631.

A series of bulliant Swedish successes followed. Gustavus Adolphus held his court in Mainz and Frankfurt, crossed the river Lech and made has entry into Munich. The empeor had dismosed Wallenstein in 169,0 but now took him back into favour, and soon the latter was once again in the field with a strong army, and the brisk war which ensued led to the battle of Litten in which Gustavus Adolphus met his death on Nov. 16 (O. S. 6), 1630.

It may be thought a matter for wonder that Sweden, a country with a population relatively so small, should have been capable of so great a political and military expension as was shown in the Thirty Years' War. The explanation lies partly in an extmoordinary national effort to svert an imminent danger. Sweden's armies were made up also in an increasing degree of foreign mercenaries, Geman, English and Dutch. In the Polish war a number of excellent Swedish generals had learned their business, and Gustavus Adolbubus was one of the foremost military leaders of the time.

Christina.—The death of Gustavus Adolphus produced a crisis in Germany. His daughter Christina, still a minor, was recognized as queen (1632-54) and the regency was undertaken by Axel Oxenstjerna. It was well that a new treaty was concluded with France in 1633 and that Wallenstein was murdered in Feb 1634, but in the autumn the Swedes suffered a defeat at Nordlingen which lowered their prestige. In 1635 Saxony concluded peace with the emperor, and its example was followed by Brandenburg in 1636; both declared war against Sweden. Johan Banér (q.v.) restored the good name of the Swedish troops by victories at Wittstock in 1636 and Chemnitz in 1639. His successor, Lennart Torstensson (q v.), thrice invaded the emperor's dominions and won the second battle of Breitenfeld in 1642. Almost everywhere Swedish interests were opposed by Denmark. Torstensson was ordered, therefore, to leave Bohemia for Denmark in 1643, and Jutland was overrun by Swedish troops. Christian IV was forced to conclude a peace at Bromsebro in 1645 by which Sweden won Jamtland, Harjedalen, Gotland, Osel and, for 30 years, Halland; exemption from the Oresund tolls was accorded for goods to Sweden and the Baltic provinces. By the treaty of Westphalia (see Westphalia, Peace of) Sweden acquired important German possessions—portions of Pomerania, Wismar, the bishoprics of Bremen and Verden as fiefs of the German empire, and prize money as rewards for the soldiers. A number of Swedes had in the course of the war amassed fortunes; the influence of the nobles in this way had been increased and a chasm had grown between them and the unprivileged classes. This was intensified by the circumstance that many foreigners had entered into Swedish service and had been rewarded with landed estates. Through them and through the impressions which Swedes had gathered in foreign countries, new ideas regarding the social status of the nobles had become prevalent.

The exercise of governmental power and the administration of the state in general were regulated by the constitution of the year 1634. Christina came of age in 1644, but laid down the crown ten years later. Richly endowed by nature, she had acquired much learning and many accomplishments but she was flightly and arbitarry, went to overload with gifts those who were momentanily 64.2 SWEDEN

in her favour. She went over to the Catholic church and died in Rome in 1680 after a life not lacking in excitement

Charles X Gustavus.—Her successor was Charles Gustavus, son of Charles IX's daughter Catherine, who had married John Casmir of Palatinate-Zwebrucken. He had been brought up in Sweden, becoming generalisations. The costs of the court were cut down, and in the rhsidag of 1655 the nobles agreed that the endowed estates necessary for administration of the kingdom, for defense of the realm and for working the mines should return to the crown, that certain estates bestowed as gifts should acquire the character of fiels with right of return to a new king, while a fourth of such estates as had been bestowed after the year 1625 forth of the control of

Charles X's short reign was occupied by war. With Poland there was as yet no peace, as the Russians had directed an attack against Poland, the king and the riksday decided to settle the matter by means of a war Charles X took Warsaw and Cracow (1655). Poland looked as though lost, but a national rising followed in favour of King John Casimir and two years of fruitless fighting resulted. Charles X qoncluded peace with the rising power, Brandenburg, and the Swedish and Brandenburgian armies together won a three days' battle at Warsaw in 1656. In that year the Russians began war and the emperor joined Sweden's enemies. and the following year Denmark, Holland and Brandenburg fol-lowed suit If all these powers could have co-operated closely Sweden's position would have been extremely perilous, but they could not Charles turned resolutely upon Denmark, took Jutland and led his troops first over the ice to Even and then across the islands to Sjalland The credit of this military exploit belongs chiefly to the quartermaster general of the army, Erik Dahlberg. Denmark was forced to make peace in 1658 at Roskilde, Sweden receiving Skane, Halland, Blekinge and Bornholm, Bohuslan and Trondheims Lan Both kingdoms undertook to make common cause to keep enemy fleets out of the sound. The king now thought of confronting his other enemies, but as certain negotiations with Denmark did not quite take the turn he expected and the Dutch were busily agitating in Denmark, he guessed that hostilities from this country would follow the moment he had become engaged in the east. He resolved to avoid this danger by completely crushing Denmark and began war anew in Aug 1658. His policy, however, failed, as in Poland, through a contingency with which the statesmen of those days seldom reckoned-the kindling of a national patriotic movement. Copenhagen withstood his attack and Holland sent a fleet which after a fierce struggle with the Swedes relieved the Danish capital. The situation was anxious, and a riksdag was called together at Goteborg. Charles X Gustavus died on the night of Feb 12-13, 1660, during its session

Charles XI,-Charles XI, a boy of four, succeeded his father as king at a moment when Sweden was surrounded by enemies The widowed queen and five officials became regent. The first thing done was to secure peace. with Poland, the emperor and Brandenburg at Oliva in 1660, whereby Sweden's right to hold Livonia was recognized and John Casimir renounced all claim to the Swedish throne, with Denmark the same year at Copenhagen, whereby Trondheims Lan and Bornholm went back to Denmark, compensation being given in the case of Bornholm; and with Russia in 1661 at Kardis, confirming the peace of Stolbova. Magnus Gabriel de la Gardie, the chancellor of state, was weak, and none took the lead in the way Axel Oxenstjerna had done after the death of Gustavus Adolphus The nation's defenses were allowed to decline although its foreign policy was adventurous. It was desired to obtain subsidies from other powers, and a rash treaty was concluded with France in 1672. In this year the king came of age, having reached his 17th year. His education had been neglected and he grew up awkward in his bearing, but he was an ardent patriot and extremely industrious.

The general decadence of Sweden became manifest when its foreign policy led to war with Brandenburg (1674) and Demark (1675). The war with Brandenburg was ill managed, and Sweden's military prestige was lowered by a defeat at Fehrbellin in

1675, most of its Geiman possessions were lost. The Danes invaded Skane where they continued to have many friends. The ling took the leadership. On the sea the Danes were successful, but Swedish victories at Lund in 1676 and other places saved the southern provinces. Peace treatise were signed in 1678 and 1679 with the different enemies. France accepted terms which in some respects were humilating for her ally Sweden. Some small regions in Germany were lost, but there was no question of any cession of land to Denmark.

Great portions of the country had been laid waste, the fleet had been destroyed, trade and commerce had suffered and finances were in disorder. A great task lay before the young king and he accomplished it, but it was by the methods of an absolute monarchy The riksdag was summoned several times-1680, 1682-83, 1686, etc .- but its attitude toward the king grew more and more complaisant and it gradually came to leave practically all matters of legislation and taxation to him. An inquiry was held into the conduct of the members of the regency, and they were sentenced to restore or pay large sums of money, a very drastic confiscation of private estates was taken in hand whereby land and incomes were made to fall to the treasury Charles then put the army and navy in good trim. The officers were remunerated by small farms; cavalry was raised by a certain number of assessed farms and the infantry by the landowners. In the year 1681 the Swedish national debt amounted to 44,000,000 dalers in silver, but on Charles's death it was only 11,500,000 dalers married the Danish princess Ulrica Leonora, but the two northern states soon fell apart again In 1681 Sweden entered into treaties with Holland at The Hague with a view to safeguarding the frontiers fixed by the peace treaties of Westphalia and Nilmegen The emperor gave his signature to the compact the following year Sweden wanted to draw Holstein into its sphere of interest so as to secure less interrupted communications between its different German possessions, Charles therefore gave what support he could to his maternal uncle Christian Albert, duke of Holstein-Gottorp, in his disputes with Denmark For Denmark, conversely, it was important to hinder the Holstein plans of expansion lest Denmark should be hemmed in on the south Charles XI died in April 1697, leaving one son, Charles, and two daughters.

Charles XII.—For the third time in the 17th century a regency was called on to act, but in Nov 169; the risking declared the 15-year-old Charles XII to be of age. At the coronation he placed the crown on his own head and gave no kinglorosaking (lindwise) with the coronation he placed the crown on his own head and gave no kinglorosaking (lindwise) "(sing's guarantee"). Charles was a gifted and precoccus youth who had been grounded in book learning and military science. He had high morality, but was inclined to obstinacy. In his early youth he was addicted to wild pranks and perflois sports. With three years of his accession, however, the Great Northern War (1700-or1) had broken out.

Poland, Denmark and Russia were united against Sweden. In March 1700 the Poles marched on Riga and the Danes against Holstein The young king showed unusual power and decision. Protected by the English and Dutch fleets he landed on Sialland (Zealand) and enforced on Denmark the peace of Traventhal in Aug 1700. In November the Swedes, under the personal leadership of Charles, won a momentous victory over the Russians at Narva In the summer of 1701 Charles marched south, drove the Russians and the Saxons over the Duna and invaded Poland Charles called upon the Poles to dethrone Augustus II the Strong who had begun the war. This stirred the national feeling of Poland and won Augustus help from other states. Charles's route went through Kaunas in Lithuania to Warsaw and Cracow which he took (1702). After continual but fruitless victories for the Swedes a Polish parliament, not constitutionally formed, declared Augustus dethroned and elected as his successor Stanislaus Leszczynski, a weak man who lacked the strength to defend his own The Polish parliament concluded peace with status as king. Sweden in 1705 In this way Poland became a kind of subject state to Sweden, but Charles miscalculated Sweden's capacity for maintaining such a relationship. During these Polish conflicts the tsar Peter took town after town in Livonia and Ingermanland, among them Dorpat and Narva. Charles, in the meantime, held

that the most important thing was to force Augustus to conclude peace before he took up his stand against Peter, and he carried war into Saxony The Swedish army was now one of the most famous in Europe, and Charles's power was very great. Leipzig was taken, and Augustus, by the peace signed for him by his ministers at Altranstadt in Sept 1706 and ratified by him in October, renounced the Polish throne and allowed Charles to remain some time in Saxony with his army. Augustus sought by intrigue to overrule the peace treaties but had to reaffirm them in Jan 1707 From different quarters came efforts to benefit by Swedish aid nearly a dozen German princes sought Charles out, and he was visited by 30 envoys from various courts. The most notable of them was the duke of Marlborough, who took note that the Swedish king did not intend to place himself on the side of France in the War of the Spanish Succession as rumour had declared Quarrels with the emperor began, but with the help of English and Dutch mediation a peace was concluded in 1707 which secured for Protestants in Schleswig the church rights promised them in the peace of Westphalia

Charles was anxious to come to conclusions with Russia, but he had given the tsar too long to prepare. The Russians had forced their way into Poland but were driven out again, and after a victory at Holowczyn (July 1708) Charles crossed the Dnieper. Adam Ludwig Levenhaupt was to have come with an army from Livonia to his support but was delayed and experienced a severe defeat, arriving eventually with a diminished force and without commissariat Devastations by the Russians made it difficult for the Swedes to provide themselves with necessaries, and when the Cossack Ivan Mazepa-Koledinsky offered his co-operation Charles concluded a treaty with him in Oct 1708 Mazepa did not manage to get his Cossacks to join with him, but Charles advanced into the Ukraine. In an unusually hard winter thousands of Swedish soldiers perished Charles began to lay siege to Poltava, the battle which followed (June 28, 1709) ended in a Swedish defeat, largely because of the fact that Charles was wounded in the foot and that his generals were not united. Charles made his way as a fugitive to Turkey and his proud army capitulated at Perevolochna on July 1, 1709

The unfortunate Russian campaign made an immense impression both in Sweden and in other countries Augustus declared the peace with Sweden invalid and marched into Poland The Danes crossed the sound and sought to overrun Skane. The government in Stockholm put forth all its powers to defend southern Sweden, and Magnus Stenbock won a decisive victory at Helsingborg in Feb 1710. The Danish troops were taken back to Denmark. The Russians occupied the Baltic provinces completely after they had taken Riga Meanwhile Charles was busying himself in Bender trying eagerly to bring about a war between the Turks and Russia. His stay in Turkey is difficult to explain; probably he did not want to return until the Russians had been either conquered or weakened. Thrice the Turks began war but without any gain to Sweden Meanwhile Stenbock made his way to Germany, but though he defeated the Danes, who had overrun Bremen and Verden, at Gadebusch (1712) he was forced to capitulate with his army at Tonningen in 1713. The Russians and Saxons failed to

From Feb 1713 Charles was held captive by the Turks, but after a swift journey he arrived at Stralsund in Nov 1714. The country was in a sad plight. The population was only 1.250,000 and the burden of the great war was too heavy. The people were oppressed by heavy taxes and services imposed by the state and worn out by consecution.

take Stralsund, but in 1713-14 the Russians swarmed over Fin-

land.

During the years that followed Charles XII strengthened Swedne's defenses against the Danes, who received help from a Kussian army and threatened an invasion of Sweden. The plan was not carried out, and Charles turned toward Notway to force the Danish king to make peace. While there he was killed by a bullet on Dec 11 (10.S. Nov. 30), 1718.

In Stralsund Charles had made acquaintance with the Holstein baron von Gortz, who afterward became his confidant and associate. Unscrupulous and resourceful, Görtz discovered new means

of taxation, simplified the state administration, lowered the value of the currency and conducted an adventurous policy abroad the poverty thus brought about evoked a hatted against him which after Charles's death led to his being their dand executed. With Charles the Swedish supremacy over the Ballic came to an end Swedish forces were withdrawn at once from Norway, one brigade which was sent against Trondheim expeniencing terrible losses in the mountains. The riksdag assembled for the special purpose of putting an end to the absolute power of the sovereign

Ulrica Leonora.-Charles's sister, the younger Ulrica Leonora, married to Frederick of Hesse-Cassel, was declared not to be the successor to the throne but was elected queen (1718-20) on condition that the riksdag alone should have the right to draw up the constitution. The changes effected in the constitution drawn up in 1719 and 1720 and in the riksdag decrees of 1723 were drastic. When the riksdag was not in session the council ruled together with the king who on most questions had only two votes. While the reksdag was sitting, decisions on foreign affairs and other matters were made by a secret committee which was formed of members of the three higher estates, the nobles, the clergy and the burghers The peasants were left in the background but they had to be heard on questions of taxation. Each estate chose its own speaker, in the house of nobles the speaker was called landmarskalk The membership of the council could be revoked only by law, and this made parliamentary government very primitive because it led to political lawsuits.

In 1710 peace was concluded with Hanower on the basis of sweden's giving up Bremen and Verden and rectiving a sum of money in return. In 1720 an arrangement was come to with Prass, which acquired a large part of Pomerana and also pead as sum of money. In 1720 also peace was made with Demark, which required a large part of Pomerana and also pead a sum of money. In 1720 also peace was made with Demark, which renounced the regions it had conquered in return for being a lowed to keep Schleswig. Russann fleets, however, were harrying the coasts of the Baltie, and an attack upon Stockholm was the great difficulty warded off. Peace was not concluded with Russia until 1721, at Nystad, when Sweden gave up Livona, Extona, lugna and parts of Finland, northern and western Finland was restored to Sweden.

Frederick I.—In 1720 the crown was transferred to the queen's consort Frederick I (1720-21). The leading statesman until the end of the 1730s was Count Arvid Hom, who pursued a pradent peace policy. The state's debts amounted to 60,000,000 or 70,000,000 silver dalers, and the emergency currency (nodmyntles) was wording much harm. A state bankruptcy was inevitable, and after this the emergency currency disappeared. With the English Navigation act as a model, a proclamation was issued in 1724 prohibiting foreign vessels from conveying to Sweden anything except the produce of the countries to which they belonged. The Swedis commercial fleet increased, an East Indian company was formed in 1731 (which caused bad blood in England), new manufactories were founded with support from the state, in particular the texture industry, thanks to Johns Alstromer, who created the manufactory at Alingsas. A new general law was framed in 1734. During the first vears following the neace of Nvstad Russis.

During the first years following the peace of Nystad Russis sought to intervene in Sweden's internal affairs. Horn therefore in 1760-77 made Sweden a member of the alliance between England, France and Prussus. Included, foregra subsidies began to have their ill effects in Sweden. Against Horn's prudent leadership there grew up an opposition which gained ground in 1734 and became victorious in the "histogia of 1738-39. Horn gave up office in the victorious party was called Hattar," the Hats' contradistion of the Victorious party was called Hattar, "the Hats' contradistion of the Table Sweden Provinces and power and a more intensity in the Sweden Provinces and power and a more intensity in houst stal policy, Sweden was to become a great power politically and economically.

The party of the Hats controlled the fortunes of the country until the 1760s, although sometimes strongly opposed by the Caps.

<sup>&</sup>quot;These party names originated in the Progressives' nicknaming their opponents—who sacrificed everything to perpetuate an inglorious peace—the "Nighteaps," they themselves receiving their name from the three-cornered hats that they wore as officers.

They dominated the council from 1739 onward with Count Karl side and it is calculated that these powers spent 3,000,000 silver Gyllenborg as their leader. Conditions seemed favourable for a war with Russia in 1741 and war began The campaign was badly conducted and the Swedish troops took to flight. Discontented thousands of peasants marched to Stockholm and could be dispersed only with difficulty At the beginning of the riksdag session in 1742 the Caps were in power, and the peasants now won for themselves a place in the secret committee. An inquiry was conducted into the actions of the instigators of the war, and two of the generals were condemned to death and executed The Hats now raised the question of the succession to the throne, the royal couple being childless, and the question soon became bound up with that of the Russian peace, as the Russian empress Elizabeth wished to see Duke Adolphus Frederick of Holstein elected The peasants particularly wanted to have the Danish crown prince, and a great conflict raged in riksdag circles, much bribing being done by foreigners In June 1743 peace was concluded at Abo. Russia retained only a small portion of its conquests in Finland, and Adolphus Frederick was chosen as heir to the Swedish throne. Denmark threatened war and Sweden's impotence became manifest when a Russian army came to the country to protect it against the Danes. While the rsksdag was in session there was a split among the Caps, and the council came to include both Hats and Caps. Adolphus Frederick came to Sweden and in 1744 married Ulrica (Ulrike; q v), sister of the Prussian king Frederick II. Russia's disposition to control the destinies of the country now took on a singularly offensive aspect. Foreign gold filled the coffers of the parties before the riksday of 1746-47 assembled. The Hats opposed the Russian proceedings resolutely and in this were supported by many of the Caps. Through new elections to the council, the Hats now came definitely into power again, with Count Anders Johan von Hopken as head of the government. Some members of the Caps party were charged with treason and the matter was investigated by a commission. This had the effect of diminishing their opposition to the Hats. An alliance was contracted in May 1747 with Prussia and France which improved the situation The successful party rewarded its friends lavishly and came down heavily upon its foes

The years which followed were comparatively quiet. The brilliant young noble Count Carl Gustaf Tessin was president of the council, which was the strongest known within the period of the riksdag's predominance, national defenses were strengthened, customs tolls were raised to help industry, which was also supported by loans and premiums; agriculture was supported also by loans on easy terms. The improvement secured by these measures was not entirely real, and great credits were extorted from the Riksbank, which had to increase its issue of notes. Notes depreciated in value and exchange offices were set up to keep the currency at the desired height.

Adolphus Frederick.—King Frederick died in 1751 and was succeeded by Adolphus Frederick (1751-71), who was under the influence of his stronger-minded wife. Controversial pamphlets and journals came out in numbers. Tension between the king and the council increased. A rash effort at a coup d'état was made during the riksdag of 1755-56; the royal couple was humiliated and an autograph stamp was introduced in order to dispense with the king's personal intervention in the government. Count Axel von Fersen came to the front as the foremost man in the Hats party; he was chosen as landmarskalk (see above), leading the bureaucracy of the nobles.

Opposition grew therefore among the unprivileged classes against the nobility and the bureaucracy. The state's finances were in a bad way, yet in spite of this the country was let in for a war, on the side of France and Austria, against Frederick II of Prussia (1757), largely because of the French subsidies. The war was badly managed, but peace was made with Prussia without loss of territory in May 1762. The Caps took office in the riksdag of 1765-66. Russia and Prussia together decided to support the Swedish constitution, to prolong its general state of weakness and at the same time to work against the French influence. A Russo-Danish alliance was also formed with the purpose of maintaining the Swedish constitution. England was on the same

dalers in order to ensure the victory of the Caps, while France's contribution to the Hats amounted to 2,000,000 dalers The corruption was shameful. Against the wishes of the royal couple. the crown prince Gustavus married the Danish princess Sophia Magdalena

The court had helped the Hats during the riksdag, and by the king's direct intervention the council was obliged to call together the riksdag which sat from 1760 till 1770. The Caps were now in a minority and their men were left out of the council which was controlled by the Hats. The court had been promised that the king's power would be increased, but the Hats did not keep their word. Nor did the riksdag succeed in solving the great financial problems In Feb 1771 Adolphus Frederick died Somewhat previously Russia and Denmark had come to an agreement that, should any change be made in the constitution of Sweden in the direction of increasing the king's power, they would uphold the existing constitution (Dec 1769) by force of arms. Sweden's constitution therefore seemed to be held in greater value by its enemies than by its own people

Gustavus III .- The crown prince was in Paris at the time of his father's death. He returned home to meet the riksdag. The Hats and the court party were receiving money from France, the Caps from Russia and England The parties were of about equal strength Gustavus now decided to precipitate a change of the constitution Col Jakob Magnus Sprengtporten crossed to Finland to stir up a rising, in which he succeeded but not so quickly as had been expected Johan Kristoffer Toll (a v ), a superintendent of forests, went to Skane and won over the garrison at Kristianstad Prince Charles, the brother of the king, also busied himself in Skane. The council got wind of the danger and the king had to act speedily On Aug 19, 1772, he collected around him the officers of the guard and arrested the council in the royal castle. The Stockholm troops declared for him and the people acclaimed him in the streets. The king became again head of the government, with the right to appoint officials. It was an attempt to divide the balance of power between the sovereign and the riksdag.

Russia and Denmark were furious but did not begin war, being much influenced by the resolute attitude of France. Gustavus surrounded himself with capable men He was unusually gifted, but too much of a visionary He had a real passion for the theatre but took up his business as king with honest intent; an inquiry into the conditions of governmental offices was initiated and a number of reforms in the administration were instituted as a result. In order to help the finances distilling was decreed a state monopoly and a number of distilleries were founded on behalf of the crown. This displeased the peasants, who wanted to be free to distil, and it increased drunkenness Another cause for dissatisfaction lay in the king's efforts to transform the nobility into a court nobility and to manage promotion so as to break the power of the old bureaucracy

A dispute with his mother discouraged the king, who next visited Italy and Paris; a subsidy treaty was concluded with France but Gustavus had no great success there. During the riksdag of 1786 the situation became worse; most of the king's measures were rejected.

Then Turkey's war with Russia in 1787 seemed to offer favourable conditions for a successful foreign policy. He began war with Russia in June 1788, taking command himself But the sea fight at Hogland was undecisive, and a conspiracy, known as the Anjala league, was formed by certain officers The conspirators opened negotiations with the Russian empress, to bring about peace. News came that Denmark had entered the war as Russia's ally, and Gustavus was obliged to hurry back to Sweden. The Swedish people became animated by patriotism and the king talked to the peasants as Gustavus Vasa had done of old England and Prussia brought pressure to bear on Denmark to leave Sweden in peace and a truce was concluded. By the beginning of the following year, 1789, Gustavus was strong enough to have the leaders of the Anjala league imprisoned. The riksdag was called together at the beginning of February. The meeting was

a stormy one, the kung, supported by the unprivileged extates, driving through the so-called Act of Union and Security, which embodied a number of far-reaching constitutional unnovations: the council cased to exist; the king acquired full powers over the administration of the state and the appointing of officials; and the rikized to its initiative in legislation. Once again the authority of the king became dominant. The rikized became responsible for the national debts, the management of which was placed in the hands of the rikized sixth emans and to issue credit notes. A number of the leaders of the oppositions of the rikized sixth emans and to issue credit notes. A number of the leaders of the opposition of the rikized sixth emans and to issue credit notes. A number of the leaders of the opposition being a second revolution. (See Gustavios III; Wakuyara, Olak)

The Russan war became a war of exhaustion on land During

Inter Aussian was bearing a water of the parts 739-90 there were several sea fights, the second of which, at Svensksund in 7990, constituted a fine victory under the king's command in Aug. 1790 peace was concluded without modification of frontiers. But Sweden's finances were destroyed and the internal strice brought to a head One result was a conspiracy against the king's life. He died on March 29, 1792, from the effects of a murderous attack by Cantain I. I. Anackarstrom at

a ball in the opera house on March 16, 1792

Gustavus IV .-- At the age of 13 Gustavus IV (1792-1809) became king of Sweden with his uncle Duke Charles as regent Duke Charles's closest associate was Baron Gustaf Adolf Reuterholm (q v), a man of great powers of work but pedantic and of little intelligence The regency brought order into the higher grades of government service and sought above all to further the prosperity of agriculture Reuterholm was not lacking in appreciation of the latest reforms, the freedom of the press was at first increased, but when the horrors of the French Revolution broke out it was restricted. The repute of the regency did not stand very high. It wavered between a French and a Russian alhance. The king, the duke and Reuterholm visited the Russian court in order to arrange a marriage between the king and a Russian princess, but the whole thing fell through when the king refused to give a guarantee of the princess's religious freedom. On the basis of a treaty concluded in 1794 between the two countries, the fleets of both Denmark and Sweden sought to protect neutral trade against privateers of England and other nations.

In 1796 Gustavus IV took the government into his own hands. He was scantily gifted but he knew how to make himself felt and combined obstinacy with passionate temper. So bad were the finances that the town of Wismar had to be mortgaged to Mecklenburg in 1801. In the course of a long journey in Germany in the years 1803-04 Gustavus came into touch with French émigrés, who inspired him with hatred of Napoleon He took part in the coalition against France in 1805-07, with the result that Pomerania and Stralsund were lost. In the treaty of Tilsit Napoleon and the emperor Alexander agreed to attack Sweden unless it declared war against England and prevailed on Denmark to do the same. The army in Finland gave way before the Russians. The strong fortress of Sveaborg was treacherously surrendered without any real struggle. In the spring the Swedes marched again to the south of Finland and won several victories, afterward immortalized by the poet J. L. Runeberg. In Dec. 1808 the Swedish forces evacuated Finland. Gustavus IV became more and more difficult and he annoved even England, his only ally. The feeling grew that the king must be dethroned. Gen, Georg Adlersparre started a revolutionary movement in Varmland, but before he reached Stockholm Adj. Gen. Karl Johan Adlercreutz had secured possession of the king's person (March 13, 1809). The king died in exile in 1837

Charles XIII.—The rikedag was called together on May 1 by the provisional government and it decided to draw up a new constitution and elect a king. The form of government which resulted was based on a division of power between the ministry, the representatives of the people and the judicature. The king was to be advised by a ministry the members of which were to be appointed by the king but to be answerable to the rikedag. General legislature was to be the work of the king and the rikedag, and the rike-

dag's control over taxation was confirmed. As soon as this constitution had been adopted Charles XIII was recognized as king (1809-18). The credit of drafting the new constitution belongs thefive to Hans Iarta.

King Charles was childless and it was necessary to choose a successor to the throne Public opinion in Sweden at this period occupied itself with Norway's union with Sweden as a compensation for Finland The rikking chose as successor to the throne Pinnee Christian Augusties of Augustenburg, who was commander under in Norway, manifestly in the hope that the choice would help to bring this union about. The prince declared that the could accept this offer only after a declaration of peace. During the late summer of 1800 the Russian war was extended to the north of Sweden and the Swedish forces met with two defeats. The Russians in the meantime had become weary of the war and no September peace was declared at Fredriksham (Hamlina); Sweden lost Finland and Aland. Soon treaties of peace followed with its other nemnies. Pomerama was returned to Sweden.

The heir to the throne, who took the name of Charles, died sud-donly in 18to, and a raksdag at Orehoo had again to deal with the question of a successor. Opinions were divided when a suggestion was made that they should elect one of Napoleon s marshals, Jean Bernadotte, prince of Ponte Corov It seemed certain that Napoleon would approve, and accordingly Bernadotte was chosen and assumed the name of Charles John, to become the founder of a new Swedish dynasty, the succession to the throne having been provided for in an ordinance passed in 18to. The old King Charles XIII had shown courage and patriotic feeling during Gustavus III's war with Kussa, but he was not very intelligent and he lacked strength of character. The crown prince therefore began to exert

In 1811 Napoleon prepared to break down Russia's resistance A great ware began, and the crown prince perceived that Sweden could not possibly go into it with France against England and Russia. He seems early to have thought out it is plans for the conquest of Norway, and in 1812 he brought about a complete change in Swedish policy with this goal in view. Napoleon's occupation of Swedish Pomerania without declaration of war facilitated this change, and Russia and England favoured the idea that Norway should pass over to Sweden from Napoleon's ally Denmark. After the defeat of the French armies in Russia Charlest John took pair the defeat of the French armies in Russia Charlest John took pair the defeat of the French armies in Russia Charlest John took pair the defeat of the French armies in Russia Charlest John took pair the defeat of the French armies in Russia Charlest John took pair the defeat of the prench armies in Russia Charlest John took pair the defeat of the prench armies in Russia Charlest John took pair the second of the Parkent Parken

The Norwegians themselves, desiring independence, held an assembly at Edsovld in May 18t, where they framed a constitution and elected the Danish prince Christian Frederick as king; but they were forced as the result of a short war to surrender. Christian Frederick laid down his crown and a storting endorsed the union with Sweden. Special conditions affecting the union were framed in the act of union or riksuke passed by the parliaments of both counties in 18t. 2001.

Charles XIV .- Bernadotte succeeded to the throne, as Charles XIV John, in 1818. The industrial economic revolution, evolving new classes which claimed their share in the government and burst asunder the old methods of representation, began in Sweden durmg his reign and embittered his later years. He was a strong personality, capable and lovable but distrustful of new ideas and apprehensive of too great changes. A liberal opposition was formed in the riksdag, above all among the burghers, and took a strong line against the government's repression of newspapers, against bureaucratic formalities and against the king's tendency to disregard the advice of his ministers From the 1830s onward there was a question of reform in the matter of the representation of the people, and a great many bills were put forward without accomplishing much. In 1840 the state council was changed by the creation of special departments. With the king's active cooperation the state's foreign debts were paid while internal debts were diminished, and in 1834 a regulation of the exchange was effected. Much was done for the canal system; one section of the Gotha canal was opened in 1822 and the rest of it in 1832. In 1842 the board school system was changed.

Oscar L.—Charles XIV was succeeded in 1844 by his son, a man of gifts and of more open mind but of less strength of will than his father. During the earlier years of his reign he stood for a policy of reform but later changed noticeably toward conservatism. During the last two years of his life he was ill, and the administration was taken in hand by his son Charles. The restrictions on agriculture and commerce were relaxed; the guild system was done away with in 1846; the old rules confining trade to the towns were removed. By decisions reached in the riksdag for 1844-45 the right to suppress newspapers was definitely abro-In 1847 an important poor-law system was introduced One of the greatest questions of that period was that of communication: railways had to be built, but there were differences of opinion as to the laying down of the main lines through the sparsely inhabited land. In the riksdag of 1853-54 it was decided that the main lines should be built by the state, and the direction of the work was placed in the hands of Col. Nils Ericson. Friends of reform concentrated more and more on the demand for a thoroughgoing change in the formation of the *riksdag*, and many proposals were submitted without any of them being accepted. The revolutionary movement which marked the year 1848 on the continent aroused feeling also in Sweden and some street disturbances occurred in Stockholm. The government produced a new scheme of representation, which, however, was rejected by the riksday of 1850. A strong Scandinavian movement manifested itself (especially in Denmark and Sweden, although the Norwegians also took part in it); great meetings of students were held, but no program for the unity of the Scandinavian countries with any real life in it was ever framed. When the Schleswig question led in 1848 to war between Denmark and the German states, a Swedish army was collected together in Skane and troops were carried over to Fven, in case Jutland should be invaded; but they never had occasion to come into action. During the Crimean War Sweden and Norway maintained neutrality. In Nov. 1855 they reaped the benefit: a treaty was concluded with England and France by which the union states undertook not to cede any portion of their territories to Russia while the two other powers undertook to prevent any Russian efforts in that direction (the November treaty), Side by side with the peace treaty in Paris there was concluded a separate agreement between Russia, France and England in which

Russia undertook not to fortify the Aland Islands.
The increasing consumption of sparts, as a result of the right to distil for household needs, called forth anxiety and led to a temperance movement conducted by persons such as Peter Wieselgren, a pastor. Pravte distilleries were done away with by the riksdeg of 1853-45 and the distilling of sparts was regulated by the state. Ever since the middle of the 197th century the question of temperature of the property of the state of the property of the state of the property of

perance has affected parties.

Charles XV.—The crown prince had conducted the government for two years, when he became high guider the name (Charles XV (1859-29). He was a fascinating man who by his liveliness of mind, personal friendliness and actisic temperament won great popularity, but he lacked the thoroughness and perseverance in work and the seriousness which are called for in a stateman. His undeniable gifts were bound up with an extravagant imagnation which in certain situations was a danger. This became most noticeable in the German-Danish war of 1865-64, when he gave the Danes dutincity to understand that they could count on an alliance between Denmark and Sweden-Norway, an idea which had never had the sanction of the state councils of either of the union countries and which was never to be realized. A number of Swedes, however, did enter the Danish army as volunteers.

The social changes which had come about in the life of Sweden necessitated a new form of electron representation, and increasingly the general feeling was that it must be solved by giving up the division into four estates and that a riksday with two chambers should be founded instead. The minister of justice, Louis de Geer (q,v), took the lead in the matter and the government submitted a bill in the riksday of 1856–56. The new constitution was finally accepted by all flour estates in the riksday of 1856–56.

and in Jan. 1867 the first riktdag of the new kind was assembled. It soon became evident that it was the peasants who had benefited most by the reform: within two years they dominated the second chamber and their party—the so-called Lantmanna party—was a power to reckon with.

Through the influence of the finance minister, Baron J. A. Gripenstedt, Sweden was led more in the direction of free trade, enstedt, Sweden was led more in the direction of free trade its treaty of commerce with France in 1865 was an epoch-making event in the development. All duties on grain were removed The right of trading was extended in 1864. Among more important reforms may be mentioned the criminal law and the manulaw of 1864. The wars which were in progress on the continencused the rakeage to grant large sums for armaments but the government's proposal for a reorganization of the national detenses was referred.

Oscar II.—After a prolonged illness Charles XV died in Sept 1872 and was succeeded by his brother Oscar II. The most noteworthy event in the latter's reign was the dissolution of the union

with Norway.

The union plans of 1815 were never quite clear, and great doubts had always existed regarding the documents in question and their precise bearing. The Norwegians, apprehensive of Swedish domination, had sought always to give the narrowest possible application to the provisions of the act of union, while the Swedes, gention to the provisions of the act of union, while the viewes, generally speaking, sought to give them a wider application, although with increased powers for Norway. The first great crisis arose over the question of the post of stathallare, or governor, of Norway At first this post had been held by Swedes, but as this had invited opposition they were succeeded by Norwegians. In 1850 the storting resolved to abolish the post altogether, but in Sweden it was contended that as the post was provided for in the act of union it could not be rejected by Norway alone. The question was shelved for a time, and in 1873 Oscar II sanctioned the resolution of the storting. The first great union committee had met in the 1840s and had been followed by several smaller committees and in the years 1865-67 by a great committee which worked out a plan for a new agreement between the two kingdoms. This, however, had been rejected by the storting in 1871. The position of the sovereign of the two kingdoms was now becoming extremely difficult, because modern parliamentarianism had progressed much further in Norway than in Sweden and the powers of the sovereign had consequently become much less extensive in Norway. Thus the king had been forced to make continual concessions to the Norwegians. In the year 1835 it had been decided that the premier or another member of the Norwegian government should be called into the Swedish-Norwegian ministerial council whenever questions concerning the foreign affairs of Norway alone or both kingdoms should be under discussion. In the 1880s a dispute arose about this joint ministerial council. From 1801 onward the storting demanded Norwegian consulates for Norway. Also, it reduced the annual grant for the court. Because of the protectionist demand of Sweden a Swedish-Norwegian joint law (dealing with reciprocal freedom from customs duties) ceased to exist in 1897. and in 1898 the king ratified a decision of the storting to remove the joint union emblem in the upper right-hand corner of the Norwegian flag; it disappeared afterward from the Swedish flag A small union committee put forward in 1902 a proposal for separate consular services but joint foreign office. Negotiations took place and in 1903 understanding seemed to be in sight. The Swedish plan provided that the foreign minister might be either a Norwegian or a Swede. But from both sides there came charges of breach of faith, and in Norway all parties demanded dissolution of the union. The Swedes were astonished when on June 7, 1905, the storting declared the union with Sweden to be dissolved. The riksdag acquiesced in the dissolution of the union upon certain conditions, such as that Norway should destroy certain frontier fortresses erected near the Swedish frontier, that the regions adjoining the frontier should constitute a neutral zone without fortifications and military manoeuvres, etc. King Oscar laid down the Norwegian crown on Oct. 26, 1905.

During the first years of King Oscar's reign, however, the question of national defense had been the dominant one, the first

chamber contending for an improved system and the peasant memhers in the second chamber making demands which could not for a long time be conceded. A number of aimy organization proposals were rejected, and during the 1880s the question of customs duties caused bitter disputes. The increasing exportation of grain from the United States and Russia together with the strong industrial competition among all countries resulted in a protectionist movement in Germany and France which extended also to Sweden. The second chamber was protectionist and the first in favour of free trade, in 1887 the majority in the first chamber was so small that it would have been possible to bring about a protectionist system by the collective vote of the two chambers king then dissolved the second chamber, which returned with a majority in favour of free trade The riksdag of 1888 on the other hand accepted the customs system, as the general election in the autumn of 1887-through a technical mistake in the election of the free-trade candidates in Stockholm-had given the protectionists a small majority. This issue had profound consequences both in the formation of parties in the second chamber and in other respects. New men came forward, the most conspicuous of whom was the landed proprietor E. G Bostrom, premier from 1891 to 1900 and 1902 to 1905 The question of the national defenses was provisionally settled by the riksdag's decisions in the autumn of 1801 (at an extraordinary session) and in 1901 In the latter year the Swedish military tenure established was completely abolished; the training time of the men hable for military service was increased from 90 to 240 days in the infantry and a longer period in the case of the navy and special branches of the army.

At this period new legislation was necessitated by industrial development and the great increase in the number of industrial workers. In 1881 the conditions of labour for children in all factories were regulated and in 1880 a law was passed on providing against injury while at work; the former law was amplified in 1900 by one dealing with the condition of industrial work for women and children. Trade unions were formed and collective agreements governing labour conditions were arranged between employers and workers. In 1880 a Social Democratic party was formed and in the autumn of 1896 Karl Hjalmar Branting was elected to the second chamber as its first Social Democratic member. The Liberals and Social Democrats demanded an extension of the suffrage for the second chamber, but it was not until the severance of the umon with Norway had given a strong impetus to a closer national union on new lines that the question came to be decided. The severance of the union led to the formation of the coalition ministry of Christian Lundeberg, a manufacturer, whose task it was to carry out the dissolution of the union He was followed at the close of the year 1905 by a Liberal ministry with Karl Staaff, a solicitor, as premier. The riksdag of 1906 rejected his suffrage bill, and the ministry resigned. Rear Adm. Arvid Lindman succeeded, with a Conservative ministry; he found a way, in 1907, of solving the suffrage question on the basis of universal and equal suffrage (with certain exceptions) together with the democratization of the communal scale of voting and proportional voting for both chambers. Among other important decisions may be mentioned the monopoly in the issuing of bank notes accorded to the Riksbank in 1897, the restriction of the right of companies to acquire land in northern Sweden in 1906, and the part ownership of the state in the Grangesberg company which owned the Lapland iron ore mines.

Gustav V to World War I (1914).—When Oscar II died on Doc. 8, 1907, the crown fell to his eldets on Gustav V. Modest and smple m his character, avoiding needless display, but capable of bearng himself with the dignity required by his postion, he proved a good king for a democratic epoch. Reforms were carried through, as, for instance, the laws on civil marriages in 1908 and for the protection of the peasants in Norrland in 1909. In the summer of 1909 the contra vinessed a great trial of strength between the industrial workers' trade unions and employers' associations, which culminated in an unsuccessful general strike.

In the autumn of 1911 the election for the second chamber was held with a doubled electorate and the Lindman ministry gave up office. Karl Staaff formed his second ministry. The Lindman

ministry had approved a cruiser of a new type but Staaff's government set asude th decision. A movement to cever the costs of its construction by private subscription produced a sum of 17,100-00 colkroner, and the ship was built. The people, indeed, had been dragmeted by the way in which the Russians were arming in Finland and with widesprared esponage by the Russians in Sweden, and new evidence of alarm was forthcoming in Feb. 19,14 when 30,000 peasants met in Stockholm to request the king that the whole question of national defense should be handled simultanetously. The king's answer was fravourable, and the Liberal ministry (which had passed a new law for workmen's protection in 1912 and introduced old-age pensions in 1913) resigned.

The king commanded the lowdshording Hjalmar Hammarskjold (v) to form a new ministry. K. A. Wallesherg became minister of foreign affairs The second chamber was dissolved and the rikedag reasembled after the election of May 1, 1074. The new government had a majority in the first chamber but not in the second.

World War I.—By World War I Sweden found itself more or less cut off from the western world, from which it had bought a large proportion of its food supplies, raw materials and finished goods. The war put an end to some of the party strife that had rent the country, particularly in connection with the strengthening of defense In due course Sweden declared its neutrality, measures for the reorganization of defense were passed, and Swednish neutrality was preserved all through the war despite extrainal and even some internal pressure by activists favouring one or the other sade. At the same time a common policy of neutrality bound the three Scandinavana states together and erased some of the hitter feelings between Sweden and Nova war assed some of

At first industry and commerce took an upward swing as a result of large purchases by the belligerents; soon, however, this intensive buying exhausted stocks which could no longer be replinished, and the export of some goods was made subject to licence. At the same time the state confiscated important goods at integ prices, distributing them by rationing, and took over creatin imports. Nevertheless, there was at times extreme shortage of some foodstuffy.

The Hammarskiöld government continued in office until 1917, when it resigned over the supply position. A Conservative ministry carried on until the general elections, which brought considerable gams for the Social Democrats. A Liberal-Socialist coalition under the Liberal Nils Eden took over, and Sweden's most famous Socialist, Hialmar Branting, entered the government for the first time The new government solved the supply problem by two agreements with Great Britain, the second one being the so-called modus vivendi agreement concluded in March 1918 The Russian Revolution, followed by the German, seriously affected Swedish thought and led to a revival of demands for a democratization of the constitution. As a consequence, a special session of the riksdag (urtima) passed a radical proposal that included inter alia votes for women. One effect of the bill was to make the Social Democrats the strongest party in the riksdag; the Conservatives were the second strongest, while the Liberals, who lost some seats, split into two groups in 1923—the National Liberals (Folkfrisinnade) and the Liberals-thereby further weakening their position. small Communist party and a Farmers' party were also formed

Another consequence of the Russian revolution, Finland's secession from the Russian empire, affected the Swedish scene. While the government recognized Finland's independence m Jan. 1918, it did not date grant military aid to the new aiton lest this should involve Sweden in the war or lead to difficulties at home—the sympathies of left-wing Social Democrats being with the soviets while a strong bourgeois opinion demanded aid for the tsarists. The government's decision adversely affected Finno-Swedish relations, and Finnish resentment was further increased by the dispatch of a Swedish awal expedition to the Aland Islands in Februarical of the Company of the C

retention of the islands did this resentment gradually die down
The Interwar Period.—The great advance of the Social
Democratic party was the most striking development between

World Wars I and II During the first decade, however, they were mainly jockeying for position.

In 1920 the Liberal-Socialist coalition was followed by the first purely Social Democratic government under Branting, but the autumn elections resulted in a small setback for his party, whereupon a "business" ministry of a moderately Conservative character carried on until after the elections of 1921, when Branting formed a new government This remained in office until 1923, to be followed by a series of short-term governments from the right or from the left, including a Liberal government under Carl Ekman that commanded only 33 votes and nevertheless carried on from June 1926 to the general elections of 1928. During this period the Social Democrats succeeded in passing a bill which greatly reduced armaments The Conservative ministry that followed Ekman's government had to deal with the effects on Sweden of the serious international grain crisis and passed legislation benefiting agriculture, only to be defeated over its proposal to increase the corn duties, whereupon another Liberal government took office in 1930 In 1932 Ekman resigned as he was involved in the scandal caused by the financial failure and suicide of Ivar Kreuger, prominent Swedish businessman, and after the autumn elections, which brought considerable gains to the Social Democrats and to the Farmers, the government resigned too.

In Oct. 1932 Per Albin Hansson formed his first ministry, with Rickard Sandler as foreign minister and Ernst Wigforss as finance minister. Its program included strong measures to overcome the depression, aiming however at financial expansion rather than economies The party was not strong enough to force these measures through the riksdag, and an arrangement with the Farmers-the so-called Kohandel-was concluded Against the combined votes of the two parties most affected by the depression, the opposition had to yield A conflict in the building industry at first slightly delayed recovery; but then general developments in industry began to justify the government measures, and unemployment began to fall steeply. Apart from a few months in 1934, when the Farmers governed alone, the Social Democratic partyeither alone or in coalition with others-remained in office throughout the ensuing period. In the elections of 1934 it nearly attained an over-all majority; but another coalition with the Farmers was formed, and this started a long series of strong governments (with Hansson as prime minister until his death in 1946). The government's policy was always prevention rather than cure of social and economic ills, and the country prospered accordingly. Consequently, National Socialism never really appealed to the Swedish people; no National Socialist was ever elected to the riksdag. At the same time the feeling of security of tenure that their strong position gave to the Social Democratic governments was reflected in the increasing atmosphere of calm that prevailed in labour relations and led to a standardization of the so-called collective agreements which by 1940 were covering about 1,000,000 workmen.

The Economic Position .- Sweden shared in the economic effects of the postwar crisis. Prices dropped quickly and war inflation was followed by deflation Early in 1922 unemployment rose to 160,000 and was fought by large-scale relief work By the close of 1922, however, the nadir had been reached, Sweden's recovery kept step with that of the world outside At the same time the democratization of the country increasingly affected the economic field. Labour had earlier been organized into trade unions and the co-operative movement flourished, but revolutionary ideas no longer prevailed and a policy of "progress by peaceful negotia-tion" was embarked upon. The eight-hour day was introduced without wage reduction, and despite shorter working hours production increased, largely because of modern business methods and mechanical improvements. Sweden's enormous untapped resources of water power were another contributing factor State railways were gradually electrified, road traffic was motorized and the merchant fleet substantially increased. Industry also progressed steadily. The production of pulp, one of Sweden's most important industries, was aided by improved forestry; agriculture

benefited by 1esearch on seed selections (largely carried out by Hermann Nilsson Ehle), and highly developed enganeering works produced increasing quantities of goods for export In addition, Sweden joined the countries which exported capital

During the depression in the early 1930s an agricultural crisis was followed by one in industry, the Kreuger scandal worsened the position still further, and unemployment assumed unusual proportions, leading to a number of grave labour conflicts Sweden followed Great Britain in abandoning the gold standard, which relieved the position temporarily; but when the Social Democratis resumed office in 1933 it was still serious and improved only gradually as the international economic position recovered

External Affairs -After the end of World War I Sweden became a faithful supporter of the League of Nations, prepared even to abandon something of the cherished policy of neutrality. However, the gradual deterioration of the international situation and the failure of the League to save Abyssinia had a sobering effect on Sweden The advent of National Socialism still further increased its apprehensions, and defense once again became a primary consideration-although a law passed in 1936 for the reorganization of the army aimed rather at modernization than at expansion When the Germans invaded Austria, Hansson proposed immediate increases in defense in open parliament, while the League was advised that Sweden proposed to resume its strict neutrality policy The fate of Czechoslovakia pointed the dan-ger still further The government declined Germany's offer of a nonaggression pact on the grounds that its declared policy of neutrality in any future conflict made such safeguard unnecessary. it unsuccessfully attempted to bring about closer relations with other Scandinavian governments and also tried to co-operate with Finland in a possible defense of the unfortified Aland Islands,

but this attempt foundered against soviet opposition World War II .-- World War II did not take Sweden by surprise The Social Democratic government immediately reiterated the country's official neutrality and took steps to strengthen defense. Negotiations moreover were opened with Great Britain resulting in a comprehensive war trade agreement in Dec 1939. The Russo-Finnish war placed Sweden in a difficult situation coalition government of all parties was formed with a nonparty foreign minister, Christian Gunther. Swedish feelings were deeply stirred, and "Finland's cause is ours" became the general watchword The material aid given to Finland was of unparalleled generosity and in the case of armaments endangered Sweden's own security, but Finnish requests for regular troops were refused, although volunteers for Finland were helped and encouraged. Conscious of the danger of German intervention, Alhed demands for the transit of British and French troops to Finland were also met with a firm refusal from Sweden as they were from Norway. The end of the Russo-Finnish war was a short-lived rehef for the whole north

The German invasion of Denmark and Norway isolated Sweden from the west. During the war in Norway the German government put heavy pressure on Sweden to allow the transit of troops and armaments, but it was only after the end of the war in Norway that Sweden entered into the agreement under which German soldiers on leave, and goods, including war material, were permitted to pass over certain Swedish railways. At the outbreak of the second Russo-Finnish war Sweden was forced to a still greater concession, when on June 25, 1941, permission for the transit of a whole armed division from Norway to Finland had to be granted These agreements aroused bitterness and widespread criticism in Sweden and were the subject of sharp Allied protests, although no action against Sweden was taken. When in 1043 Germany's position began to deteriorate and Swedish military strength had increased, the stoppage of the traffic was considered, and it came to an end in the late summer of that year. Until then Sweden, moreover, had been forced to supply Germany with iron ore and other important materials in exchange for the import of desperately needed essential goods, now stringent reductions in Swedish exports to Germany were made, and a comprehensive new war trade agreement concluded with Great Britain and the United States.

It should also be said that despite its precarious position Sweden succeeded in steering clear of all German attempts to persuade it to participate in the German "new order" policy and that all through the war, but especially during its latter part, it was a shelter for refugees from German oppression, not only Norwegnan, Danes and Finns, but also Balts and Jews of all nationalities After the war ended relief, largely in the form of credits, amounting to about £152,000,000 was extended mainly to Norway and Demmark, and medical supplies, food and clothing were sent wherever needed The Swedish Red Cross under Count Folks Bernadotte was actively engaged in adding prisoners of war and had the

government's generous support in these activities The Postwar Period.-After the war the Social Democrats dissolved the coalition and governed alone The first postwar elections in 1948 confirmed them as the strongest party. After abortive attempts to form a coalition with the Farmers they decided to continue alone, and results proved them right in this decision, The country had not yet recovered from the renercussions of the international crisis, and the unexpectedly slow recovery of devastated Europe, the cumulative effect of unfavourable world trends. Europe's growing economic dependence on the U.S and the temporary elimination of Germany from world trade seriously affected Swedish economy. To aid in the revival of Europe Sweden adopted a generous foreign credit policy When the expected revival did not materialize a serious economic crisis ensued in Sweden. Large cuts had to be made in imports and expenditure was reduced, although these reductions never affected social wel-

In Oct 1951 Tage Eflander, prime minister after the death of Hansson, formed another coaltinou with the Farmers From then until 1953 there were no major developments but the economic position gradually improved. The country as a whole apparently blamed the coalition for the high food prices, and the electrons in the autumn of 1952 resulted in slight losses for both government parties. The position of the parties in the lower house them was Social Democrates, 100 reseast (121 an 1984); Libbenls, \$5\$ (57); Conservatives, \$1\$ (23); Farmers, \$26\$ (30), and Communists, \$5(8).

Sweden joined the United Nations organization in 1946. The increasing tension between east and west confronted the government with serious problems, and the proposed formation of the North Atlantic treaty led to much heart searching. For once abandoning the old conception of neutrality. Sweden proposed in 1948 a common defense pact to Denmark and Norway. When this failed (largely because the U S, was unwilling to supply arms to such an organization), Sweden decided to revert to the tra-ditional policy and not to join the North Atlantic Treaty organization-a major reason for abstention being that adherence might indirectly affect Finland's difficult relations with the U.S.S.R It was fully understood, however, that only a strong defense could protect such neutrality, and increasing amounts were spent on armaments. In all other respects Sweden supported international co-operation, as for example by joining the Council of Europe and by taking an active part in the work of the Organization for European Economic Cooperation.

tion for European Economic Cooperation.

Brattonastrv—Ingrat Anderson, Sorigat Historia (Stockholm, 1943); R. Svanstrom and C. F. Palmutierna, Short History of Sweden (London, 1944); C. Hallendorf and A. Schuck, History of Sweden (Stockholm and London, 1983); Ell. F. Heckacher, Swerigez Ekonomika Historia (Stockholm, 1984); the Tidnes Forling, Swenish Arbeterikassen Historia (Stockholm, 1964); the Tolkacher, Swenish Historia (Stockholm, 1964); Royal Bustitute of International Affairs, The Examinasion States and Fainard (London, 1951). For a further selective list see S. E. Bring, Bibliografia Handbok illi Sverage Historia (Stockholm, 1944); for a more extensive one, K. Setterwall, Svensk Historia Bibliografia (Uppsala, 1967), 1031, 1039. E., Staterwall, Svensk Historia Bibliografia (Uppsala, 1967), 1031, 1039.

### POPULATION

The population of Sweden is low in comparison with the area of the country (44 per square mile) and unevenly distributed.

Table I shows the distribution of population in 1950 in the administrative districts (lan), which differ from the former division into provinces (landskap).

TABLE I - Area and Pobulation

Old provinces	Lan	Area (sq m1)	Population,
Norrland			
Lapland, Norrhotten	Norrbotten	40,750	241,596
Lapland, Vasterbotten	Vasterbotten	22,837	231,836
Angermanland, Medelpad	Vasternorrland	0.024	283,754
lamtland, Harredalen	Tamtland	19,966	144,024
Halungland, Gastrikland	Gayleborg .	7,609	285,074
Svenland			
Dalarna (Dalecarlia)	Kopparberg	11,661	267,096
Varmland	Varmiand .	7,497	281,458
Narke	Orebro	3,476	247,023
Vastmanland .	Vastmanland	1011	203,512
Sodermanland	Sodermanland	2,634	211,056
Uppland	Uppsala	2,054	286,522
	Stockholm, district	2,969	814,850
Gotsland	Stockholm, city .	73	814,030
Ostergotland	Ostergotland .	4.270	347,674
	Skaraborg .	3,264	248,397
Dalsland	Alvaborg	4,928	359,005
Bohuslan	Goteborg och Bohus	1,086	557,545
Halland	Halland	100.1	163 400
	Jonkoping .	4.446	271,475
Smsland (and Oland)	Kronoberg	3,828	IS7,713
	Kalmar*	4,283	236,847
Blekinge	Blekinge	1.173	146,135
Skane	Kristianstad	2.478	258,800
	Malmohus	1,878	582,422
Gotland	Gotland†	1,225	58 993
Totals		173,436‡	7,044,039

\*Including the island of Oland †With adjacent islets | Hachiding the four great lakes, Vaner, Vatter, Majar and Hjalmar, 3,505 30 mi

The total number of inhabitants was in 1950 about four times as large as it had been in 1750 (1,780,000) and twice what it had been in 1850 (3,480,000). The average annual excess of births was 7,86 per 1,000 in the 1961 hectury, reaching a maximum of 10,39 in the years 1841-60; in the 1930s it had fallen to 2,78, with a minimum of 2 og in 1935. There was a rise during World War II culminating with 9,57 in 1945. After that it diminished again, being 6 4 in 1950

Emigration, sepecially to the United States, increased rapidly from 1860 onward, with a maximum during the period 1881-90 (average 38,000 a year). Then the U S legislation on immigration and also the attainment of a comparatively high standard of living in Sweden in the years after Woold War I caused a decline in the number of emigrants, and in the 1940s there were practically

The immgrants were at earlier periods considerably fewer, but they exceeded the emigrants during World War I and after 1930. The highest figure after World War II was approximately 33,000 in 1948. Besides the large number of refugees, many immgrans were attracted by the favourable conditions for obtaming employment, and skilled labourers (particularly from Italy and Germany) were offered employment through the intermediacy of the government

In 1950 there were 3,510,000 male and 3,540,000 female inhabitants. The population is racially more homogeneous than in most other countries. There were in 1950 about 34,000 Finns living in the frontier region and 5,300 Lapps in the far north

Population is denser in the south than in the north: in Dec. 1950 Malmohus Jan had about 260 persons per square mile and Norrhottens Ian 6. The annual excess of births over deaths in 1941-45 was about 66,050, or 03 per 1,000. The low birth rate of the 19,08 was one of several reasons for expecting the working population to be stationary up to 1960, when the lincrease in the birth rate that took place during and after World War II should begin to have its effect upon the abour market.

The uwhan population was 47% of the total in 1950. Up to 1860 this percentage had remained nearly stationary at about 11, 1870-ing subsequently with the progress of the industrialization. Stocholm, the capital of Sweden, had in 1951 as population of about \$200,000 (spread over the whole metropolitan area), Glotchorg about 560,000 and Malmo nearly 200,000. Nortkoping, Heising-borg, Orebro, Uppsala, Vasterns and Linkoping had each between 50,000 and 100,000 inhabitants In all, there were about 70 towns with more than 10,000 inhabitants.

Religion.—More than 99% of the total population belongs to the Established Church of Sweden, which is Lutheran and has the king as its supreme head. Among the minorities the Jews (about 6,700 in 1950) and the Roman Catholies (5,500) are the most important. There are also certain rather important "free-church movements" (numbering about 400,000 adherents), many of which are recognized within the Estabhished Church. Freedom to leave the Estabhished Church without joining a "foreign religious community" (1 e , without becoming a Jew, a Roman Catholic, a Methodist Episcopalian or a Swedenborgian) was introduced at the beginning of 1952 but did not seem to bring about any immediate Consequence.

With the archbishop of Uppsala as primate, the Established Church of Sweden is divided into 13 dioceses each headed by a bishop. The church parishes number 2,500.

Baugation—Public elementary education became free and compulsory in 1842 Besides the two old universities in Uppsala and Lund, there are universities in Stockholm and in Gotoborg Stockholm has also special graduate schools of technology, forestry, commerce, educative, the stockholm has also special graduate schools of technology and commerce; and Malmo has a graduate school of densities, for advanced studies in social work and public administration, there are special institutes in Stockholm, Lund and Gotoborg. Self-education is an outstanding feature in Swedish cultural life nearly 3,000 study or crede were an action in 1925, with students numbering about 340,000. Considerable government subsidies are given for this form of adult education as well as for popular lectures

People's colleges, the first of which date from the 1860s, provide a special type of voluntary education for persons about 20 years of age Organzed as boarding schools, many of them are sponsored by political parties, by bodies concerned with the labour

market or by popular movements

Social Welfare.—About 10% of the national income is used for welfare and social security, including maternity benefits, child allowances, old-age pensions, rent relates to large families, free school luncheau and school books and equipment. A considerable share of the costs of medical care and of sickness and accident insurance (about one-third of the total social budget) is met by the state. On May 27, 1953, the riksdeg approved a far-reaching compulsory health insurance sheme

Conditions on the labour market are often regulated by voluntary decisions taken jointly by leading organizations concerned (the central body of trade umons, the central body for the professions, certain agricultural organizations and the employers 'union'). In In this way it was agreed in 1964 that 'enterprise councils' should be introduced into industry. Working hours, vacations (three weeks') path followly, safety arrangements and other provisions for protecting the workers, collective bargaining and rights of association are settled by law

Traditions and Recreations—In some parts of Sweden— Dalecarlia, Varnland, Gotland—old customs are well preserved and picturesque peasant costumes still sometimes worn at festivals. Christmas is the main festival of the year. People dance round Maypoles on Midsummer's Eve and light bonlines on the eve of May day. Of later origin are the celebrations for the "queen of lights" (St. Lucia) on Dec. 13.

Special dishes include hard rye bread in flat cakes (knackbrod) and amorgashorf, an hors d'ouver consisting of different kinds of snacks (herring, salmon, eel, salads, shees of meat, etc.) and often served at the beginning of a meal with bread and butter and, sometimes, a glass of hupor (snapp). In view of the social evils associated with drunkenness prohibition was suggested by the temperance movement in 1910, but was rejected by a plebisset in 1922. Ivan Bartis' system of rationing, introduced in 1917, subjected the purchase of liquor to severe control by law. Wine and beer are consumed in small quantities, and there are limitations on

BURG'LICENSING SWITMA)

Swedish gymnastics since the time of Per Henrik Ling  $(q \ v)$ , have had a world-wide following. The National Athletic association, formed by the various clubs, has a total membership of about 600,000. Other favourtie forms of sport in Sweden are sking, skating, ice hockey, bandy (an ice game with a bell), salling, rifle shooting and track finding. Lawn tennis had a special patron in

the consumption of strong liquor at restaurants. (See "Gothen-

King Gustavus (Gustaf) V and became increasingly popular. Association football, however, is now the most popular sport.

## GOVERNMENT, JUSTICE AND DEFENSE

Sweden is a limited monarchy, the constitution resting primarily on the Constitution act (Regeringsformen) of 1809. June 6, the day of enactment and also the day when Gustavus Vasa entered Stockholm in 1523, is now celebrated as Sweden's national day The throne is hereditary but may be occupied only by male members of the royal family The executive and judicial authority is vested in the king alone, but his resolutions must be countersigned by a member of the cabinet (statsrad). The cabinet is appointed by the king and is responsible to the parliament (riksdag), without the consent of which it cannot act. The government consists of a prime minister (statsminister): the heads of the 11 departments of administration, which are justice, foreign affairs, defense, social affairs, communications, finance, church and education, agriculture, commerce, interior affairs, civil services, and three or four ministers without portfolio Administrative posts are equally open to men and women Holders of government offices are appointed by the king Apart from provincial governors and a few others, who are as a rule appointed for a period of six years, Swedish civil servants are undismissable except in case of default and after trial and judgment. The central administration outside the ministries is on the whole independent of politics. which usually play little part in appointment to government offices. The cabinet shares legislative powers with the riksdag and introduces new bills in it; and their members have also the right to introduce new bills In order to take effect legislative bills must be approved by the government as well as by the riksdag By the 1950s the general tendency in the Swedish political life seemed to be toward increasing the influence of the government, which for the two preceding decades had been based on a majority in the riksdag.

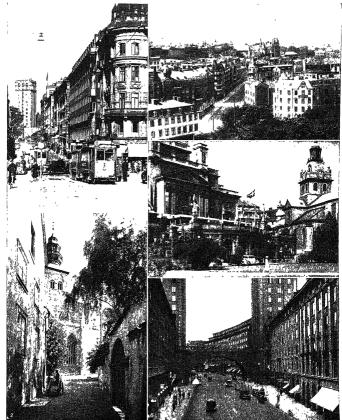
The riksdag is bicameral. Members of the upper chamber (150 seats), who sit for eight years, are elected by the town and county councils, and one-eighth of their number stands for election every year. The 230 members of the lower chamber are elected every year. The 230 members of all men and women over 12 years of age (universal suffrage dates from 1521). Candidates must be 35 years old to be eligible to the upper chamber, 23 to be eligible to the lower. The two chambers have equal authority and their agreement is required to enact a bill

Amendments to the constitutional law, in which siter alia the freedom of the press is guaranteed, must be decided twice by the riksdag and the cabinet in two different sessions with a general election intervening. There are nine standing joint commit-

tees for different fields of legislation.

Local Government.—Sweden is divided into 25 administrative districts or ian (see Table 1). The chief official of the lan is the governor (landshovding), appointed by the king in council. Under him is the administrative board of the district with executive, fiscal and civil defense functions and control over the "local" police (under the ultimate authority of the ministry of the interior). Whereas these are the local branches of the state administration, there is on the other hand a far-reaching local self-government in the parshes, dealing inter aids with health and sanitation, poor relief, education, fire and certain police work. Matters relevant to larger areas are decided upon by the representative bodies of the land (landsting). An average parish has a few thousand inhabit and; the areas represented by the landsting have several hundred thousand. The local units have the right to decide upon their own taxes to raise what money they need.

Justice.—Justice is administered by tribunals of three instances. In the first place there are 116 rural judicula circuits (domsgor), the court of which (haradsratt) consists of a judge and from seven to nine lay assessors (nonndemen), who assist the judge with information and advice regarding the case. If seven out of eight or mne assessors present are unaumously of a different opinion from the judge, they can outvote him; but this seldom occurs. The town courts, called radhurratt, consist of the mayor (who in Sweden is a judge, not a chief of the local government) and at

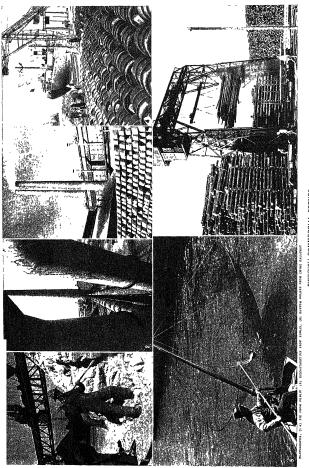


BY COURTEST OF (2) THE SWEDISH AMERICAN LINE (3) PIX FROM PUBLIX, (5) DE COU FROM EWING GALLOWAY

# STOCKHOLM, GÖTEBORG AND VISBY

- 3. The business centre of Goteborg, principal scaport and second largest
- L. Kungagatan, one of the busiest streets of Stockholm
  2. The 13th-century cathedral church of St. Mary at Virby, on the Island
  of Goldsand
  5. Another view of Konzasta data of Konzasta data of Konzasta data of Konzasta

PLACE II SWEDEN



SWEDISH COMMERCIAL SCENES

4 Barrels of arsenic awaiting shipment. Arsenic ore usually ranks third to iron and coal in volume of Swedish mineral production 1. Some 10,000 tons of pure sulphur are ordinarily produced each year at the Roeanskaer mines 2 Pipe lines at the Roennskaer smelting works

3 Electrolytic copper bars stacked for export

Small timber at a yard in Ostersund Paper, wood and wood products comprise Sweden's chief export

651

TABLE II -Industry, roso

Industries	Fener that	10 workers	11-50	norkers .	\$1-200	workers	201-1,00	norkers	More than :	,000 worker	To	tals	Value of production
mustres	Factories	Workers	Factories	Workers	Factories	Workers	Factories	Workers	Factories	Workers	Factories	Workers	(in millions of kronor)
Mining and metal Earth and atone Wood Paper and printing Food Textile and clothing Leather, hair and rubber Chemical and technical Power, lighting and water Totals	230	15,000 3,000 10,000 2,000 9,000 3,000 2,000 1,000 2,000 47,000	2,010 554 1,202 489 745 745 274 187 150 6,460	45,000 12,000 27,000 11,000 17,000 18,000 6,000 5,000 3,000 144,000	\$58 135 166 147 184 361 106 62 43	\$2,000 12,000 10,000 10,000 17,000 34,000 11,000 6,000 4,000 168,000	210 21 36 84 30 105 27 11 539	89,000 9,000 11,000 33,000 11,000 39,000 5,000 9,000 5,000	43 1 5 3	78,000 1,000 6,000 4,000 4,000 1,000	5,178 1,310 3,162 1,132 2,607 1,581 713 507 841	279,000 37,000 64,000 67,000 54,000 98,000 28,000 22,000 14,000 603,000	8,238 664 1,598 2,827 4,979 2,475 778 1,157 806 23,822

least two aldermen; they have assessors only in serious criminal

Second, there are six courts of appeal (hovratter), which are established in Stockholm, Jonkoping, Malmo, Umea, Goteborg and Sundsvall

Third, the supreme court (hogsta domstoles) passes sentences in the name of the king, who is sominally the highest pudical authority. Cases dealing with administrative name eventually referred to the supreme administrative toward eventually referred to the supreme administrative court (regengeraties), but there is no court trial of the constitutionality of administrative decisions. After 1948, when fegal proceedings were reformed, argument was in principle oral rather than written.

Defense.—Sweden's armed forces consist of three services, the army, the navy and the air force. The command of all armed forces is held by the lung and, under him, by the supreme commander, who has the defense staff at his disposal, co-ordinates the activity of the three services and directs military planning. Military service is compulsory for all males between 20 and 47 years of age; about 4,000 conscrited become liable every year

In the army the preparatory training lasts to to 11 months (1952), to be supplemented later by three operational training courses each of one month's duration and with an average interval of six years. In wartime the army comprises about 600,000 men mobilizable in a short time. The home guard is an integral part of the army and recruitment is voluntary, its members being mostly drawn from the age groups under 20 or over 47.

The navy, which includes the coastal artillery, consists of 3 armoured coast-defense ships, 4 cruises, 2 of destroyers and fast fingates, 21 motor toppedo boats, 24 submarines and about 100 small surface vessels. A program confirmed in 1092 subpulsed that 61 light vessels were to be constructed by 1050. The coastal artillery is responsible for the defense of harbours, anchorages and potential invasion areas. Its permanent installations are as a rule blasted into the rock.

The air force in 1952 comprised 50 squadrons, 30 of which consist of day fighters, 3 of night fighters, 12 of attackers and 5 of ieconnaissance aircraft. It was resolved that the transition to fet propulsion should be effected by the middle of the 1950s.

The armed forces are supported by various voluntary defense associations comprising several hundred thousand men and women, they make increasing use, for example, of the Swedish women's volunteer service. Equipment is to the greatest possible extent designed and constructed by Swedes. Every Swedish citizen between 16 and 65 years of age who does not belong to the armed forces may have to serve in the civil defense, which is trained in peacetime to be responsible in war for first aid, clearing and fire services as well as for protection against chemical and biological warfare. Air-aid shelters are often basted into the rock in an endeavour to give protection even against atomic bombs.

### ECONOMY

An important change in the structure of Swedish economic life took place after the 1870s. In those years about 7-% off the population carned its living from agriculture, but in 1951 less than 30% did so. During the same period industry increased its proportion from 15% to 41% of the population, becoming in the process the most important source of national wealth. The corresponding figures for commerce and communications are 5% (1870) and 20% (1945).

Agriculture.-Less than 10% of the whole area of Sweden is under cultivation, with the main agricultural regions in the south and around the big lakes in central Sweden; natural meadowland covers about 3% More than half the land area is covered by forests, the rest is mountainous and barren Sweden is practically self-sufficient as far as agricultural products are concerned. The yield per acre is high and exceeded by few countries in Europe Wheat cultivation, through scientific plant breeding, has been extended almost to the Arctic circle and is superseding the cultivation of rve Sugar beets are grown in southern Sweden and on the islands of Oland and Gotland, the crop being nearly equal to the domestic demand. After the outbreak of World War II homegrown oil plants provided raw material for making margarine and fodder cakes Nearly 50% of all agricultural income is derived from milk and milk products After 1030 and particularly after World War II a large-scale mechanization and modernization took place within Swedish agriculture; the number of tractors in use grew from 2.100 in 1030 to 10.100 in 1030 and from 21.300 in 1045 to 76,200 in 1952, when there were, moreover, about 10,000 light tractors; and between 1044 and 1048 there were notable increases in the numbers of combines (from 407 to 2.100), mechanical binders (from 71,000 to 86,300) and milking machines (from 40,000 to 62,700) in use The government encourages small farms to pool their machinery, and nearly every farmer is a member of the producers' co-operative groups for marketing agricultural products, About 90% of the arable area is privately owned, and not more than 20% of it is held on lease Of the 414,000 farms, about 75% had in 1944 less than 25 ac of arable land, while less than 2% had 125 ac. or more. In central and northern Sweden the farms mostly include some forest The principal aim of Swedish agricultural policy is to further the creation of larger operative units Industry.-The bases of Swedish industry are the forests, the

Industry.—The bases of Swedish industry are the forests, the iron ore deposits, the water power and the technical skill of the workers Between 1955 and 1950 the volume of industrial production was doubled, and between 1900 and 1950 it grew sevenfold. Small enterprises predominate. (See Table II)

Larger firms with international reputations include A B Svenska Kullagerfabriken (S.K.F.), which makes ball bearings; Svenska A.B. Gassccumulator (A.G.A.), which makes automatic beacons; A.B. Separator; A B. Slektrolux, which makes refrigerators; and A.B. dc Lavals Angturbin and Svenska Turbilafbriks A.B. Ljungstrom, which make steam turbines. The largest industrial concern is the Swedish Electric company, A.S.E.A. The telephone system in many toreign countries is technically administered by Telefon A.B. I. M. Ericsson or its subsidiaries.

By far the greater part of Swedish industry is in private hands, Of the industrial workers only 5% are employed in governmentowned factories and 4% in co-operative enterprises; thus privately owned firms employ or % of industrial workers.

Timber and Wood Products.—Forests, mainly pine, cover about 8,700,000 sqim, or more than 50% of the surface area of Sweden. Current annual growth available to the timber industry is estimated at 60,000,000-70,000,000 cuyd. Cutting and conservation are regulated by law, and large-scale scientific research is conducted by experimental stations and institutes with a view to increasing the yield per acre. One-half the forest area is owned by private persons, one-fourth by companies, one-fifth by the state and the rest by the church and local communities. After the outbreak of World War II the industry was concerned to supply not only the traditional timber, pulp, paper and board but also more

Table III -Duection and Values of Trade, 1951

Countries	Fo	od	Ores	Fuel	Wood pulp and paper	Wood prod- ucts	Tex- tiles	Cher	nical lucts	Meta semi-fi prod	nished		inery id ments	Miscel	laneous	Alla	goods
	Exports	Imports	Exports	Imports	Exports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
Denmark, Finland and Nor- way German Federal Republic Besolux countries Groub Britain USS R. Other European countries Umited State Argentina Australia Other countries World totals	80 220 8 80 1 110 14 26 550	156 26 72 25 36 272 114 86 58 649	20 193 113 112 — 107 79 4 18 616	13 235 /0 123 5 451 181 — 611 1,680	121 309 381 975 4 817 245 219 165 661 3,896	124 87 183 430 28 13 14 78 168	35 114 228 410 1 336 95 5 94 255 1,573	36 11 13 24 4 39 6 11 4 71 215	97 82 85 83 I 120 48 14 2 32 504	168 47 67 55 22 175 74 68 19 220	92 259 359 136 1 120 53 3 112 1,145	486 24 75 32 149 310 21 81 17 320 1,524	81 407 77 549 2 243. 283 9	93 25 40 24 1 45 28 10 4 56 326	16 96 70 169 22 283 70 33 7 141 1,057	1,128 916 883 1,750 173 1,631 480 495 291 1,549 9,206	640 1,219 970 1,405 68 1,825 86,1 1,38 164 1,806 9,189

\*Less than soo ooo kranor

valuable products such as rayon, alcohol, plastics, dyes, glue, resns, turpentine, etc. In 1948 the output of sulphite cellulose was 1,350,000 tons, sulphate cellulose, 980,000 tons; paper, 970,000 tons; mechanical pulp, 680,000 tons, sawn pine timber, 3,200,000 cum; and planed boards, 1,40,000 cu m.

Iron—Sweden's iron ore deposits are among the richest in the world. They consist of the long-worked mines in central Sweden (Bergslagen; estimated deposits 220,000,000 tons) and of the later workings in northern Lapland (Kirunavara, Gallivare, etc.; estimated deposits 2,000,000,000 tons). The domestic iron industry uses mainly ore from Bergslagen, which contains a singularly pure fron. The Lapland mines, the ore of which is phosphorus bearing but very rich in inco content (50% to 70%), are worked for export. More than 90% of the output of iron ore is exported, about 13,000,000 tons were exported in 1951. Of Europe's total resources in ore of high ron content, more than 90% is to be found in the Lapland mines. There are also some ore deposits containing gold, silver, copper and arsenic; also zan or is mund.

Finel and Power—Sweden's coal deposits, which are found only in the south, normally produce not more than 300,000 tons a year, together with firebrick and fire clay, though output was doubled during World War II Imports of coal and coke were estimated to amount to 7,200,000 tons per year in the 1950s, theirly from England, Poland and the German Federal Republic In addition, approximately 1,00,000 tons of crude oil and 2,000,000 tons of motor and combustible oil were imported. Wood and peat are also used as fuel. But electric power has more and more replaced fuel in homes as well as in industry.

After Switzerland and Norway, Sweden has the world's highest consumption of electricity per person. It was planned that the installed hydroelectric capacity in 1952 should amount to about half the total estimated potential of \$,00,000. We The output of energy was 9,000,000,000 km km, per year before World War II and was estimated at 2,000,000 for 1953, after the harnessing of about half the ensting water-power resources. More than half the electric power is supplied by private companies. The trunk transmission line from Harspranget in the far north to central Sweden, opened in 1952, first in the world to have a voltage as hugh as \$80,000 has a transmission capacity between two and three times as high as that of lines with a voltage of 190,000.

Foreign Trade.—The value of Sweden's foreign trade (export and import) per inhabitant is relatively high. In 1950 it was about the same as in Great Britain, Table III shows how this foreign trade is distributed.

In tariff policy Sweden is very little given to protectionism. Communications—More than 50% of Sweden's imports and exports are transported on Swedish vessels. The merchant navy grew considerably in the course of the soft centurry, with a gross tonnage of somewhat more than 2,00,000 in 1957, if put Sweden in the sixth place among the world's seafaring nations or, if we reckon according to the relation of the tonnage to the population, in the fourth (after Norway, Great Britain and Denmark). In 1951 more than half the tonnage was engaged in ocean trading, on regular runs to all parts of the world. One of the foremost ship-

building nations, Sweden is considerably exceeded only by Great Britain in the amount of tonnage launched (more than 400,000 tons in 1951, mostly for foreign owners).

In 1950 the Swedish, Norwegian and Danish commercial air lines were merged into one company, the Scandinavian Airlines System (S A.S.).

Sweden possesses a highly developed network of railways, the oldest of which date from the riscos From the beginning the state took an active part in the construction of trunk times. The total length of the lines amounts to about 10,000 mm (more in relation to the population than that of any other European country), of which about 40% has been electrified (this portion hower accounted for 86% of the total traffic in 1051). An act of partiament of 1039 provided for the gradual nationalization of railways that were still privately owned. Ferres connect the railways with continental lines through Demmark and Germany

The total length of public roads is about \$8,000 mi, national highways covering a,700 m. and provuncial highways 124,00 ft bis total 3,400 mi are paved. Motor vehicles registered in 1952 comprised \$9,000 trucks, 7,800 butses and 31,5000 cars (including 10,000 taxicabs). The density of population being so low, bus lines are naturally of great importance to Sweden.

In 1950 Sweden had 1,600,000 telephones, or 228 per 1,000 inhabitants, which as the second highest proportion in the world. The number of radio sets in relation to the population is surpassed only by the United States. There is only one broadcasting system (Radiotjans!), it is partly state-owned and nonpolitical and carries no advertising in its program. There are about 250 newspapers, of which approximately 150 are dailies (around 20 appear also on Sundays). Their total circulation is 5,300,000 copies The Liberal press covers more than half the circulation.

Finance.—The state budget is divided into two parts, the budget of current expenditure and the capital budget, the latter being in principle devoted to government investments (which are covered by national loans). Government expenditure amounted to 1,349,000,000 kronor in the budgetary year 1938–39, to 4,103,000,000 in 1944–45, to 5,449,000,000 in 1950–51 and to 6,600,000 in 1931–52. Whereas the expenditure of 1951–52 was nominally 4.9 times that of 1938–39, the increase in real terms was only by 2.4 times if the consumption price index is used as a base. The gross national income, calculated at factor cost by calendar years, rose from 12,060,000,000 known in 1939 to 36,800,000,000 in 1951; the slight effect of World War II may be judged from the index series 1939 = 100, 1948 = 150, 1945 = 153, 1951 = 305. Details of revenue and expenditure may be seen in Table IV, which gives the budget estimate for 1923–53.

The total national debt, which in the 1930s was still comparatively small, increased during World War II from 3,000,000, 000 to 11,000,000,000 kronor and amounted in 1931 to about 12, 500,000,000. The gross national income was in 1950 estimated to be about 32,000,000,000 kronor.

The unit of currency is the krona (plural, kronor). Its exchange rate against the pound sterling was 145 kronor = £1 in 1952 (cf. 16.92 kronor = £1 before 1940); against the U.S. dollar the rate was 5.18 kronor = \$1 in 1952 (cf. 3.60 kronor = \$1

before devaluation in 1949).

TABLE IV —Budget, 1952-53
(In millions of kroner)

Revenue		Expenditure				
Item	Amount	Item	Amount			
Income tax Customs receipts Automobile tax Tobacco tax Alcoholic beverage tax Other taxes and receipts	4,873 8 350 0 505 0 575 0 849 0 1,238.6	Defense Social welfare Roads and communications Education Agriculture Other expenditure	1,504 8 1,865 8 571 2 785 5 441 5 2,228 2			
Total revenue .	8,391 4	Total expenditure	7,397 0			

The Swedish credit market is characterized by the multiplicity of types of credit institutions, official, semiofficial and private, among which the distribution of the functions and of the operating fields is not always clearly defined. The Bank of Sweden (1657), which is the oldest national bank in the world, is subordinated to the riksdag and not to the government There were 19 commercial banks in 1052. Two of these Syenska Handelsbanken and Skandinaviska Banken, held each about one-quarter of the assets of the whole commercial banking system; two others, Stockholms Enskilda Bank and Goteborgs Bank, held about one-tenth, and the fifth largest was state-owned. Whereas these five have a more or less nation-wide network of branch offices, the other commercial banks are regional or local. Savings banks numbered about 450 in 1952, the total of deposits in them amounting to not much less than that in the commercial banks. Special state organizations supervise the activities both of the commercial and of the savings banks. Mortgage loans are advanced by a number of special institutions (for housing, agriculture, shipping, etc.).

of special institutions (for housing, agriculture, shipping, etc.).
BRILIOGRAFF.—I W. Ahlman et al, Suerige Nuis: ellas were joils,
land ech naringer (Stockholm, 1949), Royal Institute of International
Roberts, for Overseas Economic Survey, Sueden (London, Hild So,
1950), Swedish Social Welfare Board, Social Sweden (Stockholm,
1951), Royal Central Bureau of Statistics, Statistics Aribot for
N. Alzelius, Books in English on Sweden, 3rd et (Stockholm, 1951)
N. Alzelius, Books in English on Sweden, 3rd et (Stockholm, 1951)

SWEDENBORG or SWEDBERG, EMANUEL (1688-1772), Swedish scientist, philosopher and theologian, born at Stockholm on Jan. 29, 1688. His father, Jesper Swedberg, subsequently professor of theology at Uppsala and bishop of Skara, was under suspicion of heterodoxy, as he placed more emphasis on the cardinal virtues of faith, love and communion with God than on dogma. On completing his university course at Uppsala in 1710, Emanuel travelled in England, Holland, France and Germany, studying natural philosophy and writing Latin verses, a collection of which he published in 1710. In 1715 he returned to Uppsala, devoting himself to natural science and engineering. From 1716 to 1718 he published a scientific periodical, Daedalus hyperboreus, a record of mechanical and mathematical inventions and discoveries. In 1716 Charles XII appointed him assessor extraordinary on the Swedish board of mines. Two years later he distinguished himself at the siege of Frederikshall by the invention of machines for the transport of boats overland from Stromstadt to Iddefjord, a distance of 14 mi. At the death of Charles XII Queen Ulrica Leonora gave him a patent of nobility, by which his name was changed from Swedberg to Swedenborg, the "en" corresponding to the German "von." In the Swedish house of nobles he spoke on economic subjects-the currency, the decimal system, the balance of trade and the liquor laws (where he was the pioneer of the Goteborg system). He strongly opposed a bill for increasing the power of the crown. The next years were devoted to his official duties, which involved visiting the Swedish, Saxon, Bohemian and Austrian mines. In 1724 he declined the chair of mathematics in the University of Uppsala, on the ground that it was a mistake for mathematicians to be limited to theory. As early as 1721 he was seeking a scientific explanation of the universe, when he published his Prodromus principiorum rerum naturalium, and had already written his Principia in its first form. In 1734 appeared in three volumes Opera philosophica et mineralia, the first volume (his Principia) containing his view of the first principles of the universe, predicting the nebular hypothesis and some of the modern ideas on the atom The other volumes dealt with (1) iron and steel, (2) copper and brass, their smelting, conversion and assaying, and chemical experiments thereon

Swedenborg's volumnous writings were not properly collected and examined until toward the end of the right century; it was then seen that in almost every department of scientific activities were shown to prove the was ahead of his time. He work on palacenology's shows him the predecessor of all the Scandinavian geologists. He was also a great physiciat and had arroved at the nebulan hypothesis theory of the formation of the planets and the sun long before Kant and Laplace, he write a bucd account of the phenomena of phosphorescence, and adduced a molecular magnetic theory which antespated some of the chief features of modern hypotheses. The French chemist Jean Dumas credits him with the first attempt to establish a system of crystallography. He was first to employ mercury for the air pump, and devised a method of determining longitude at sea by observations of the mono among the stats

In 1734 he published Prodromus philosophiae ratiocinantis de infinito et causa finali creationis, which treats of the relation of the finite to the infinite and of the soul to the body, seeking to establish a nexus in each case as a means of overcoming the difficulty of their relation. From this time he applied himself to discovering the nature of soul and spirit by means of anatomical studies. He travelled in Germany, France and Italy in search of anatomical knowledge and, as a result, published his Oeconomia regni ammalis (London, 1740-41) and Regnum ammale (The Hague, 1744-45; London, 1745). In no field were Swedenborg's researches more noteworthy than in physiological science. 1901 Max Neuberger of Vienna called attention to certain anticipations of modern views made by Swedenborg in relation to the functions of the brain, and the University of Vienna appealed to the Royal Swedish academy for a complete issue of the scientific treatises. Swedenborg showed (150 years before any other scientist) that the motion of the brain was synchronous with the respiration and not with the action of the heart and the circulation of the blood, a discovery the full bearings of which are still unrealized. He arrived at the modern conception of the activity of the brain as the combined activity of its individual cells. The cerebral cortex and, more definitely, the cortical elements (nerve cells) formed the seat of the activity of the soul, and were ordered into departments according to various functions. His views as to the physiological functions of the spinal cord were in agreement with later research, and he anticipated modern research on the functions of the endocrine glands.

At middle age, Swedenborg left the domain of physical research for that of psychical and spiritual inquiry. Late in life he wrote to Oetinger that "he was introduced by the Lord first into the natural sciences, and thus prepared, and, indeed, from the year 1710 to 1745, when heaven was opened to him." Before his illumination he had been instructed by dreams, and enjoyed extraordinary visions and heard mysterious conversations. According to his own account, the Lord filled him with His spirit to teach the doctrines of the New Church by the word from Himself; He commissioned him to do this work, opened the sight of his spirit and so let him into the spiritual world, permitting him to see the heavens and the hells and to converse with angels and spirits for years; but he never received anything relating to the doctrines of the church from any angel but from the Lord alone while he was reading the word (True Christian Religion, no. 779). He elsewhere speaks of his office as principally an opening of the spiritual sense of the word. In 1747 he resigned his post of assessor of the board of mines, took up afresh his study of Hebrew and began his voluminous works on the interpretation of the Scriptures.

Between 1756 and 175e three instances of supernormal cognition were attested of him; for an account of them and of Kant's interest in them see C. D. Broad, "Immanuel Kant and Psychical Research," Proceedings of the Society for Psychical Research (London, 1950). His life theneoforth was spent alternately in Sweden, Holland and London, in the composition of his works and their publication, till his death, which took place in London on March 29, 1772. He was burried in the Swedish church in Princes square, St George's-in-the-East, and on April 7, 1908, his remains were removed at the request of the Swedish government to Uppsala cathedral.

Swedenborg never attempted to preach or to found a sect. He believed that members of all the churches could belong to the New Church without forming a separate organization His theosophic system is most briefly and comprehensively presented in his Divine Love and Wisdom The point of view from which God must be regarded is that of His being the Divine Man. His esse is infinite love, His manifestation or body is infinite wisdom Divine love is the self-subsisting life of the universe. From God emanates a divine sphere, which appears in the spiritual world as a sun, and from this spiritual sun proceeds the sun of the natural world. The spiritual sun is the source of love and intelligence, or life, and the natural sun the source of nature or the receptacles of life, the first is alive, the second dead The worlds of nature and spirit are perfectly distinct, but they are intimately related by analogous substances, laws and forces. In God there are three infinite and uncreated "degrees" of being, and in man and all things corresponding three degrees, finite and created They are love, wisdom, use; or end, cause and effect. The final ends of all things are in the Divine Mind, the causes of all things in the spiritual world, and their effects in the natural world. By a love of each degree man comes into conjunction with them and the worlds of nature, spirit and God The end of creation is that man may have this conjunction and become the image of his Creator and creation. In man are two receptacles for God-the will for divine love and the understanding for divine wisdom-that love and wisdom flowing into both so that they become human.

Swedenborgianism is based on the belief in Swedenborgs claims to have winessed the last judgment, or the second advent of the Lord, with the inauguration of the New Church, through the new system of doctrine promulgated by him and derived from the Scriptures, into the true sense of which he was the first to be introduced. The doctrines of the New Church as given in the Liturgy (which also contains the "Creed" and "Articles of Faith") are as follows:

are as follows:

1. That there is one God, in whom there is a Divine Trinity; and

that He is the Lord Jesus Christ.

2 That a saving faith is to believe on Him.

3 That evils are to be shunned, because they are of the devil and from the devil.

4. That good actions are to be done, because they are of God and from God.

From June 5. That these are to be done by a man as from himself; but that it ought to be believed that they are done from the Lord with him and by him.

and by him.

Swedenborgians constitute a widely spread and considerable society, with a regularly constituted ecclesiastical organization and a zealous missionary activity (see New Jerusalem Church).

a zealous missionary activity (see New JERUSALEM CHUKCH).
BIRLIGORAPHT—Lithographed facsimiles of the manuscripts of
Swedenborg's works were edited by R. L. Tafel, 10 vol. (Stockholm,
1869-70); another edition in 18 vol. was published at the same place
(1901-16). Numerous editions of the single works have appeared in

Irmitation & See R. L. Tafel, Documents Concerning the Life and Character of Swedenborg, collected, translated and annotated, 3 vol. Swedenborg Society (1857-7); I. Iyade, A Blogneyhy of Swedenborg, Swedenborg Swedenborg, Swedenborg, Swedenborg, Swedenborg, Swedenborg, Swedenborg, Swedenborg, Swedenborg, Swedenborg, Swedenborg, State Swedenborg, Sweden

SWEDISH LANGUAGE AND LITERATURE. The Swedish language is about 1,000 years old. It began in the viking age when the Scandinavian national states first emerged, and the characteristic features which separate the modern Scandinavian languages developed. Old Swedish was originally spoken in languages developed. Old Swedish was originally spoken in Sweden itself—excepting the most northerly and southerly parts and certain western areas—in the coastal belts of Finhand, Estonia and Livouia, with their islands, and in certain parts of Russia conquered by vikings, who here and there maintained themselves until the 15th century. In the modern world it is used by about the 15th of the 15th of 15

The ultimate ancestor of Swedish is Common Norse, one branch of the family of Germanic languages commonly divided into three

groups (1) East Germanic (Gothic); (2) West Germanic (Dutch, English, Frisian and High German), and (3) North Germanic ie, Scandinavian (Swedish, Danish, Icelandic, Norwegian and Faroese) Swedish with Danish form the East Scandinavian group, the three others are West Scandinavian Modern Swedish. though still more inflected than contemporary Danish or Norwegian, has dropped a great many of the inflections current, in some instances, into the 18th century (see below). The verbs are di-vided into four conjugations, the nouns into five declensions and the gender of these nouns into common (den) and neuter (det) Only two case forms have survived for the nouns, nominative and genitive The genitive is formed by adding s to the nominative both in the definite and indefinite form, both in singular and plural; thus dag, dags, dagens, dagar, dagars, dagarnas As an example of the changed forms compare singular nominative definite dagen with the classical Old Swedish daghr-in, dagens with daghsins, dagarna with dagha-nir, dative form daghum-in and accusative dagha-na; cf Anglo-Saxon daeg (modern English "day"), German Tag and Danish dag The adjectives are declined according to gender, number and definite and indefinite forms Examples of the sound mutations between Danish and Swedish are Danish gade and Swedish gata ("street"), Danish bog and Swedish bok (book)

(book)
Runes—Runes are the oldest form of Swedish writing About
2,500 runic inscriptions survive from the earliest period of formsvenska (c. A. 56.00-1225); most of them are found in Uppland
and date from the rith and rith centuries. Cut in stone, often
put into metrical form, they commemorate the genealogy and
achievements of the dead. The most remarkable stone, Rökstenen
in ötetgogloand, dates from the gith century and is unique in the
length and interest of its inscriptions, written in seven different
types of script. Other interesting inscriptions have been found
in Hälsungland, including the Nalstadsten, in the so-called "staffless" script. Unfortunately, save for the runes, nothing of the
earliest Swedish literature has survived, but it is likely that there
was some sort of literary culture akin to that of Iceland.

# CLASSICAL PERIOD OF OLD SWEDISH

We possess a greater and more reliable knowledge of Swedish after the religious orders (first Casterclans, later Domnicans) had introduced the Latin alphabet, orignally for the transcription of religious texts, and had founded schools to assist their mission-ary work. The earliest examples of Latin letters are on coins of the time of Olaf Skotkonung (993–1022). Then follows the classical period of Iold Swedish (c. 1225–1373), with the beginnings of a native literature, inferior in quality and volume to that of Ledand. The purest Swedish language of this time is highly inflected, uses simple constructions and is surprisingly free from foreign influences, the few Greek or Latin loan words generally relating to church matters. Nouns have four cases, the sufficed article is inflected, and there is also much infliction of verbs.

The oldest extant manuscript in classical formsumska is not a translation from Latin, but part of a native legal code, Frienghalagent, compiled in the 1200, A number of such local codes survive; e.g., Scistpladagen, Daldalagen, records of provincial laws set down by a magistrate and preceding the lawbooks like Upplandslagen (1206) and Södermanslagen (1337), compiled on official initiative and ratified by the king. These codes are forceful and full of concrete images; they often use alliteration and solemn prose rhythm to make their pronouncements more memble. They offer the happiest examples of the vermacular interature in their age, and culminate im Magnus Eriksson's Londslag (On the Conduct of Kings and Princes), probably written about 1330 for the guidance of the same ruler. This reflects both Swedish respect for law and the influence of Christian culture, even of scholasticism.

Dialects.—Differences of dialect occur in the runic inscriptions and in these legal codes, as in other products of this old literature. Two main groups of Swedish dialects, each comprising a number of subdivisions, have been classified: the Swea group, including the northern areas, Uppland, Hälsingland, etc., and parts of öster-

götland; the Gota group comprising Värmland, Vastergötland, complete translation of the Bible (Gustav Vasas Bibel, 1541), conparts of Småland, etc , and more recently the south Swedish provinces, which till long after the Reformation were Danish-speaking regions The archaic language of Gotland is excluded from this classification. Even in the period of Old Swedish it differed so fundamentally from the Swedish of the mainland that forngutniskan ranked as a separate language. It may be studied in about 200 rume inscriptions and a 13th-century Gutalag

Religious and Secular Literature.-The importance of Christianity in the cultural development of Sweden is immense, yet the new religion prevailed only gradually, and pagan rites existed well into the middle ages and in remote districts for much longer. Slowly, too, the primitive society of viking times was replaced by a more complex organization, dominated by the nobility and the clergy, patrons and providers of literature Latin eclipsed the vernacular as a literary medium, and this helps to explain the derivative nature of mediaeval Swedish letters. Thus, though the poetry of chivalry reached Sweden, the Swedish writings inspired by chivalrous ideals were mere free adaptations of French or German originals Eufemiausorna, the best-known of these works, three verse romances translated anonymously between 1303 and 1312, are in rhymed doggerel, a metre again employed in the chronicle romance Erikskromkan, a record of the fortunes of the Swedish kings between 1220 and 1320, probably compiled soon after the latter date. An anonymous and hybrid work, it is the most powerful single poem of mediaeval Sweden.

Only in religious writing, from among unknown Latin hymn writers, compilers of logendaries, etc., do a few personalities emerge. The Dominican Petrus de Dacia (c 1235-80), with his Vita benedictae virginis Christi Christinae, is often considered the first Swedish author; Bishop Brynolf Algotsson (c. 1250-1317) is the first distinguished Latin hymn writer in Sweden. But both were overshadowed by St. Bridget (c. 1302-73), the founder of Vadstena monastery. Only the Latin version of her text, the Revelationes, survives, first printed at Lubeck in 1492.

### YOUNGER OLD SWEDISH

The downfall of the Folkunga dynasty and the death of Bridget mark the end of a period Under the impact of the stormy Unionstiden, with its foreign rulers, the character of society and of language changes, and we get the yngre fornsvenskan (c. 1375-1526), a language diluted with German loan words-mostly technical and commercial terms-and with Danicisms, which sheds a number of its inflections. At the same time there occurs a standardization of the literary language, largely under the influence of Vadstena kloster, the main focus of culture in Sweden until the Reformation. Both Latin and German affected the syntax of the vernacular

Literature.- The insecurity of these times had an adverse effect on literature, yet with the growth of a reading public, translations and adaptations multiplied. They included versions of books of the Bible, a long doggerel romance of Alexander (c. 1380) and a political allegory, the poem Schacktavelslek (The Game of Chess, c. 1465). In the rhymed chronicles, too-e.g., Karlskrömkan, Sturekrómkan and Lilla Rimkrönikan (which treats events up to 1520)-political interest prevails. Of greater literary value are the Latin hymn Rosa rorans bonitatem by Bishop Nicolaus Hermanni (1326-91) and the two short lyrics Frihetsvisan and Trohetsvisan that have earned for Bishop Thomas Simonsson (c. 1380-1443) the title of the first Swedish national poet Yet the most accessible genre of Swedish mediaeval letters-the folkvisor (ballads or folk songs)-is anonymous and undated. The oldest probably go back to 1300, but they were not transcribed until much later. Though outnumbered by the Danish, and often deriving from Danish or Norwegian sources, many of the Swedish folkvisor have a strong and lasting appeal.

## EARLY NEW SWEDISH (c. 1526-1700)

As Gustavus Vasa's accession (1523) and the breach with Denmark mark the beginning of modern Swedish history, so the printed translation of the New Testament (1526) is considered to usher in den didre nysvenskan. Yet in both this work and the servatism is visible in the word order and in the maintenance of inflections already shed in less solemn contexts The translators excluded the Danicisms typical of the kanslisprak (clerical style), but were much influenced by Luther. Still, a standardized literary riksspråk does grow up during this period, and an increase of interest in grammai, vocabulary and orthography is visible during the 17th century. The centralization of government in Stockholm and the influence of the court affected both the written and spoken noims, while Swedish intervention in the Thirty Years' War led to the assimilation of many foreign words.

Literature of the Reformation.-The Reformation stimulated no immediate growth of letters, such books as appeared were still mainly religious and didactic Closely involved in the Bible translations were Olaus Petri (c 1493-1552), his brother Laurentius (d 1573), the first Lutheran archbishop, and Laurentius Andreae, at one time Gustavus' chancellor. Of these, Olaus seems to have had the most robust personality. After studying at Wittenberg he returned to Sweden full of reforming zeal, which won him the king's favour; later, his independence and critical spirit nearly cost him his life. His vigorous approach is revealed in his published sermons, in his hymn translations, in catechism and in legal writings; it is shown, too, in his Swensk kronika, the first authentic historical work in Sweden, far surpassing the official chronicle of Peder Swart. Petri may have written the biblical Tobie comedia (1550), the first complete extant Swedish play.

Uppsala university (founded 1477), closed in 1517 because of political unrest, was not revived until late in the 16th century and became a focus of learning and letters only in the 17th century. Johannes Rudbeckius, one of the first Swedish educators, was associated with it, and so was Johannes Messenius (1579-1636), who wrote several mythical-historical plays, such as Disa (1611) and Sigmil. Although formless and crude these plays enjoyed great popularity, as did Magnus Olai Asteropherus' more successful Tisbe (1610), the first nondidactic drama in Swedish

In the first half of the 17th century literature remained limited in scope and quantity. Some Latin poetry, the sermons of Rudbeckius and a handful of plays-including Judas Redivivus (1614) by I. Rondeletius, Gustaf den forste by A. Prytz and some comedies by J. Chronander-are worth recording. A unique contribution, however, was made by the vagrant adventurer Lars Wivallius (1605-60), whose lyrics, many of them written in prison, reveal a feeling for nature new to Swedish poetry.

Literature of Stormaktstiden, 1650-1730 .- With its intervention in the Thirty Years' War and the ensuing military triumphs, Sweden established itself as a European power (Stormakt) This led to a great development of national pride and culture that is revealed in the literature of this epoch. The first and probably the best work is Georg Stiernhielm's allegorical epic Hercules, written about 1647 in vigorous hexameters. Stiernhielm (1598-1672) was the greatest literary figure of the 17th century. His followers include the two brothers Columbus, of whom Samuel (1642-71) was Stiernhielm's secretary and wrote Odae susticas and the prose Målroo eller Roomål, a charming collection of anecdotes which illumine Stiernhielm's character. A rival to Stiernhielm was the unidentified "Skogekar Bergbo," whose Wenerid (1650; published 1680) was the first sonnet cycle in Swedish. Another unsolved problem of this period is the authorship of the epithalamium Brillopsbeswärs Ihugkommelse, a realistic poem long attributed to Stiernhielm. Several of Stiernhielm's admirers, including Urban Hiärne (1641-1724), formed a coterie at Uppsala in the 1660s. Hiärne led a troupe of student actors who in 1665 performed his play Rosimunda before the young Charles XI. He also tormed his play Accommense beaute the young chanted stat. And we wrote lyrics and the pastoral Stratonice (1666-68), the first Swedish "psychological" narrative.

Stiernhielm was eager to revive old Swedish words and eliminate

foreign loans. Columbus also demanded a more vigorous, flexible language for prose and poetry, as did "Skogekar Bergbo" in Thet swenska språketz klagomål. National pride and religious feeling are combined in the works of the bishops Haqvin Spegel (1645-1714) and Jesper Swedberg (1653-1735) father of Emanuel Swedenborg Both were hymn writers and ardent philologists. Spegel wrote a selfgrous epic, Gudz work och kwule (1685) and sponsored the plan for a new hymnhook whoch appeared in 1695 and became the petry book of the Swedish people, and, like Gustav Vauxa Babba, of lasting findiunen. Even Lara Johansson (1683-24, pessudonym "Lucidor") was represented therein This poet, though one of the most attractive fyricts of the period, otherwise stands apart from the general development, some of his poems have survived in a postthumous collection, Rélecons blomburs aves survived in a postthumous collection.

At Uppsals meanwhile the scholar Petrus Lagerlof (1628–69) worked on poetus and attempted to impose classical standards, and O Verelus (1618–82) edited and translated Icelandic tagas. Olius Rudbeckus (1636–710.), a man of vest energy and learning, became interested in Verelus' work on antiquities and entusastacily developed the theory that Sweden was the lost Atlants and had been the cradle of western cuitation These theories he launched in a massive work Atland eller Manhem (1679–170.) deliberately written in Swedish to prove that the language was suited to scientific purposes. The work was translated into Laint a Atlantica and attained Eurocana fame

Rudbeckus had encouraged Hinare's actors. Lagerlof now sponsored a scond Uppsais company, which moved to Stockholm in 1686 and acted in Leponkulan (the "Lion's Dea"). This became Sweden's first regular (though short-head) theatre in "Leponkula" plays show little dramatic talent but reveal how Lagerlift's technip had produced more correct verse.

Baroque tendencies are found in the work of some late 17thcentury poets, notably Gunno Eurelius (ennobled as Dahlstiera, 9.0) (1661-1709), who dedicated his elaborate Kunguskuld (1697) to Charles XI J Runius (1697-1713) expresses a Christian stoticism found among the Swedish people during the disastrous early decades of the 18th century. J Frese (1691-1793) is a genifier and more intimate poet; his jivrica and hymns contain some of the emotional pietism that became a feature of 18th-century thought.

#### MODERN NEW SWEDISH (c. 1700 AND AFTER)

Den yngre nysvenskan is the form of Swedish now current; it is intelligible (except for a few words and expressions) to a modern reader without commentary Olof von Dalin's Then swänska Argus is the first important literary work in this form, During the 18th century several grammars and dictionaries contributed to standardization, and the Swedish academy (founded 1786) was given the task of "working for the purity, strength, and sublimity of the language" It issued a grammar in 1836, but its dictionary (Svenska Akademiens ordbok) did not appear until the 1890s. Meanwhile, C. G. af Leopold of the academy had published (1801) a treatise on spelling involving the radical Swedicizing of foreign words, especially the numerous French loans absorbed during the previous century. Few changes in orthography occurred during the 19th century; the most recent spelling reform was made in 1906. The importance of the written language increased after 1850; it was much affected by the press (dating, in a modern sense, from the foundation of L. Hierta's Aftonbladet in 1830), and the gap between the spoken language of educated men, modelled on the written norm, and the printed word was gradually reduced. An important aspect of this tendency was the speech usage whereby the singular form of the verb was employed with a plural subject, this became the norm of the press in the 19405.

Literature, 1730–1809.—After the death of Charles XII (1718) and the collapse of hie empire, a more vitiliarian attitude to life and letters gradually set in. Old von Dalin (q v), (1708–66) is the outstanding popularizer of the new ideas of French and English Enlightenment. Educated at Lund university (founded 1663), he later went to Stockholm and began to publish, anonymously, Thes. sodwinks Agray, modelled on Joseph Addison and Justus van Ellen, almost the first serious journalistic venture in Sweden. In forceful, supple prose, Dalin riddiciel the foblise of the capital. Sagas on histon (The Story of the Hortes, 1740) showed his mastery of allegorical satire, occasional verses and songs his skill as a lyric poet. He became a court poet and favour-tie and a member of Queen Lovisa's Vitterhetskademi (1753).

In spite of the increasing secularization of literature during Prihestitides (1718–72), the drama still lacked life; neither Count Karl Gyllenborg's comedy Den seenske spitathoken (The Swedish Fop. 1737) nor O Celsius' tragedy Ingeborg has more than historic interest

With the second phase of the Ballghtenment, marked by the deepening influence of France, are associated Hedvig (Bahelotta Nordenflycht (1718–63), Count Gustaf Creutz (q.n.) (1731–82) and Count Gustaf Gylenhorg (1731–1888) Fru Nordenflycht published in 1743 Den sorjande turturdufusus (The 'Sorrousung Turtitedove), in which she lamented the death of her husband in short lyrics. Creutz was a more sophisticated peisonality He wrote bittle, devoting his life after 1703 to diplomacy, but his few writings, of which Afts soch Camullo is the most important, reveal a mastery of form and Epicurean views Gyllenborg did not achieve his french? formal elegance, but his best poems, Varläsforaktaren and Visiterkvade, have nobility and feeling for nature.

Prose—particularly the novel—developed more slowly. The first genuine novel was Adalth's old Glothild (142s-44) by J Mork and A. Torngren, showing the influence of the Icelande sags and of Madeleme de Scuddry. But the nexiest prose of this penod is found in J. Wallenberg's Min son ph galegan (My Son on a East Indiaman. The most notable historian was S. Lagerbung, and J. Ihre entired historical philology with his Glossarium svio-golikecum (1769). The only two 18th-century Swedes with European reputations were scientists: Carl von Linde (Linnaeu; qu) (1707-78) and the versatile and mystic Emanuel Swedenborg (qv) (1768-772) Linné's work at Uppsala much enhanced the prestige of the university, and his Swedish travel books were later praised for their understanding of nature and freshness of style

The Gustavan perod (1771–7809) takes it name from the brillant Gustavus III (1746–99) and his intolerant son Gustavus IV Gustavus III saw himself as the patron of art and letters, at his court he collected the best writers of the turn, and by founding the Swedish academy he gave them official status. He was especially interested in drama and opera; thanks to his patronage a proper theatrical tradition was begun and the leading authors—often against their will—land to produce texts for performance. Gustavus himself sketched out some of these works, of which the opera Gustafy Ivaz, thanks to Johan Kellgren's versee, has vivived longest. The comedies of the Gustavian era were modelled on the French, the tragedies were pseudoclassical.

Johan Henrik Kellgren (q v.) (1751-95) was the greatest academic poet of this epoch and the arbiter of taste. In his best poems, such as Den nya skapelsen (The New Creation), thought and emotion are fused. In Stockholmsposten, the main organ of hterary opinion in the capital, Kellgren used his polemical wit against Thomas Thorsld (1759-1808), the truculent champion of individual genius, who wrote a long poem, Passionerna (1781), but is chiefly remembered for his polemical prose. After Kellgren's death the controversy was continued by C. C af Leopold (1756-1829), who still imposed pseudoclassical standards on the academy and applied them in his rhetorical odes and his plays. Johan Gabriel Oxenstierna (1750-1808) did his most original work in 1770-74 while a diplomat in Vienna; Skördarne (The Harvests) and Ode till Camilla reveal an elegiac, pre-Romantic feeling for the beauty of nature. Unfortunately he revised these poems before publishing them. Bengt Lidner (1759-93) was a follower of Thorild but showed much more poetic inspiration than Thorsld in his play Erik XIV, his opera Medea-both lyrical rather than dramatic in tone-and in his most successful work. the ode Grevman Spastaras död (1783). The influence of both Milton and the Bible may be traced in his use of language.

Carl Mikael Bellman (q, v).  $(r_1q_0-g_5)$  stands apart from the conflicting ideals of his time. A poet and muscian, he fused his gifts in the lyrics of Predmans epistlar  $(r_1q_0)$  and Predmans edited ending of  $r_1q_0$ . His combination of stylight endism with humour and the most delicate sense of language and rhythm is unique in Swedish. He is the greatest Swedish lyricist of the  $r_1q_0$  century

The dissertation Om upplysning (On Enlightenment) by Nils

von Rosenstein, the first secretary of the academy, nobly expressed the highest teleals of the Gustavan apoch; and various memors, by G G Adlerbeth, G J Ehrensvard, Count Fredrik Acel Feren, Duckess Hedwig Ehzabeth and others, evoke the writty but artificial atmosphere of Gustavus III's court and illustrate the development of pose Gustavus IVI do not encourage literature, however, the energetic Anna Maria Lenngren (1754–1821), wife of Stockholmspostarie editor, worte some of he hest verse satures between 1795 and 1800, many of her annoymous shafts being simed at anistocratic foolkes. The sentimental dylels of F M Franzén (q v), (1773–1847) also belong to these years; they are full of a pre-Romantic dielasm imbled from German and English sources and later toned down under pressure from the academy.

### LITERATURE, 1800-70

The Romantic Movement—The loss of Finland in 1808, the deposition of the king and the new constitution of 1809 all greatly affected Swedish literature, for out of them an ardent national spirit emerged as one of the motifs of Swedish romanticism. The teaching of B. Hoigier (1705–1821), admirer of Immanuel Kant and F. W. J. von Schelling, at Uppsala land the basis for the idealism which soon became the core of Swedish romanticism.

Then the impact of Goethe and Schiller and of the German Romantics was felt, and Swedish romanticism became as much dominated by German culture as the previous era had been by French Student societies became the focuses of the new movement, and the periodicals issued by them and their adherents-e g., Polyfem (1809-12) and Fosforos (1810-13)-attacked the academy Fosforos, from which the Fosforister took their name. played an especially important initial role in the controversy between the old school and the new during 1810-20, in it Per Daniel Amadeus Atterbom (1790-1855), the most gifted poet of the Fosforister, first revealed his talents in his *Prolog*. V. F Palmblad, publisher and prose writer, led the practical polemics at Uppsala, L. Hammarsköld, with J. C. Askelof and C. J. Livijn, carried on the frav at Stockholm, while I. D. Valerius and P. A. Wallmark championed the old school, as for a time did J. O. Wallin, who later became the greatest hymn writer of the century (hymnbook of 1819).

Meanwhie another society, Gotiska Forbundet, had been founded in Stockhohm in 1810, with the object of raxing the moral tone of society by study of the heroic, "Gother" past. Enk Gustaf Geljer (q v v)  $(r g s_0 - 1 s_0 v)$ , one of the founders, suggested the publication of a periodical, and the first issue of I dame consisted largely of his own poems, Visingen, Odalbonden, etc. Most of Geljer's poetry, including the first Swedish translation of Shakespeare (Macbeth), was written before 1816. Esains Tegnér (q v)  $(r 1 g s_0 - 1 s_0 v)$ , professor of Greek at Lund, also contributed to Idana, though he refused to engage in literary controversy, and P. Ling  $(r 1 g - 1 s_0 v)$ , to was associated with it.

A brief golden age of Swedish letters occurred in the 1820s. Atterbom published his most remarkable work, the verse drama Lycksalighetens O (The Isle of Bliss) in 1824-27; here, in often obscure but beautiful language, he expressed his philosophy in the allegory of Astolf and Felicia. His other verse drama, Fagel blå (The Blue Bird), was never finished, and his later years were devoted to a lyric cycle called Blommorna, to university work and to Svenska Stare och skalder (1841-55), which in a sense laid the foundations of literary history in Sweden. In 1820-25 Tegnér published Frithiofs saga, an epic on an Icelandic theme; this became the most popular poem of the first half of the century, and Tegnér, poet, orator and letter writer, who combined Gustavian wit and sense of form with idealism, was the greatest personality of the age. Erik Stagnelius (1783-1823), a complex and brilliant writer, published his Liljor i Saron in 1821 and his verse drama Bacchanterna in 1822, but most of his work appeared posthumously. Though influenced by the Romantics, Stagnelius held aloof from them and died in deliberately sought isolation.

A number of minor Romantic writers should be mentioned e.g., A. Törneros (1794–1839); P. Elgstrom (1781–1810); S. Hedbom (1783–1849), author of several attractive hymns and bal-

von Rosenstein, the first secretary of the academy, nobly expressed the highest ideals of the Gustavann epoch; and various 1871, collector of folk songs (Svenska folkwar från forntiden, memorrs, by G G Adlerbeth, G J Ehrensvard, Count Fredrik 1814-16), and E. Sjoberg (Vitalis).

The Romantic cultivated verse rather than prose, though Palmbiad certainly contributed something to prose with his long short story Amala (1817) and his novels, including Fomilien Falhersuisaid Mail Montgomery Silverstolpe's Memoarer (published 1908-11) gives a naive picture of the Romantic circle at Uppsala Geijer's cumbersome histonical works—Svoze Rikes Hafder (1829), etc.—do not reveal his stimulating personality, but Mimen (Memoris) of 1834 are full of the fresh charm of his

The Coming of Realism .- The most complex personality among the later Romantics was Karl Jonas L Almqvist (q v.) (1703-1866), who combines an extravagant imagination, as in Drottningens pivelsmycke (The Queen's Jewel), with the realism which is increasingly prominent in his works after 1836. Almqvist, a master of prose style, was at his best in the long short story (the novell), of his works in this genre Det går an (1839), an outspoken attack on marriage, foreshadows Strindberg's method of raising problems for debate. Almqvist was enormously productive and versatile, most of his works were published in the volumes of Tornrosens bok (1832-51). Meanwhile the realistic novel had made some headway. F. Cederborgh (1784-1835) wrote Uno von Trasenberg (1800-10) and Ottar Tralling, light-hearted satures on life and manners; but the novel as an accepted genre was really established by Fredrika Bremer (qv.) (1801-65), whose "sketches from ordinary life" appeared from 1828 Her novels, Grannarne, etc., have dated considerably, but were formerly very popular in both Europe and America. Sofie von Knorring (1797-1848) wrote novels principally about aristocratic families, and the very popular Emilie Flygare-Carlén (1807-92) produced a long series of stories, including Rosen pa Tistelon (1847), usually dealing with life on the west coast.

Realism, then, made only slow headway, in spite of the social consciousness of the liberal paper Aftonbladet and the example of the great Finnish-Swedish poet J. L. Runeberg (q.v.) The literature of the 1840s and 1850s is mainly an aftermath of romanticism, though the critic B. E. Malmstrom imagined that he opposed this movement. His elegy Angelica (1840) had kinship with the graceful but insipid poetry of his contemporary C. V Bottiger and the older K. A. Nicander. There was a fresher feeling about G Wennerberg's Gluntarne (1847-50), songs about Uppsala student life, but there is nothing new in them The movement known as Scandinavianism produced a good deal of verse. C V. A. Strandberg (Talis Qualis, 1818-77) was the fieriest poet of this type. Later he did excellent translations of Byron. O. P. Sturzen-Becker (Orvar Odd, 1811-69) was a versatile writer with talents in verse and the short story (Samlade Arbeten, 7861-62). Popular reading was provided by August Blanche (1811-68), particularly in the successful Bilder ur verkligheten (1863-65), which depicts Stockholm life with humour and vivacity. He also wrote popular dramas. Frans Hedberg (1828-1908) held the field at the Royal theatre with pompous historical plays such as Brollopet på Ulfåsa. The quasi-historical novels of M. I. Crusenstolpe (1795-1865), a brilliant and unscrupulous polemical writer, were much appreciated in their day. The most influential historian was A. Fryxell (1795-1881), with his Bilder ur svenska historien; and the dominating philosopher was the idealistic C. Boström (1797-1866).

Poetic realism became the official program of Signaturesladerus (the "Pseudonym Peets"), a small group of the 1860s influenced by the Norwegian critic L. Dietrichson. They included C. D. at Wirsen, E. Bickström and P. Wilmer, but only Count C. Snoilsky (1847-1903) had sufficient temperament and poetic gift to carry out the program. Some of Snoilsky's best work is found n Dikter (1869) and Sometter (1871). Meanwhile Wirsen had established insself as the conservative literary critic, and from his post as secretary of the academy he laumched formidable opposition against all innovators, including Snoilsky. A V. Rydberg (q.n.) (1828-95) exemplifies this rather uneasy transition from idealism on anturalism even more patently than does Snoilsky, Novelist,

poet and critic, he began as a radical journalist and ended as a professor and as author of the philosophical Dikter (1882-89) His most important early work was the ideological novel Den siste Athenaren (1859), and his treatise Bibelns lara om Kristus (1862) had considerable influence through its attack on the narrow orthodoxy of the Swedish Church and prepared the way for scientific rationalism

## LITERATURE FROM 1870

Strindberg.-Four influences combined to free Swedish literature from its petrifying conventions. English thought in the writings of Charles Darwin, Heibert Spencer and J S Mill, French naturalism as taught and practised by Émile Zola, the drama of the Norwegians Henrik Ibsen and B Bigrison, and the criticism of Georg Brandes Modern Swedish literature begins with the work of Johan August Strindberg (qv) (1840-1912), for the modern drama dates from his Master Olof (1872) and the modern novel from his Roda rummet (The Red Room, 1879). By his originality, his mastery of prose and dialogue, his great energy and the influence of his work and personality on Swedish, not to say European, literature he is by far the greatest writer Sweden has yet produced

The 1880s .- Strindberg overshadowed all other writers of the 1880s G af Geijerstam (1858-1909), author of Erik Grane (1885) and of several other novels and short stories, longed to lead his age, but could not do so. A. M. Edgren-Leffler (1849-02), later duchess of Cajanello, wrote a number of stories called Ur livet (From Life) in which she satirized conventions adversely affecting women. The more gifted Viktoria Benedictsson ("Ernst. Ahlgren," 1850-88) died-by her own hand-before she had fulfilled her promise; she too, but more boldly, was concerned with the position of women in society. Her stories, Från Skåne (1884). have lasted better than her novels, Pengar and Fru Marsanne, and reveal how much regional characterization had entered into the new style of literature. With her was associated Axel Lundegard (1861-1031), who soon turned his talents to the historical novel Alfhild Agrell (1849-1923) wrote her best stories about Norrland. Regional poetry was written by A. U. Bååth (1853-1912) of Skåne, it was surpassed in beauty and originality by the work of another Skåning, Ola Hansson (1860-1925), novelist, critic and poet Hansson's early poems (Notturno, 1885) and his sketches. Sensuiva Amorosa (1887), reveal the boldness in imagery and the interest in psychological nuances which are more typical of the next decade.

interest in psychological nuances which are more typical of the next decade.

1899–1910.—Though, except for the work of Strindberg, little of lating value was achieved in the 1880s, it must be remembered that the generation just discussed accustomed the public to the debating of lating value was achieved in the 1880s, it must be remembered that the generation just discussed accustomed the public to the debating of the 1881 strength of the 1881 st

Meanwhile Selma Lagerlof (1858-1940) had developed the prose tale Het long series of novels and short stories, beginning with Gosta Berlings saga (1891), reached an international public, she was, mideed, the first Swede to win the Nobel prize for literature (1909) mdeed, the first Sweede to wan the Nobel prize for literature (1990). She often used oid Varimhand tales for material, though one of her notice of the state of t numan passions, often against a mediaeval or Renaissance background. human passons, often against a mediaeval or Kenaissance background. Romantic, too in his love for the skerries, was Albert Engstrom (1867— 1910), story write, cartoonist, founder of the popula humorous papel Sfrrs and one of the most beloved of Swedish witters To Hedberg, son of Frans Hedberg (see above), began with the style of the 1868s, his most lasting work was in the tragedy Johan Ullsjærne (1997) and in the lyric

Both Hjalmar Soderbeig (1869-1941) and Bo Bergman (1869-) had links with the rationalism of the 1880s and with the aestheticism of the 1890s, yet both stand apart from the neo-Romantics Both, like Strindberg, loved Stockholm, which perpetually recurs as the setting of their works. Soderberg's forte was the short story (Historietter), in which his psychological subtlety and irony are happily combined, but his novels, including Martin Bircks ungdom (1901) and Doktor Glas (1905), have an appreciation of mood and an awareness of the faults of contemporary society which make them unique in Swedish fiction Soderberg, especially, is one of the masters of Swedish prose Beigman Soderberg, especially, is one of the masters of Swedish prose Reigman also achieved memorable short stones (Prommen, 1904, Skeppet, 1915, etc.), but his real medium was the lyric, he developed and refined his talent in a series of collections from Manonetteria (1903) to Ribet (1944) Like Soderberg, he is a passionate enemy of hypocrisy and brutality, but his characteristic tone is subdued reality, but his characteristic tone is subdued reality.

and bruilalty, but his characteristic tone is slubtuced reasism modutant, and the state of the s 1949) and Sigfrid Siwertz (1882- ) Hellstrom's work as journalist took him to the continent and to the United States, and long residence in England greatly influenced him. His irony and careful realistic deon England greatly influenced hm. His romy and careful realistic clear lill emerge in his best-known wovel, Snormabar, Likholin fit en uid still emerge in his best-known wovel, Snormabar, Likholin fit en uid Siwertz is a mose elegant stylist—like so many Swedes he began as a yrickis—and a declavie influence upon hum was the philosophy of Henri Bergson, reflected in En Flanor (1914). His weightest works are the Bergson, reflected in En Flanor (1914). His weightest works are the Bergson, reflected in En Flanor (1914). His weightest works are the ling World War 1, and Ionas and Deposit of Steckholin duri writer of short stories. Nordiston came from Nortand, and his birth-place—Hainosand—is preprietated in his works as "Obacka" Overplace—Hanosand—ss perpetuated in his work as "Obacka" Over-llowing with vitality and grifed with keen but grotesque humoun, he did some of his best work in Landsorts-bohème (1911) and Planeten Mrkstafan (1927), but his most satisfying productions are the short stories in Fishere (1907), Obackabor (1921), etc. Eim Wagner was an ardent paddist and feminist, her horror of militarism is shown he ne noved Sakten Jernaphogos framgång and her feminism in many of her witty, short stories Her most powerful work is the peasant novel witty, short stories Her most powerful work is the peasant novel Asa-Hanna (1918).

The outstanding novelist of the second decade of the 20th century The outstanding novellst of the second decade of the 20th entury in Hjanna Berman (1885–1931). Gittlet with a fantastically word stores many of which are set in "Wastloping" (his native Orebo) and stores many of which are set in "Wastloping" (his native Orebo) and to sturroundings, others in Halv. In Lovenshinsteric (1931), as in other words, Bergman depicts an irrational, impulsave, unsuccessful other words, Bergman depicts an irrational, impulsave, unsuccessful other control of the control of the control of the control of the control of the few irrans beginning of the few irrans and Swedsh consciences, are his most wadely known works. Bergman's witty dialogue and rapid characterization, and his inventiveness, both tragic and burlesque, make him one of the most original of Swedish writers, and as dramatist the only native successor to Strindberg.

Meanwhile the "proletarian" novel had been developed-not always Meanwhile the "proietariah" novel had been developed—not always by working-class writers—by G. Hedenwind-Eliksson (1880—), M. Koch (1888—1940) and I. Lo-Johansson (1907—), who is particularly concerned with the miscres of the stataens (fram labourer's) life. There is particularly harsh and telling criticism of wisking-class life in Lars Hard and other stories by Jan Fridegård (1879—). V. Moberg (1898— ) wrote both realistic and historical novels of peasant life. The autobiographical element, strong in many of these von Krusenstjerna (1894-1940) in her novel cycles (e.g., Tonyo-böckerna and Fróknarna von Pahlen) she describes her own arnsto-COCKETING AND CYCRIGATING VON Pahlen) she describes her own aristocratic and upper-middle-class environment, and analyzes a degenerate and perverted psychology. Her works constituted a new departure in Swedish literature.

The greatest Swedish writer of this period is undeniably Pär Fabien Lagerkvist (1891—), who won the Nobel prize in 1951. He was a wital force in literature after World War I and influenced both form and

content. His angushed search for a personal philosophy iscalls Strendberg, it is the heads of plays such as *Strenders demighed* (1970) and the semipled (1970) and the semipl

) were self-educated profesarians who turned more and mose to experiment with form Johnson's best work was probably his auto-bographical Romanes on Olof (1934-37) Martinson wrote both poetry and prose but achieved his most straing efficies in prose, in Rag-Parvail (Cape Farewall) and in Veges till Rokerhie (1940) Wittels of gest oppolisaty; too, were Old Hedders (1855— 1, a witty novelst of middle-class like, F Nilsson-Piraten (1855— 1, a skine) humorist, and his lellow-Lundensian Prants G Bengstons, author of the historical-humorous novel Rode orm (1941-45) and a masterly essayist Of the youngest authors, Stig Dagerman (1943-45) lar promise in his play Skuggan av Mart (1948) ) showed particu-

Lir pionise in his play Skaggen av Mart (1488)
Many other pames occur in connection with the development of bric postry. V Electural (1880-1949) developed the dithyrambe form of the property

Henrik Schuck (1855-7947), with his emphasis on the historical approach to literature, was the father of modern Swedish criticism Levertin, A Blanck (1881-1950) and M Lamm (1880-1950) were his

Levertin, A. Blanck (1881–1950) and M. Lamm (1856–1950) were his most distinguished stepath. Bistory H. Schuck and K. Warbung, H. Istierrad seemsh listerativishistoria, vol. 1-va, grd ed, rev., H. Schuck (ed) (Stockholm, 1952-3). E. Stattm, shirt, vol. 1. h, theraiture, 1950–1914 (Stockholm, 1952-3). E. H. Linder, ibrd, vol. vm, literature, 1910–1914 (Stockholm, 1952-3). E. H. Linder, ibrd, vol. vm, literature, 1910–1914 (Stockholm, 1952-3). E. Breddooff, B. Behück, Swerges literaturishistoria (Stockholm, 1954). H. Schuck, Swerges literaturishistoria (Stockholm, 1954). H. Schuck, Gonzalesson Literaturishistoria ( ture (Copenhagen and Cambridge, 1951) Anthology. H Schuck, R. G Berg and F Book (eds.), Sveriges national-litteratur, 1500-1900, A. G. Berg and F. Book. (eds.), 20eriges naisonat-miteratur, 1300-1300, 30 vol, 2nd ed. (Stockholm, 1021-22); G. Bergman, A Short History of the Swedish Language (Stockholm, 1947)

(B. M. E. M.)

SWEELINCK or SWELINCK, JAN PIETER (also known as Jan Pieterszoon) (1562-1621), Dutch organist and composer, was probably born at Amsterdam, although his family came from Deventer. It has been persistently stated that he was a fellow pupil with Giovanni Gabrieli and Leo Hassler of the great Andrea Gabrieli in Venice, but this was disproved by F H. J. Tiedeman in the Vereeniging voor Nederlandsche Muziekgegeschiedenis (Amsterdam, 1876). Sweelinck was the son of the organist of the Old church, Amsterdam, and lived in Holland from about 1577 onward

At a date not later than 1581 he was appointed organist to the Old church, his father having died in 1573, and this post he held until his death on Oct. 16, 1621,

A complete edition of his works, edited by Max Seiffert with prefaces,

was brought out by Breitkopf and Hartel in 1894-1901. See also Grove's Dictionary of Music and Musicians.

SWEET, HENRY (1845-1912), English philologist, was born in London on Sept 15, 1845 Educated at King's college, London, Balliol college, Oxford, and Heidelberg university, he was a recognized authority on phonetics, and a readership in phonetics was specially created for him in 1901 by the University of Oxford

Sweet died at Oxford on April 30, 1912.

Sweet used at UNIORI on April 30, 1912.
His works include Anglo-Saxon Reader (1866); Student's Dictionary of Anglo-Saxon (1807); A Short Historical English Grammar (1865); He History of Language (1900); and many editions of Old and Middle English texts. The Collected Papers of Henry Sweet were edited by H C. Wyld (1921).

SWEETBREAD, a popular term for certain glands of animals, particularly when used as articles of food; these are usually the pancreas, the stomach sweetbread of butchers, and the thymus, or neck sweetbread. The term is also sometimes used to include the salivary and lymphatic glands. (See LYMPHATIC SYSTEM; PANCREAS.

SWEETBRIER (Rosa eglanteria or R. rubiginosa), a tall, stiff-stemmed rose, called also eglantine, native to Europe, widespread in Great Britain and extensively naturalized in eastern 41h-AA

North America The erect, somewhat branching stem, aimed with stout hooked prickles, grows usually from 5 to 8 ft high It bears fragrant leaves, of five to seven leaflets, and solitary white or pinkish flowers, I to 2 in across. While the sweetbrier is infrequently grown for ornament, various hybrids with other roses are in cultivation (See Rose )

SWEET CLOVER, the common name for plants of the leguminous genus Melilotus (except M. indica, which is called sour clover) comprising about 20 species, native of southeastern Europe and Asia Minor They are annual or biennial, erect herbs, with trifoliolate leaves of usually small narrow leaflets and small yellow or white flowers, borne in slender axillary clusters (racemes) Most of the species contain coumarin resulting in a

sweet-smelling odour and bitter taste.

Biennial white sweet clover (M alba), biennial yellow sweet clover (M. officinalis) and sour clover (M indica), a winter annual adapted only to the southern and southwestern United States are of agricultural importance for pasture, soil improvement and hay in the United States and Canada. The first two species have become widely naturalized throughout the United States and Canada, while sour clover is widely scattered where adapted. M. suaveolens, a yellow-flowered species, is grown in a limited way in the southern prairies of Canada, and occasional plants of M, altissima have been collected in the eastern states. Annual forms of many of the biennial species have been found and several new varieties have been developed,

See "Sweetclover," leaflet no. 23, and the 1937 Yearbook of Agri-culture, US Department of Agriculture (E. A. H) SWEET CORN: see MAIZE; VEGETABLE.

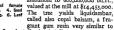
SWEET FLAG: see Acorus Calamus.

SWEET GALE (Myrica gale), a shrub of the family Myricaceae, called also gale, sweet willow, bog myrtle and Dutch myrtle, widely distributed in the north temperate zone It grows usually from 2 to 4 ft high, with numerous twiggy branches. narrow, short-stalked, fragrant leaves; inconspicuous, unisexual flowers, borne in short spikes, and small, waxy-resinous, drupelike fruits attached to the persistent flowering bracts. The sweet gale occurs extensively on bogs and moors in the British Isles and widely also throughout the northern United States and Canada. The leaves are used as tea and as a country medicine.

(See WAX MYRTLE.)

SWEET GUM (Liquidambar styraciftua), a handsome North American tree of the witch hazel family (Hamamelidaceae), called also red gum, liquidambar (q.v.) and bilsted, found from Connecticut to Missouri and southward to Florida and Mexico It has a straight trunk, sometimes 140 ft, high and 5 ft in diameter, with rough bark, corky-winged branches, large, deeply lobed leaves, and drooping, spiny, globose, capsular fruiting heads containing winged

seeds. The hard reddish-brown wood is known to the lumber trade as red gum or satin walnut. In 1936 the cut of red gum lumber in the United States amounted to 606,000,000 bd.ft.,



FROM HARRAR, "GUIDE TO SOUTHERN THEIST (MCGRAW HILL BOOK COMPANY, INC.) SWEET GUM 1. Follage. 2. Male and female flower clusters. 3. Fruit. 4. Seed (much enlarged), 5. Twig. 6. Leaf

the storax produced by L. orientalis of Asia Minor. SWEET PEA: SEE PEA.

SWEET POTATO (Ipomoea batatas), a food plant of the family Convolvulaceae (q.v.), a native of tropical America, widely cultivated in tropical and the warmer temperate climates. It is a



tender perennial grown as an annual in regions where frost occurs. The stems are long, trailing, sometimes short, with entire to palmately-lobed leaves of quite variable shape. The flowers, horne in cymes in the axis of the leaves, are funnel-shaped, tanged with rose-volet or pink, and are similar in size and shape to those of the common bindwed. The edible part is the much enlarged tuberous root, varying in shape from fusiform to oblong or pointed oval Root colours inage from white through cream to crange, and occasionally purple inside, and from light buff to brown or rose, copper and purplish red outside The solids of the root consist largely of starch and the orange-fleshed varieties are high in caroties.

The sweet potato rarely produces flowers under common cultural conditions in latitudes higher than about 35°, and produces no seed above about 30° except under special cultural treatment

The seeds produce plants that are unlike the parent plant, therefore the sweet potato as propagated vegetatively by sprouts arising from the roots, or by cuttings of the vines Seeds, however, are produced commonly in the field in the tropics. They have a very hard seed-coat that may retard germination as much as a year, unless the seed coat is nicked or abraded, after which the seeds germinate promptly.

The sweet potato is extensively grown in the United States, in tropical America, the warmer islands of the Pacific, in Japan, and from 1730 its culture increased rapidly in the U S R I is best adapted to the lighter, more frishles coils such as sandy Jounns and sandy soils, producing excessive vine growth and small yields or irregularly shaped roots on very roft, heavy soils. At least four to five months of warm weather are required for large yields. In Japan the crop long has been grown for drying and for manufacture of starch, but starch manufacture was initiated in the United States only after 1935, and up to 1942 only one factory remained in operation. The crop has been grown cheefy for use as a vegetable but in the United States is henge grown to an increasing extent (1943) as stock feed, either freshly harvested or shiedded and dired.

In the United States the sweet potato is propagated usually by bedding the roots close together in sand or light soil in a hot-bed heated by manure, by flues or electricity, about 4 or 5 weeks before the frost-free date. The sprouts which emerge are pulled from the roots and transplanted to the field about 1 to 11 ft apart on ridges 8 to 12 in. high, 3 ft. apart, after the weather and soil have become warm. The roots are harvested mostly about the time of the first frost in autumn since cold soils cause them to deteriorate. The crop responds well to heavy applications of chemical fertilizers low to medium in nitrogen and high in phosphorus and potash Heavy applications of animal manures or green manures are conducive to the formation of elongated, irregular roots and to root surface injury by scurf, a fungous disease. If the roots are to be stored, they should be placed in the storage house immediately upon harvesting, at a temperature of 85° F. and a relative humidity of 85% to 90% which is maintained for a week to 10 days. Then the temperature 1s lowered to 50-55° where it is kept as long as the roots are in storage. The "curing" period at high temperature and humidity is essential to hasten the healing of wounds caused in harvesting, thus reducing danger of loss from decay The eating quality-and also the market quality and storage life—are greatly improved by curing. If diseases are controlled, roots that are properly cured and stored remain in good edible condition 6 to 7 months The sweet potato is very susceptible to several diseases, control of which requires great care in field and store house sanitation and management, seed-stock treatment with disinfectants, and crop rotation

In the United States from 1930-42 about 800,000 ac. annually, vielding about 190000,000 bu, were grown for commercial purposes. The principal producing states were Georgia, Louisiana, Alabama, North Carolina, Mississippi, Texas, South Carolina and Tennessee The crop is grown commercially as far north as New Jersey and Iowa Average yields per acre range from 60 to 140 bu, among the several states.

SWEET-SOP or SUGAR APPLE, botanical name Annowa symmotox (family Annonaceae), a small tree or shrub with the solutions of the solution of the solution of the solution speem fruit, like a shortened pine cone in shape with a tubercle corresponding to each of the carpels from the aggregation of which it has been formed The fruit is 3 to 4 in, in diameter and contains a sweet creamy-yellow custard-like pulp It is a native of the West Indies and tropical America, it is much praced as a fruit, and has been widely introduced into the eastern hemisphere A muricata is the sour-sop (q v) A seticulata is the custard apple (q v), and A palutists the alligator apple.

SWEETWATER, a city of western Texas, USA., on federal highways 80 and 84, county seat of Nolan county.

Population in 1950 federal census was 13,610, (1940) 10,367. The district specializes in blooded Hereford stock, and has gas and oil fields. Sweetwater was founded in 1882 and charteted as a city in 1897. It adopted a commission-manager form of government. South of the city are the ruins of Fort Chadbourne, built in 1832.

SWELLENDAM, town, South Africa, in the valley of the Breede river, 192 m. E by S of Cape Town by rail; 33° 59' S, 20° 23' E, altitude 500 ft

Swellendam is one of the older Dutch settlements in the Cape, dating from 1745, and was named after Hendrik Swellengrebel, then governor of the Cape, and his wife, whose maiden name was Damme

Early in 1795 the burghess of the town and district rose in revolt against the Dutch East India company, proclaimed a "free tepublic," and elected a so-styled national assembly. At the same time the burghers of Graaff Reinet also rebelled against the Cape authorities, who were powerless to suppress the insurrectionary movement. One of the claims of the "free republic" was "the absolute and unconditional slavery of all Hottentots and Bushmen" In September of that year Cape Town surrendered to the British and the "National" party at Swellendam quietly accepted British rule. The town thereafter lost much of its former importance. The total population of 4,003 in 1346 included 2,331 whites, 1,631 "coloured" (mixed), 38 natives and 3 Assattis

SWETCHINE, MADAME (1782-1857), Russian mystic, whose maden name was Soymanof, was born in Moscow, and under the influence of Joseph de Maistre became a member of the Roman Catholic Church in 1815. In the following year she settled in Paris, where, until her death, she maintained a famous salon remarkable no less for its high courtesy and intellectual brillance than for its religious atmosphere Though not physically beautiful, she had a personality of rare spiritual charm, untrured in the private chapel of her house Her husband, General Swetchine, was 35 years her senior.

Her Life and Works (of which the best known are "Old Age"

and "Resignation") were published by M. de Falloux (2 vols, 1860) and her Letters by the same editor (2 vols, 1861).

See Sainte-Beuve, Nouveaux lundis, vol. i; and E. Scherer, Études sur la littérature contemporame, vol i.

SWETE, HENRY BARCLAY (1835—1917). English theologian, was born at Bustol on March 14, 1835, and educated at King's college, London, and Caius college, Cambridge He was ordained in 1858, and became in 1865 dean of Caius college In 1877 he accepted the college living of Ashdon, Essex, and 1832 was made professor of pastoral theology at King's college. London

In 1890 he succeeded Westcott as regius professor of divinity at Cambridge, retiring with the title of emeritus professor in 1915. He died at Hitchin on May 10, 1917.

Swetch works on Biblical texts are of the highest importance. In 1889 he published the first volume of his edition of the Greek text of the Old Testament, completing the series in 1894 (4rd ed., 1907-197); in 1898 the Greek text of the Gospiel OS K Mark with notes and of St. John (and ed., 1907). He was the editor of Combridge Theodogical Europy (1905) and Contributed to Smith and Wace's Dictionary of Christian Bugraphy (1808-67) and Hasting's Dictionary of the Buble (1809-1900). His

hatorical and critical works include The Apoullet' Creed in Relation for the Recommendation of the Recommendat

Bluetooth, the christianizer of Denmark, by his peasant mistress Aesa, according to the Jomsvikinga Saga, though more probably his mother was Queen Gunild, Harold's consort. The lad was a born champion and buccaneer His first military expedition. m alliance with the celebrated Jomsborg Viking, Palnatoke, was against his own father, who perished during the struggle (c o86). Six years later he conducted a large fleet of waishins to England. which did infinite damage, but failed to capture London During his absence, Denmark was temporarily occupied by the Swedish king. Eric Sersel, on whose death (c 994) Sweyn recovered his patrimony, About the same time he repudiated his first wife Gunild, daughter of duke Mieszko of Poland, and married King Eric's widow, Sigrid This lady was a fanatical pagan of a disquicting strength of character Two viceroys, earlier wooers, were burned to death by her orders for their impertinence, and she refused the hand of Olaf Trygvesson, king of Noiway, rather than submit to baptism, whereupon the indignant monarch struck her on the mouth with his gauntlet and told her she was a worse pagan than any dog. Shortly afterwards she married Sweyn, and easily persuaded her warlike husband to unite with Olaf, king of Sweden, against Olaf Trygvesson, who fell in the famous seafight off Svolde (1000) on the west coast of Rugen, after a heroic resistance immortalized by the sagas, whereupon the confederates divided his kingdom between them. After his first English expedition Swevn was content to blackmail England instead of ravaging it, till the ruthless massacre of the Danes on St Brice's day, Nov. 3, 1002, by Ethelred the Unready (Swevn's sister was among the victims) brought the Danish king to Exeter (1003). During each of the following eleven years, the Danes, materially assisted by the universal and shameless disloyalty of the Saxon ealdormen, systematically ravaged England, and from our to your the wretched land is said to have paid its invaders in ransoms alone £158,000. Sweyn died suddenly at Gainsborough on Feb 13, 1014

The data relating to his whole history are scanty and obscure, and his memory has suffered materially from the fact that the chief chroniclers of his deeds and misdeeds were ecclesiastics

His most remarkable exploit, Svolde, was certainly won at the expense of Christianity, resulting, as it did, in the death of the saintly Olaf. It is not surprising, therefore, that Adam of Bremen, and the monkish annalists who follow him, describe Sweyn as a grim and bloody semi-pagan, perpetually warring against Christian states But there is another side to the picture. Viking though he was, Sweyn was certainly a Christian viking

He built churches, he invited English bishops to settle in Denmark (notably Godibald, who did good work in Scania), and on his deathbed he earnestly commended the Christian cause to his son Canute. He was cruel to his enemies but he never forgot a benefit. Thus he rewarded the patriotism of the Danish ladies who sacrificed all their jewels to pay the heavy ransom exacted from him by his captors, the Jomsborg pirates, by enacting a law whereby women were henceforth to inherit landed property in the same way as their male relatives.

Of his valour as a captain and his capacity as an administrator there can be no question His comrades adored him for his liberality, and the frequent visits of Icelandic skalder to his court testify to a love of poetry on his part. Indeed one of his own strophes has come down to us.

He had a long cleft beard, whence his nickname of Tiugeskaeg or Fork-Beard

See Danmarks riges historie. Oldtiden og den aeldre middelalder, p.364-381 (Copenhagen, 1897-1905). (R. N. B.; X.) DP.364-387 (Copenhagen, 1807-1905). (R. N. B.; X.)

SWEYN II or ESTRITHSON, King of Denmark (d. 1976), was the son of Estrith, sister of Canute the Great, and of the Earl Ulf When his father was murdered by Canute, Sweyn fled to Sweden, where he remained until the accession of Magnus the Good to the throne of Norway, at which time Magnus named

him earl of Jutland and viceroy of Denmark. Sweyn, however, was not satisfied with this position, aspiring to become king of Denmark He therefore involved Denmark and Norway in a war which was only terminated in 1047 with Magnus' death, caused by a fall from a horse as he rode in pursuit of the defeated and fleeing Sweyn His dying wish, however, was that Sweyn be made king of Denmark, and Swevn thus began the Estrith dynasty. known as the second or middle Danish dynasty, which ruled for nearly 200 years.

Sweyn was almost immediately embroiled in conflict with Harald Haardraade, Magnus' heir to the throne of Norway, who wished also to become king of Denmark. For 17 years, until 1064, the battle between the two countries was pursued sporadically and at the end of that time, although the Norwegians had decisively defeated the Danes in the naval battle of Nissa, the two monarchs declared a truce and the boundaries of Norway and Denmark were declared to be the same as when the war started After Harald's death in 1066, Sweyn felt free to turn his attention to some other project than the defense of his country. In 1060, therefore, he sent a fleet to assist an internal rebellion against William I of England, a country which he, as nephew of Canute. felt he was entitled to rule. William, however, was able to bribe Sweyn's lieutenant and thus to forestall that threat. In 1075 Swevn made another similar effort which proved equally abortive

Sweyn was a devout Roman Catholic, and although he was at one time embroiled with the aichbishop of Bremen over Sweyn's marriage to his own stendaughter, he did much to encourage the development of the church in Denmark He died in 1076 He left numerous sons, perhaps as many as 14, all illegitimate. Five of

them subsequently became kings of Denmark

SWIFT, GUSTAVUS FRANKLIN (1839-1903), U.S industrialist, was born June 24, 1839, at Sagamore, then known as West Sandwich, Massachusetts When he was 14 he left school to take a position at a salary of \$1 a week working for his brother, a butcher. By 1859, at the age of 20, he had gone into business for himself as a buyer and slaughterer of cattle on a small scale. In that year he opened his own butcher shop in Eastham and soon became the manager of a number of small shops, which he opened himself and placed in charge of other men In 1872 he became the partner of James A. Hathaway in the firm of Hathaway and Swift. Three years later Swift, who was the cattle buyer for the firm, transferred his headquarters to Chicago, where the centre of the cattle market had shifted He soon determined that the meat packing business would be substantially more profitable than the meat selling business if some method were devised for shipping fresh meat from Chicago to the east, instead of sending live cattle to be slaughtered on arrival, as was the custom. He therefore hired an engineer to design a refrigerator car which would make this possible, and in 1877 he successfully shipped the first refrigerator carload of fresh meat to the east. In 1878 he formed a partnership with his brother and in 1885, with a capitalization of \$300,000, the firm of Swift & Company came into being, with Swift as first president. At his death less than 20 years later, the capitalization had increased to \$25,000,000, more than 80 times the original size. In addition to his promotion of refrigerator cars, which was one of the most important factors in the development of the meat packing business, Swift was a leader in the field of turning previously unused parts of slaughtered animals into valuable by-products He died March 29, 1903, in Chicago.

See Louis F. Swift and Arthur Van Vlissingen Jr., Yankee of the

Yards (1927). SWIFT, JONATHAN (1667-1745), dean of St. Patrick's, Dublin, British satırist, was born at No. 7 Hoey's court, Dublin, on Nov. 30, 1667, a few months after the death of his father, Jonathan Swift (1640-1667), who married about 1664 Abigaile Erick, of an old Leicestershire family. His grandfather, Thomas Swift, vicar of Goodrich near Ross, appears to have lost his possessions by taking the losing side in the Civil War and died in 1658 before the restoration could bring him redress. He married Elizabeth, niece of Sir Erasmus Dryden, the poet's grandfather. The young Swift was supported by his uncle Godwin, a Tipperary 662 SWIFT

official, at the age of six he entered Rilkenny school, where Congreve was a fellow student, and he completed his education at Tranty college, Dublin Here he exhibited few signs of preconcus genus, and it was only by special act of midulgence that he obtained his degree, then, on the death of his uncle, he left Ireland and sought counsel of his mother in Lecester.

His first employment commenced towards the close of r689, when he became secretary to Sir William Temple, who had returd to Moor Park, near Farnham, after the rapid decline of this indicate to Moor Park, a sear Farnham, after the rapid decline of this indicate during the critical petied of Charles IT's regn. It was there that Swift's ocquantance with Esther Johnson, the "Stella" of the famous Journal, was begun Stella's mother was living at Moor Park, as servant of Temple's astert, Lady Giffard Swift was 22 and Esther S years old at the time, and a curious friendship sprang up between them He taught the hitle garl how to write and gave her advice in reading On his arrival at Moor Park, Swift's duties were merely those of account-keeper and amanuensis, but his ability gradually won him the confidence of his employer and he was entrusted with some important missions.

In 1644, however, Swift (who had in the meantume obtained the degree of M A ad eundem at Oxford) quitted Temple, who had, he considered, delayed too long in obtaining him preferrents, but it was only after five months' delay, when Swift had unwillingly begged the favour of a testimonial from his discarded patron, that he was able to obtain the small prebend of Kilroot near Belfast (Jan 1695).

In the meantime he had grown tired of Irish life and was glad to accept Temple's proposal for his return to Moor Park, where he continued until Temple's death in Jan, 1600. During this period he wrote much and burned most of what he had written He read and learned even more than he wrote Moor Park took him away from brooding in Ireland and brought him into the corridor of contemporary history, an intimate acquaintance with which became the chief passion of Swift's life. His Pindaric Odes. written at this period or earlier, in the manner of Cowley, indicate the rudiments of a real satirist, but a satirist struggling with a most uncongenial form of expression. Of more importance was his first essay in satiric prose, which arose directly from the position which he occupied as domestic author in the Temple household. Temple had in 1692 published his Essay upon Ancient and Modern Learning, transplanting to England a controversy begun in France by Fontenelle Incidentally Temple had cited the letters of Phalaris as evidence of the superiority of the ancients over the moderns William Wotton's criticism of Temple's general conclusions caused Swift to write Battle of the Books in 1697 in refutation Boyle's Vindication and Bentley's refutation of the authenticity of Phalaris came later. Swift's aim was limited to co-operation in what was then deemed the well-deserved putting down of Bentley by Boyle, with a view to which he represented Bentley and Wotton as the representatives of modern pedantry, transfixed by Boyle in a suit of armour given him by the gods as the representative of the "two noblest of things, sweetness and light," Though written in 1697, the satire remained unpublished until 1704, when it was issued with The Tale of a

After Temple's death, Swift suffered several disappointments in attempting to find employment, but he eventually secured the rectory of Agher in Meath with the united vicarages of Laracor and Rathbeggan, to which was added the prebend of Dunlavin in St. Patrick's-the total value being about £230 a year. He was now often in Dublin, at most 20 mi. distant, and through Lady Berkeley and her daughters-Lord Berkeley was now a lord justice of Ireland-he became the familiar and chartered satirist of the fashionable society there. But he very soon began to grow tired of Ireland again and to pay visits in Leicester and London His resolution to exchange divinity for politics must appear fully justified by the result. The Discourse on the Dissensions in Athens and Rome (Sept 1701), written to repel the tactics of the Tory commons in their attack on the Partition treaties "without humour and without satire," and intended as a dissuasive from the pending impeachment of Somers, Orford, Halifax and Portland, received the honour of being generally

attributed to Somers himself or to Burnet, the latter of whom found a public disavowal necessary. In April or May 1704, appeared a more remarkable work Clearness, cogency, masculine simplicity of diction, are conspicuous in the pamphlet, but true creative power told the Tale of a Tub Although it lacks coherence and attains no conclusion, it is the most strikingly original of Swift's saturical works In his kindred productions he relies mainly upon a single element of the humorous-logical sequence and unruffled gravity bridling in an otherwise frantic absurdity, and investing it with an air of sense. In the Tale of a Tub he lashes out in all directions. The humour, if less cogent and cumulative, is richer and more varied, the invention, too, is more daringly original and more completely out of the reach of ordinary faculties The book is throughout a mine of suggestiveness At the same time, it lacks unity and coherence, it attains no conclusion, and the author abuses his digressive method of composition and his convenient fiction of hiatuses in the original manuscript

In Feb. 1701, Swift took his D D degree at Dublin, and before the close of the year he had taken a step destined to exercise a most important influence on his life, by inviting two ladies to Laracor Esther, daughter of a merchant named Edward Johnson, a dependant, and legatee to a small amount. of Sir William Temple's (born in March 1680), whose acquaintance he had made at Moor Park in 1689, and whom he has immortalized as "Stella," came over with her companion Rebecca Dingley, a poor relative of the Temple family, and was soon permanently domi-ciled in his neighbourhood. Meanwhile the sphere of his intimacies was rapidly widening. He had been in England for three years together, 1701 to 1704, and counted Pope, Steele and Addison among his friends In 1708 he wrote the finest example of his irony, the Argument to prove that the abolishing of Christianity in England may, as things now stand, be attended with some inconveniencies, and about this time, too (Nov. 1707), he produced his best narrative poem, Baucis and Philemon.

The next few months witnessed one of the most amusing hoaxes ever perpetrated against the quackery of astrologers, the victim being a Protestant alarmist and plot vaticinator styled John Partridge, In Jan 1708, Swift, under the name of Isaac Bickerstaff, issued a solemn prediction that the notorious almanac maker, Partridge, would die at 11 o'clock P.M. on March 29, and on March 30 he published a letter confirming this prophecy Partridge's fatuous denial and reply to Bickerstaff elicited Swift's musing Vindeaction of Isaac Bickerstaff, Sag, in April 1700. The episode has left a permanent trace in literature, for when, in 1709, Steele was to start the Tailer, it occurred to him that could secure the public car in no surer way than by adopting the name of Bickerstaff.

From Feb 1708, to April 1709, Swift was in London, urging upon the Godolphin administration the claims of the Irish clergy to the first-fruitis and twentieths ("Queen Anne's Bounty"), already granted to their brethren in England His having been selected for such a commission shows that he was not yet regarded as a deserter from the Whigs, although the ill success of his representations probably helped to make him one. By Nov 1710, he was again domiciled in London, and writing his Journal to Stella, that unique exemplar of a giant's playfulness In the first pages of this minute record of a busy life we find him depicting the decline of Whig credit and complaining of the cold reception accorded of Whig credit and complaining of the cold reception accorded

of Wang creant and companising or the color reception accorded in by Godolphin, whose penetration had doubtless detected the precariousness of his allegiance. Within a few weeks he had become the lampooner of the fallen treasurer, the bosom friend of Oxford and Bolingbroke, and the writer of the Examiner, a journal established as the exponent of Tory views (Nov 1710). He was now a power in the state and the associate of ministers on a footing of perfect cordiality and familiarity For a brief time he seemed to resume the whole power of the English press in his own pen and to guide public opinion as he would—his services to his party as writer of the Examiner, which he quitted in July 1711, were even surpassed by those which he rendered as the author of telling pamphlets. We need not suppose that he was consulted respecting the great Tory strokes of the creation of

663 SWIFT

the twelve new peers and the dismissal of Marlborough (Dec. 1711), but they would hardly have been ventured upon if The Conduct of the Allies and the Examiners had not come first

Generous men like Oxford and Bolingbroke cannot have been unwilling to reward so serviceable a friend, especially when their own interest lay in keeping him in England. Swift still had formidable antagonists in the archbishop of York, whom he had scandalized, and the duchess of Somerset, whom he had satirized. Anne was particularly amenable to the influence of priestly and female favourites, and it must be considered a proof of the strong interest made for Swift that she was eventually persuaded to appoint him to the deanery of St Patrick's, Dublin In June 1713 he set out to take possession of his dignity, and encountered a very cold reception from the Dublin public. The dissensions between the chiefs of his party speedily recalled him to England. He found affairs in a desperate condition. The queen's demise was evidently at hand and public opinion was turning towards the Whigs when the Tories manifestly could not be trusted to maintain the Protestant succession Bolingbroke's brain teemed with the wildest plans. Swift's mediation was unavailing

When the discord of Oxford and Bolingbroke had become patent to all the nation, Swift, foreseeing, as is probable, the impending fall of the former, retired to Upper Letcombe, in Berkshire, and there spent some weeks in the strictest seclusion. This leisure was occupied in the composition of his remarkable pamphlet, Some Free Thoughts on the Present State of Affairs, which indicates his complete conversion to the bold policy of Bolingbroke The utter exclusion of Whigs as well as Dissenters from office, the remodelling of the army, the imposition of the most rigid restraints on the heir to the throne—such were the measures which, by recommending, Swift tacitly admitted to be necessary

to the triumph of his party.

Bolingbroke's daring spirit, however, recoiled from no extreme, and, fortunately for Swift, he added so much of his own to the latter's ms that the production was first delayed and then, upon the news of Anne's death, immediately suppressed This incident only just anticipated the revolution which, after Bolingbroke had enjoyed a three days' triumph over Oxford, drove him into exile and prostrated his party Almost the first acts of Bolingbroke's ephemeral premiership were to order him £1,000 from the exchequer and despatch him the most flattering invitations. The same post brought a letter from Oxford, soliciting Swift's company in his retirement, and, to the latter's immortal honour, he hesitated not an instant in preferring the solace of his friend to the offers of Bolingbroke. When, a few days later, Oxford was in prison and in danger of his life, Swift begged to share his captivity; and it was only on the offer being declined that he finally directed his steps towards Ireland, where he was very ill received. The draft on the exchequer was intercepted by the queen's death.

During these four busy years of London life, Swift had entered deeply into the literary life of the period. He was treasurer and a leading member of the Brothers, a society of wits and statesmen which recalls the days of Horace and Maecenas. He promoted the subscription for Pope's Homer, contributed some numbers to the Tatler, Spectator, and Intelligencer, and joined with Pope and Arbuthnot in establishing the Scriblerus Club, contributing to Martinus Scriblerus, his share in which can have been but small, as well as John Bull, where the chapter recommending the education of all blue-eyed children in depravity for the public good must surely be his. His miscellanies, such as A Meditation upon a Broomstick, and the poems Sill Hamet's Rod, The City Shower, The Windsor Prophecy, The Prediction of Merlin, and The History of Vanbrugh's House, belong to this period. A more laboured work, his Proposal for Correcting, Improving and Ascertaining the English Tongue (1712), in a letter to Harley, suggesting the regulation of the English language by an academy, is chiefly remarkable as a proof of the deference paid to French taste. His History of the Four Last Years of the Reign of Queen Anne is not on a level with his other political writings.

To Swift the change from London to Dublin, meant for the time the fall from unique authority to absolute insignificance. All share in the administration of even Irish affairs was denied him:

every politician shunned him, and his society hardly included a single author or wit Before and after his elevation to the deanery of St Patrick's, Esther Johnson and Mrs. Dingley continued to reside near him, and superintended his household during his absence in London. He had offered no obstacle in 1704 to a match proposed for Stella to Dr William Tisdall of Dublin, Whatever the cause, his conduct proved the fatal embitterment of his life and Stella's and yet another's. He had always been unlucky in his relations with women Esther Vanhomrigh, "Vanessa" Feb 14, 1690), the daughter of a Dublin merchant of Dutch origin, had become known to Swift at the height of his political influence He lodged close to her mother, and Vanessa insensibly became his pupil, while he became the object of her impassioned affection

But Swift was devoid of passion Of friendship, even of tender regard, he was fully capable, but not of love, and Vanessa's ardent and unreasoning display of passion was beyond his comprehension Yet Vanessa assailed him on a very weak side. The strongest of all his instincts was the thirst for imperious domina-Vanessa hugged the fetters to which Stella merely submitted. Flattered to excess by her surrender, yet conscious of his binding obligations and his real pieference for Stella, he could neither discard the one beauty nor desert the other. When Vanessa's mother died (1714), she followed him to Ireland, taking up her abode at Celbridge within ten miles of Dublin. Unable to marry Stella without destroying Vanessa, or openly to welcome Vanessa without destroying Stella, he was thus involved in the most miserable embarrassment; he continued to temporize Had the solution of marriage been open Stella would undoubtedly have been Swift's choice, but some mysterious obstacle intervened.

Meanwhile Swift's efforts were directed to soothe Miss Van-

homrigh, to whom he addressed Cadenus [Decanus] and Vanessa, the history of their attachment and the best example of his serious poetry, and for whom he sought to provide honourably in marriage, without succeeding either in his immediate aim or in thereby opening her eyes to the hopelessness of her passion Worn out with his evasions, she at last (1723) took the desperate step of writing to Stella or, according to another account, to Swift himself, demanding to know the nature of the connection with him, and this terminated the melancholy history as with a clap of thunder. Stella sent her rival's letter to Swift, and retired to a friend's house Swift rode down to Marley Abbey with a terrible countenance, petrified Vanessa by his frown, and departed without a word, finging down a packet which only contained her own letter to Stella. Vanessa died within a few weeks She left the correspondence for publication, but it was suppressed until it was published by Sir Walter Scott. Five years after Vanessa's death Stella died, on Jan. 28, 1728.

Between the death of Vanessa and the death of Stella came the greatest political and the greatest literary tnumph of Swift's life Although he was not an Irish patriot in the strict sense of the word, his pride and sense of equity alike revolted against the stay-at-home Englishmen's contemptuous treatment of their own garrison, and he delighted in finding a point in which the triumphant faction was still vulnerable. His Proposal for the Universal Use of Irish Manufactures, published anonymously in 1720, urging the Irish to disuse English goods, became the subject of a prosecution, which at length had to be dropped. A greater opportunity was at hand. A patent for supplying Ireland with a coinage of copper halfpence was accorded to William Wood on such terms that the profit accruing from the difference between the intrinsic and the nominal value of the coins, about 40%, was mainly divided between him and George I.'s favourite duchess of Kendal, by whose influence Wood had obtained the privilege Swift now had his opportunity, and the famous six letters signed M. B. Drapier (April to Dec. 1724) soon set Ireland in a flame Every effort was used to discover, or rather to obtain legal evidence against, the author, but none could be procured; the public passion swept everything before it; the patent was cancelled.

The noise of the Drapier Letters was followed by the anonymous publication of Travels Into Several Remote Nations of the World, in four parts, by Lemuel Gulliver, first a surgeon and then a captain of several ships (Benjamin Motto, Oct 1726), the work being well advanced it would seem, by 1720 The keenness of the satue on courts, parties and statesmen certainly suggests that it was planned while Swift's disappointments as a public man were still rankling and recent. Although he was afraid of the reception the book would meet with, especially in political circles, the world chose to be diverted by it. In the first two parts the misanthropy is quite overpowered by the fun. The third part, equally masterly in composition, is less felicitous in invention, and in the fourth Swift has indeed carried out his design of vex-

ing the world at his own cost Swift's grave humour and power of enforcing momentous truth by ludicrous exaggeration were next displayed in his Modest Proposal for Preventing the Children of Poor People from being a Burden to then Parents or the Country, by fattening and cating them (1729) The Directions to Servants, a satire on domestics, was first published in 1745, while Polite Conversation, written in 1731 was published in 1738 Little beyond occasional verses— trivial and often indecent—followed, but the delightful Hamilton's Bawn, and the verses on his own death (1721) are exceptions, and in The Legion Club of 1736 he composed the fiercest of all his verse satires. His popularity remained as great as ever (he received the freedom of Dublin in 1729), and he governed his cathedral with great strictness and conscientiousness, but the attacks of giddiness to which he had always been subject increased upon him, and he grew more and more capricious and morbidly suspicious In March 1742 it was necessary to appoint guardians of Swift's person and estate In September of the same year his physical malady reached a crisis, from which he emerged a helpless wreck, with faculties paralysed rather than destroyed, and he eventually sank into the dementia which preceded his death on Oct 10, 1745 He was interred in his cathedral at midnight in a coffin by the side of Stella's His epitanh was written by himself.

An object of pity as well as of awe, Swift is one of the most tragic figures of English literature. His master passion was imperious pride-lust for despotic dominion, place, profit and literary fame were comparatively indifferent to him Contemptuous of the opinion of his fellows, he hid his virtues, paraded his faults, affected some failings from which he was really exempt, and, since his munificent charity could not be concealed from the recipients, laboured to spoil it by gratuitous surliness. "To think of him," says Thackeray, "is like thinking of the ruin of a great empire." Among those influenced by Swift may be mentioned Chesterfield, Smollett, Cobbett, Hazhtt, Scott, Borrow, Newman, Relloc

Belloc.

Binizogaphy —The contemporary lives of Switt, most of which contum a certain amount of apocrypha, are those of Lord Orrey (1971), Dr. Delany's Observations on Orrey's (1974), Dena Switt's Essay upon the Life of Swift (1975), and Thomas Sherdan's Life (1976), and Thomas Sherdan's Life (1976), and Thomas Sherdan's Life in the Control of the C uabb in many respects, it exhibited the process as well as the result of biography, and never got beyond 1711. The Life by St Heinry Craik (1883 and resissues) now holds the field Valuable monographs have been produced by St Leilis Stythen (Men of Letters and the have been produced by St Leilis Stythen (Men of Letters and the Manuscritt, by W. R. Wilde, in his Cloting Feory, Diese Style (Life, by Lecty, in his Leaders of Pablic Opinion, by G. P. Mornary, J. Churton Collins (1883), Max Simon (1893), Hernrette Cordiel (1997) and Sophis Shilletto Smith (1990). The ancelotes of Swift related in Spence, Lestilia Phisington, Wilson's Swiftlana, Delany's Autobiography, Let, though often amusing, can hardly be accepted and the produced of the control of as authentic

as authentic.

The collective editions of Dr. Hawkesworth (various issues, 1755-19), T. Sheridan (1782), John Nichols (1807, 2804, 1806), Scott (1907), T. Sheridan (1782), John Nichols (1807), Scott, 1806), Scott respects supersected by the edition in Bohn's Standard Library in 14 volumes (including the two subsequently issued volumes of Porenty 1897-1910), Tarranged as follows: I. Biog Introduction by W. E. H. Leckey; Taile of a Tub; Buttle of the Books; Critical Esnay upon the Feathlist of the Mind; The Buckertaff Pomphist, etc., cd. "Pemple

Scott II Journal to Stella, ed F Ryland (two portuaits of Stella). III and IV Writings on Religion and the Church, ed Temple Scott VI Historical and Political Tracts—English, ed Temple Scott VI II the Stellar of Political Tracts—Insh, ed Temple Scott VII The Praper's Letters, ed Temple Scott VII and XI Literary Bessays, Historical and Political Treats—Irish, ed Temple Scott VIII The Desper's Leiters, ed Temple Scott VIII and XI Literary Essays, mcluding Gulfaver's Travels (ed G R Dennas), A Proposal for Correcting, Improving and Australams, the English Transpar, Haustonian and Company of the Control of the Index Twelve portraits of Swift are included in the work, in addition to two portraits of Stella and one of Vanessa XIII and XIV Poems, Ernst Browning

Translations and editions of Gulliver's Travels have been numerous "Valuable Notes for a Bibliography of Swift" were published by Dr S Lane Poole in The Bibliographer (Nov 1884) (R G, X) were published by 84) (R G , X )

SWIFT, a bird so called from the speed of its flight Despite its appearance, the swift (Apus apus) is in no way related to the swallow and is not even a Passerine bird, its affinities being with



the humming birds The common swift is a summer visitor to Europe, arriving in May and returning to Africa at the end of August It nests in holes in buildings, less frequently in cliffs and quarries On the wing it gives the idea of a bow and arrow, it is a larger bird than the swallow and its flight is swifter and steadier Except for a greyish-white patch under the chin, the plumage is entirely sooty black Near sunset the birds often sweep round in screaming bands, and sometimes then ascend out of sight. It has been stated that they may spend the night on the wing at great heights, further CHIMNEY SWIFTS (CHAETURA PE- observation on this point is need-LAGICA), SHOWN WITH NESTS AND ed, as also on the assertion that swifts actually pair in mid-air A

larger species, A. melba, with white under parts, inhabits the mountains and cliffs of southern Europe and is very numerous in the old water tower at Lucerne

The allied genus Collocalia construct nests of saliva and these are used by the Chinese for soup. The birds breed in caves, and range from north Madagascar to the Marquesas, one species occurring in the hill country of India The chimney swallow of the United States (Chaetura pelagica) is also a swift, cementing its nest with saliva. It is migratory.

SWIFT & COMPANY.—Gustavus Franklın Swift (1839-1903), founder of Swift & Company, entered business for himself at West Sandwich, his home village on Cape Cod, with \$20 borrowed capital That was in 1855 when he was 16. By 1875 he had developed an extensive live stock and meat business and had moved to Chicago to buy cattle for his eastern firm. He recognized the mefficiency of shipping live animals to the East, and foresaw and helped to bring about a revolution of methods in the live stock and meat industries of the United States and of the world Giving up his eastern business to enter meat packing at Chicago, G. F. Swift experimented immediately with refrigerator-car shipments of dressed beef to New England, succeeded, and then worked to overcome eastern prejudice against western beef. For his part in making the western dressed beef trade a year-round commercial success he is regarded as one of the true pioneers of the modern packing industry.

Incorporation of Swift & Company in 1885 with capital of \$300,000 marked the beginning of a phenomenally rapid growth. Capitalization reached the present \$150,000,000 in 1018. Sales have exceeded a billion dollars in a single year. Ownership in 1939 was distributed among 59,000 shareholders, of whom more than 8,500 were employes and 26,000 were women Employes totaled 60,000 men and women Swift & Company processes hvestock and sells meat and by-products at wholesale Butter, eggs cheese, poultry, gelatin, soap, glue, animal feeds and tertilizer are among other leading products The company operates 50 packing plants, 100 produce plants, 375 branch selling houses, and 1,000 plant sales routes, all using 6,000 refrigerator cais, 33 cotton oil mills, 20 fertilizer plants, 9 refineries, 2 soap factories and more than 100 foreign sales agencies (G F Sw)

SWIMMING, the action of self-support and self-propulsion on or in the water, though used by analogy of manimate objects. the term is generally connected with animal progression and especially with the art of self-propulsion in the water as practiced by man Natation (the synonym derived from Lit nature) is one of the most useful of the physical accomplishments of man There have been many cases in which beginners have demonstrated some ability in the art upon their first immersion in the water, but generally speaking it is an art which has to be acquired

Swimming was rated highly in the days of Greece and Rome. practised widely and stressed in the training of warriors But the art fell into almost complete disuse throughout Europe in the middle ages, when the belief became general that outdoor bathing helped to spread the scourging epidemics which so often swept the continent It was not until the second half of the 19th century that the prejudice was overcome sufficiently for aquatic activities to be resumed. Competition was resumed, first in Great Britain. then elsewhere, and the study of swimming technique led to gradual improvement in methods

As knowledge grew, there came steadily increasing appreciation of the value of swimming in protecting life, as well as in physical education, for it had gained recognition as the most beneficial of all forms of exercise. Physical educators agreed that there is no physical activity that can contribute as much as swimming to an individual's well being from the physical, the psychological, the recreational and the safety standpoint. The teaching of it was taken up by the schools, sectional and national learn-to-swim campaigns were fostered in most countries, during World War II nearly all belligerent nations conducted thorough courses in functional swimming as a part of the battle training of service men. After World War II the gains in swimming instruction and promotion made by the demands of the war were consolidated and furthered by national organizations such as the U.S. Conference for National Cooperation in Aquatics. This organization, operating informally and meeting annually, sought to further the cause of swimming specifically because of the safety value of aquatics m a national emergency, but also, because of the value of swim-ming as an "all around" exercise The US Conference for National Cooperation in Aquatics included all of the outstanding national organizations Young Men's Christian association; Young Women's Christian association: Boy Scouts of America: American Association for Health, Physical Education and Recreation; American Camping association; American National Red Cross, American Recreation society; Boys' Clubs of America; Girl Scouts of America, Amateur Athletic Union of the U.S., National Collegiate Athletic association, National Jewish Welfare board; National Safety council, United States office of education; and the armed services.

Progression in methods of swimming was marked by apparently separate and unrelated findings. The over-all picture discloses a series of sequent and connected steps in the evolution of the competition, the standard racing style was the side stroke in which both arms remain submerged throughout, while the legs execute a wide scissor kick, opening and closing in movements resembling those of walking. The first advance was made when swimmers conceived the idea of minimizing resistance by thrusting the upper arm forward above the surface, instead of underwater The new stroke was called single overarm. The double overarm followed, with both arms recovering above the surface. This stroke was made prominent in 1893 by an Englishman, J. Trudgen, who told of picking it up in South America. It took his name, misspelled Trudgeon in some countries, and served later to introduce the basic arm action of the crawl, most efficient mode of swimming de- line from hands to pointed toes. The orthodox stroke may be

veloped so far

The changes in leg drive were marked by a consistent trend toward narrower and faster movements Following the advent of the trudgen, the wide seissor kick of the side stroke, originally performed with legs bent excessively, was reduced in scope and executed with the legs a good deal straighter. Then, with the introduction of the crawl, the legs began to whip up and down alternately in a gradually quickening and diminishing thrash, speeding up by degrees from 2 to 10 proportionately smaller scissors to each cycle of the two aims

The Teaching of Swimming .- Many methods of swimming instruction were tested as changes in stroke took place, but in the long run the great majority of teachers enrolled in two predominant schools, the European, whose protagonists believe the breast stroke should be taught first, and the US whose followers assert the crawl is mastered far more readily than any other stroke. Both schools favour preliminary drills on land or in shallow water, that the beginners may gain some knowledge of the required move-

ments before attempting to swim

The greatest handicaps in learning are failure to relax and haste in performing the action Fear of the water, or the mere nervousness experienced by most nonswimmers, generally causes muscle tension and engenders the feeling that it is necessary to thrash wildly with arms and legs in order to keep afloat Every effort must be made to overcome these natural tendencies, for rapid progress is dependent upon complete relaxation and unhurried movements Instructors usually help pupils to become accustomed to immersion by having them play in shallow water, ducking the head and trying to pick up objects from the bottom, before starting schooling

During World War I and World War II, when great numbers of older troops in then late 20s and early 30s had to be taught and where time was of the essence, a method of starting the pupil on his back was developed. In this position floating was facilitated, developing confidence in the water; normal breathing was utilized in contrast to the breathing difficulty in face-down strokes, and a very simple propulsive action was taught-a frog kick with a synchronous short arm stroke, the arms being under water to prevent splash, moving from side, horizontal, downward to the thighs. This beginning stroke is a definitely advantageous one to be used with adults

The Breast Stroke.-Two styles of breast stroke have been evolved, the ancient and orthodox variety, believed to be the oldest of all strokes, and the butterfly, a racing adaptation brought out in 1935 by Henry Myeis, of the U.S. The orthodox, used for teaching beginners, is a stroke of great practical value. It affords the means to assist a tired swimmer or support a drowning person with comparatively little effort, it enables one to advance safely, head up, through waters littered with flotsam or wreckage; it is the only stroke which makes it possible for soldiers to swim under the burden of heavy packs and arms. It also has the advantage as a wartime stroke of being noiseless, as the arms and legs are under water in recovery and propulsion. The butterfly is a competitive style only.

The two styles are distinguished by differences in the action of the arms. In both the arms start their drive from full extension in front, hands close together on the surface, palms down But in the orthodox they propel by pressing down and outward at a slant which places them at an angle of about 80° on reaching the shoulder line, when the elbows are brought to sides, the hands to chest, again palms down, and the arms shot forward underwater to original position. In the butterfly the arms pull under the body all the way to the thighs, then emerge and fling forward above surface in circular motion. The leg action of both, known as the frog kick, is performed by drawing up the legs in a manner somewhat like that of squatting, knees apart, feet close and pointed. then the feet are turned outward and, with a continuous sweep, the legs are kicked vigorously back and out to an angle of about 90° and snapped sharply together. The closing movement occurs as the arms shoot forward in recovery. After the kick the body is allowed to glide motionless for a brief spell, forming a straight used comfortably head up, but greater speed is attained in both styles by raising the head to inhale during the drive of the arms and dipping the face to exhale underwater during their recovery. The butterfly is the faster by a wide margin

The butterfly was revised by the Federation Internationale de Natation Amateur (Helsinki congress, 1952) to permit a synchronous up and down action of the legs characterized by the term

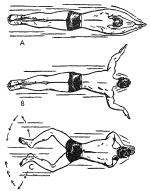


FIG. 1 — THE BREAST STROKE

A. Position at start and finish of stroke B. Drive of arms, swimmer inhaling. C Start of recovery of arms; legs ready for kick, swimmer exhaling under water. Arrows indicate continuation of leg drive.

"fishtail kick," which further increases the speed of this type of breaststroke

The Side Stroke.-The side stroke is valued chiefly for lifesaving purposes, as it is used in the most efficient carries devised for the rescue of the drowning But it is liked for openwater pleasure swimming also, because it is faster than the breast stroke and the face remains constantly above water. The body stays steadily on its side, as the name implies, and the arms propel alternately. The underarm starts from comfortable extension overhead and pulls below the body to the waist, then bends upward and pushes forward; the upper arm drives a little outside the body line, sweeping to the thigh, and recovers close to the surface. The legs open slowly for the scissor kick, the under moving backward, the upper forward, both knees bent a little, feet pointed; when at an angle of about 50° they whip smartly together, the closing movement timed with the finish of the upper arm drive. This stroke is also an excellent one for survival swimming or for emergency situations where it is imperative that the arms in all actions be kept underwater.

The Crawl Stroke—The crawl is the fastest of all known strokes, yet it requires little effort, as attested by the fact that many of the greatest feats of, endurance achieved by men and women stand to its credit, including the crossing of the English channel and the Panama canal. Its remarkable speed not only has made it supreme in the compelitive field, but extremely valuable in such emergencies as burrying to the aid of drowning people, getting away from a sinking ship and battling strong tides or currents in the effort to reach select or craw for the contract of the

There is evidence that the crawl was well known in some of the South Sea islands long before Richard Cavill of Australia introduced it about 1900 and broadcast its merits by breaking the world

recoid for roc yd with it. It is also a matter of knowledge that alloing before the introduction of the crawl stroke in Australia sportsmen in Honolulu frequently arranged swimming taces for young Hawaian swimmers at Walkiki beach in which the boused a stroke very similar to the one later demonstrated with such success by Duke Kahnamnokik.

It was soon revealed that Cavill had acquired the crawl from Alex Wickham, son of a Solomon Islands planter, then residing in Sydney, and this led the Australians to undertake inquiries. They ascertained that the stooke had been popular in the Solomons is far back as the oldest natives could remember. The strange name of crawl was comed as the result of a press account or the mittal showing of the stroke. The writer stated that Cavill appeared literally to "crawl" over the water. Somehow the word captured the pubble fancy, and the christening was the outcome

Cavill performed two kicks per full stroke, and his action was adopted universally in Australia, so the leg drive remained unchanged until the stroke made its way to the US

The earliest knowledge of the crawl obtained in the US was gleaned by hay newspaper accounts and descriptions of Cavill's strokes. In attempting to imitate the action, US swimmers unitingly developed a faster leg drive, executing four escasioning lacks per stroke instead of the two performed by Cavill. The new leg drive was combined with the double overarm action of the trudgen, and the resulting stroke was called the four-beat crawl, to distinguish if from the two best variety.

Meanwhile, experiments had led to the belief that the four-beat leg thrash was most effective when composed of one comparatively wide and three very narrow scissoring motions. This style, termed the four-beat trudger crawl or the four-beat single rhythm crawl became the accepted racing stroke. The combination of movements was responsible for so notable an improvement in average performances that technical experts conceived the possibility of obtaining still greater speed from a six-beat drive set to a double rhythm—two major and four minor kicks—which would minimize resistance and afford more even distribution of propelling power. But coaches were unanimous in declaring that the swift thrash would prove entirely too laborious for distances longer than 100 yd., and the subject was dropped temporarily.

Late in 1917, two young swimmers of the New York Women's Swimming association, Chailotte Boyle and Claire Galligan, determined to give the sax-beat crawl a trial and by the summer of 1918 they broke records with it over the longer regulation courses, 88 yd and one mile. So convincing was this demonstration that it caused a sudden change of mind among the coaches and competitors. The sax-beat crawli immediately won favour in the U.S, presently in other countries, and within a few years it had become the recognized stroke the world over, not only for racing but also

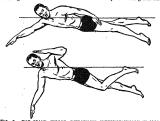


FIG. 2 -THE CRAWL STROKE, INTRODUCED INTERNATIONALLY IN 1908

for all around purposes. Another Women's Swimming association member, Ethel McGary, successfully developed in turn the eight- and ten-beat varieties of the crawl.

As the eight- and ten-beat strokes were found to require excep-

tonally lmbet legs and in time the su-beat crawl came to be accepted as the standard action. Nevertheless, a great many women and some men used the eight-beat successfully. It enabled Gertrude Edderle of the US to cross the English channel in 1; hr 34 min and break the men's record for the ourse, 16 hi 33 min. No men and very few women have made their mark with the ten-beat craw.

The extent of the progress made in the U S through the adoption and development of the crawl is best illustrated by the lowering of the U S records in regulation competitive events-the 100 vd., 220 yd., 440 yd in 25 yd pools, and 880 vd. and 1 mi over long courses (50 yd and upward) By 1953 the men's record in the 100 yd had dropped from 58 6 sec to 49 2 sec , in the 220 yd. from 2 min. 254 sec to 2 min 55 sec, in the 440 vd from 5 min 22.2 sec to 4 min 28 I sec, in the 880 yd from II min. 24 2 sec to 9 min 37 5 sec, and in the mile from 25 min. 24.4 sec. to 10 min. 40 4 sec The answer to what will be the ultimate in speed swimming, a question asked often because of the frequency of record breaking seems to be that the development of speed swimming is still in its infancy as witnessed by the rapid advances made in skill since the introduction of the crawl stroke fifty years ago The surface of development has only been scratched With increased facility in water propulsion by humans due to widespread and ever expanding instruction and facilities, it is difficult even to guess what the future holds for a skill of such recent development.

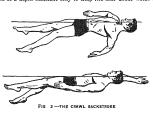
The correct position for swimming the crawl is like that assumed in standing erect on tiptoe. The arms move alternately, so timed that one will start pulling just before the other has completed its drive, thereby making the propulsion continuous Each arm catches in front of the body in line with the shoulder on the same side, almost fully extended with elbow and shoulder slightly flexed Such slight flexion affords greater strength and arm position than does full extension. The elbow on catch should be slightly higher than the hand, forearm turned slightly inward, wrist straight, hand palm down, fingers and thumb close but not cupped. The power of the arm stroke can be thought of as pressing downward and backward during the first third of the stroke, pulling the middle third and pushing through and backward but not upward during the final third of the action, completing an arc of roughly 180°. The direction of pull should be on a line from the shoulder moving slightly under the body and out past the thigh on recovery. On recovery the elbow is bent, the elbow quickly flexes and the forearm circles quickly out and around until it points toward the place of entry. Then the elbow is extended for the catch of the arm on a line with the shoulder The legs are held fairly straight but fully relaxed The legs whip up and down alternately in an undulating action so that in both the up kick and down kick there will be a backward push against the water with the lower leg and more so with the foot. The scope of the thrash must vary somewhat according to the individual length of leg, the number of beats used per stroke and the distance to be covered.

Breathing is effected by turning the head to either side during the recovery of the upper arm, for the purpose of a gasing inhalation, and then dropping the head squarely face downward, exhaling through the nose or nose and mouth. One breath is taken for every full stroke (right and left arm). The skilled swimmer learns to breathe on either side, but the regular breathing puttern is established on one side or the other.

Crawl balance is attained by working the arms independently of the shoulders so that the hody lies perfectly flat even during the action of inhalation, when the head turns without distorting the tunk position. The shoulders are level at all times; the water line of the head as the eyebrows when the face is down, and any distortion of the trunk in the shoulder or pelvic girdle should be avorded.

The Backstroke.—The style of the backstroke in vogue prior to 1912 was aptly described as an inverted breaststroke. But that year Harry Hebert, the U.S. champion, annaed spectators in the Olympic race at Stockholm with his supine crawl, never before seen in Europe, winning in record time. That exhibition son drove the old stroke (double overam on the back with a from the old stroke (double overam on the back with a from the control of th

lack) into discard, for the back crawl is a good deal faster, requires less effort and is case it to learn. In the back crawl the swimmer's position is such that the body is in a horizontal plane, head lifted slightly upward looking at the feet, with hips slightly lower than the shoulders. The arms work alternately and are intertuned as in the pione crawl or free style. Each arm stretches above the head and enties the nater six nucles to a foot outside the shoulder line, pulling and driving to the thigh with a circular outward morn at a debth sufficient only to keep the arm under water in a



plane parallel to the surface of the water. The arms in ecovery, are carried straight or with a partially flexed elbow to the cetth, either in line with the shoulder or in a semicircular motion sideward and upward. The shoulders and trunk are kept flat without any rolling The legs execute an alternate thrash as in the prone crawly. The knoses bend more but are kept under water at all times in makes for a much deeper leg kack (leg and foot) than in the prone crawl. In the back crawl, with the face out of water all of the time, the breathing presents no difficulties as it does in the breast stroke and prone crawl.

The back crawl appeared on the scene last of all of the competitive styles and has undoubtledly made the greatest strides in record breaking. For roo m the 1912 time was 1 min 18,4 sec, and has dropped to 1 min 3,5 sec; for 150 yd from 1 min 5,8 sec to 2 min 29 sec.; and for 200 m from 2 min 48,4 sec to 2 min 18,4 sec 10 2 min 18,4 se

Competitive Swimming .- Swimming joined the ranks of standardized competitive athletics in 1869, when the Amateur Swimming association was founded in England Other countries followed the lead at intervals, the U S. launching the Amateur Athletic union in 1878, and before many more years nearly all progressive nations had formed governing bodies and taken measures to promote the sport. Eventually, national championships for men and women, as well as intervarsity and interscholastic title tests, were instituted everywhere. International competition was inaugurated with the holding of the revived Olympic games at Athens in 1896. Swimming events were placed on the program and Great Britain earned high honours. Activities grew apace thereafter and frequent intercountry encounters were added to the quadrennial Olympiads, making increasingly evident the desirability of unifying rules and regulations. To this end, the Federation Internationale de Natation Amateur, composed of controlling national organizations, was formed in London in 1908. It undertook to draft a code, supervise and register world's records, and outline programs for Olympic games. As membership was made conditional to the observance of all F.I.N.A. rules, universal standards were established in time, for nearly 50 nations became affiliated. The federation chose swimming, diving and water polo as the branches of the sport over which it would assume authority. The three classes of swimming events already popular were retained free style, permitting the use of any kind of stroke; backstroke, regulated by the one provision that the entire course must be covered in supine position; and breast stroke, confined to this mode of swimming and governed by strict rules concerning the execution of the action. Free-style races have always furnished the bulk of the competition. The Olympus schedule for men consists of three induvdual free-style letsys and one free-style lety, against one backstroke and one breast-stroke event. In national championships, free-style predominance is even greate. Although long distance races are an integral part of summen activities, most of the competition takes place in pools. Enclosed and heated pools are being built in ever-increasing numbers speeding the growth of aquatic contests during the winter months

Great Britain maintained for some time the world leadership gained at Athens in 1896, but the Olympiad at Stockholm in 1912, marked by the initial appearance of women contenders saw Germany forge to the fore decisively World War I caused the 1916 games to be cancelled By 1920, at Antwerp, the US was ready to put to profit the earnest study given the crawl by the home technicians Its men and women, the latter competing for the first time in the Hellenic tests, swept to conclusive victories They again triumphed in both fields at Paris in 1924 and Amsterdam in 1928 But the meet at Los Angeles in 1932 brought a startling unset While the U.S. women successfully defended then laurels, the men went down to crushing defeat at the hands of the vastly improved Japanese, winners of all but one of the contested swims The competition was close in Berlin in 1936, with the US coming up a bit in the men's swimming, which resulted in three victones for Japan, two for the US and one for Hungary In the women's competitions, the US team suffered as outstanding a reversal as the men had in Los Angeles The powerful team from the Netherlands won four of the five races-the 100 and 400 m. free style, the backstroke and the relay losing only the breaststroke event to Japan This was the first time that Japan had taken a first place in the Olympic games in women's swimming Also, for the first time since World War I, the U.S. women's team was unable to win a first place. The Olympic games were abandoned during World War II

Great Butain conducted the London Olympic games in 1948, and the US mes' team won first place in all six events. This was the first time since the Olympic games revival in 1896 that any nation had achieved such a sweep. In women's swimming, the team from Denmark which had been sharing top-flight bonous with the Dutch team in international swimming circles after 1936, won two first places—the Ico m. free style and the buckstoke. The team from the Netherlands won the breast-stroke event; and the US team with the great Ann Curlis won the

400 m. free-style race and the relay

At the Helsinki Olympic games, 1952, the international swimming competition reached an all-time high. Seventy-one nations at that time held membership in the FINA Fifty-one were represented at Helsinki by 649 competitors, compared with 36 nations with 341 competitors at London in 1948. In men's swim-ming the U.S maintained its leading position, winning four races -the 100 and 1,500 m free style, the backstroke and the relay. France, after great advances during several Olympiads, won a magnificent victory in the 400 m free style, and Australia, the cradle of the modern racing stroke and long a leader in swimming, won the breast stroke At Helsinki, women's swimming supremacy saw another great shift, from northern Europe, the Netherlands and Denmark to central Europe. The women's team representing Hungary won four of the five races in a most outstanding and convincing manner-the 100 and 400 m free style, the breast stroke and the relay. The backstroke race was won by South Africa, the first time this team had ever won an Olympic swimming competition.

With increased facilities the world over and means of communication and transportation making possible more and more international meetings in addition to the Olympic game gatherings, it is easy to understand that excellence in performance follows no one pattern or nation, which a checking of the record books will clearly indicate.

The summary of first places in swimming in the Olympic games undicates the broad spread and scope of the sport since the first of the modern games in 1896. In men's swimming the order through 1952 was as follows: U.S. 33, Germany 8, Japan 8; Great Brialin 7; Hungary 6, Australia 5, Sweden 3; Canada 2; Argentina

1; Austria 1, France 1 In women's swimming first place results were US 16, the Netherlands 6, Hungary 4, Australia 2, Den-

mark 2, Great Bittain 2, Germany 1, Japan 1, South Africa 1 In Olympic water polo competitions, victories were as follows Great Britain 3, Hungary 3, France 1, Germany 1, Italy 1, and US 1. In the early days of Olympic competition, Great Britain, which developed and fostered so many games, was outstanding in the spott. After World War 1, Hungary had the outstanding teams

In diving, springboard and platform, the US monopolized the first places beginning in 1920. Before that time the Swedish and German divers divided the honouis, but with the introduction of aerobatics and increasing difficulty into the diving program, the US divers took and manitamed the top position in both men's and women's diving. In springboard diving (3 m.) championships, the US thingth 1952 led with 8. In plain and fancy diving from the platform, now combined with plann and fancy diving from the platform, now combined with plann and fancy diving from the platform, the score was Sweden 3, Australia T. The total of all Olymper diving contests for men was US 15, Sweden 4, Germany 3, and Australia T. The first place score in women's diving was US 15, Demmark 1, and Sweden 1.

The last of swimmers officially credited with breaking international records is a long one, but not many earned lasting fame Athletic skill and training methods in all sports improved so much in the first half of the 20th century that it is difficult to keep up with the pogress constantly being made. This is especially true in the sport of swimming, as the modern speed stroke, the crawl, is of iectent ouigin. As a result improvement in records is inevi-

table and great advances are yet to be made.

Channel Swimming—Much interest has centered in the many attempts to swim across the English channel, the first seconded attempt was made on Aug 24, 1872, by J. B Johnson, who started from Dover, but remained in the water only 65 min On Aug 12, 1875, Capit Matthew Webb made his first attempt. He started from Dover and remained in the water 6 hr 49 min, until the weather became too rough for him to continue It is estimated that he was about 13½ mi across when he had to give up

On Aug. 24 and 25, 1875, Webb swam across the English channel, diving from the Admiralty pier, Dover, and touching Calais sands, after swimming for 21 hi 45 min, at the time this accomplishment created a great sensation in England

Open Water Swimming.—The enjoyment and pleasure that is derived from bathing and swimming in salt or lake waters make it among the most popular of all sports and recreational activity the world over, but proper caution in water activities should be taken.

Swimming in unsupervised areas should be avoided. One should never swim outward from shore for any great distance without an accompanying hoat. If caught in sen grass or weeds, do not struggle against it but rather gently shake the arms and legs until the grass floats free. Riptides, undertow and tides must be noted in offshore swimming, and knowledge of safety skills in such circumstances can save lives. Riptides are truer-like masses of water caused by the contour of the bottom. They are bound on both sides by eddies that swing back toward shore. A swimmer should never attempt to fight a riptide but rather swim diagonally with it and to its edge, then swing into the eddy and be carried in toward shore.

Undertow or backwash is simply the receding portion of the water that has been carried in by the breakers Because of its movement outward from the shore, it is very disconcerting Fortunately the water travels in two directions at two levels. The upper level travels inward and the swimmer should push off the bottom and energo at the surface and go with the breakers toward shore

Tides may cause currents running diagonally toward the beach, and the best procedure is to swim across or with it until shallow water is reached.

Due to the increased activities such as sailing, boating, underwater spear fishing, water skiing and surfboarding, more people are taking to the open water as a form of recreation. A large percentage of drownings could be eliminated if caution were exercised and a thorough understanding of the individual's abilities realized before engaging in these sports Common sense should be applied in order to enjoy these activities

Floating .- One of the most useful accomplishments of a swim-

Doction

ILLUSTRATIONS FROM OFFICIAL A M M SUIN HING HANDROOK BY COURTESY OF AMA YEUR ATHLETIC UNION OF UNITED STATES

where detonations may occur, the percussion danger is minimized. facilitating survival with fewer internal injuries

The movement of the legs in an alternating walking motion and the downward pressure of the hands and torearms is the only motion required to keep the body comfortably affoat in the back floating position.

Diving .- The method of entering the water with either head foremost or feet foremost is known as diving Shortly after man learned to swim, the dive became closely related to swimming, perhaps only as a quick way of getting into the water as a refuge from wild animals or fire Diving for pleasure and exercise. as it is done today, can most easily be performed by standing on the edge of a pool or dock, holding the arms overhead, bending forward at the hips, until the balance is lost The entry into the water will be smooth and without ill effect

Diving, plain and fancy, which is today a part of all aquatic contests, developed rapidly through the first half of the 20th century. Many gymnastic and tumbling stunts can be performed before the entry is made into the water and the thrill of this combination HINTER ANDBOOK OF COURTER OF MANTEUR ATMLETIC UNION OF UNITED STATES has been a challenge to young Fig. 5.-BACKWARD HEADER DIVE people to achieve perfection in

this stimulating sport. Diving became a part of the swimming program of the Olympic gumes as early as 1904. The program at that time was plain high at the edge of a platform and rotates backward } a turn to 21/2

mer is that of floating It is a matter of buoyancy which has a varying degree in individuals Buoyancy cannot be taught, but body balance in the water can be accoured through knowledge In learning to float, the heginner experiences difficulty in keeping the legs in the horizontal plane, and this can be remedied by the counterbalance of extending the arms beyond the head, whether in face down or back floating

Floating motionless is an ait which floaters can perform with proper breath control and body balance Bending the knees to shorten the axis will very often permit better balance in the water Supine or back floating with a minimum of motion of the arms and legs has become one of the most valuable of personal safety skills for the swimmer, as well as for the novice. Wartime research by naval authorities con-Fig. 4 -- FORWARD HEADER DIVE cluded that this type of floating

NING conserves energy, and in areas nent in the diver's repertoire, and a forward 14 somersault is often

> German athletes, the US divers dominated international competition Perhaps this supremacy can be credited to two great coaches

on the American scene, Ernst Brandsten, an outstanding Swedish diver in the 1912 games, and Fred Cady, a sports-minded art-

Brandsten's contribution was his thoroughness in teaching fundamentals and his success in standardizing equipment. Fred Cady, through his artistic sensitiveness to grace and poise, was a great influence This combination of ideas and tuitions produced U.S diving champions in all of the Olympic games beginning in 1920.

The competitive dives are divided into five groups which encompass springboard dives and fixed platform dives, with the addition of armstand dives which are done from fixed platforms The first includes the forward dives (fig 4) in which case the person will dive out away from the platform and rotate 1 a turn to 3½ turns before entering the

ILLUSTRATIONS FROM OFFICIAL A A U SWIN MINS HANDSDOK BY COURTESY OF AMA TEUR ATMLETIC UNION OF UNITED STATES water. The second group comprises backward dives (fig. 5) In this instance the diver stands

FIG 6 -- HALF GAINER DIVE (RUN-

diving and variety high diving, with contestants performing from both the 5 m and 10 m firm platforms The contest was composed of compulsory dives and voluntary dives Springboard diving, plain and variety, was performed from a board of elastic character at heights of 1 m and 3 m above the water. It was necessary to have judges to mark the dives performed, with at-

tention paid to the take off, the bearing of body in the air and the entrance into the water

The Olympic committee composed a table which listed the type of dives allowed, their description and a value for each dive based on the difficulty of performance. These early tables comprised a mere 14 dives from the high firm platform and 20 from the springboard, as compared with the 42 and 50 of to-

To inducate the advances made in diving, it can best be described by comparing the dives of yesteryear with today's complex stunts The report following the 4th Olympiad suggested elimination of the double somersault because it was believed that the divers could not control the execution of such numerous spins without chance of murv Today, divers Chance of injury Today, divers time authorized to courtey of Martens from most sections of the world Atherications of united to the confidently compared the confidently confidently compared the confidently compared the confidently compared the confidently confidently confidently compared the confidently compared the confidently are confidently somersaulting

24 times backward and forward from both firm and springboard elevations The combination of spins and twists are quite promi-

combined with a double twist, being performed with great skill and Beginning with the Olympic games of 1920, which excluded

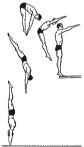


FIG 7 -BACK JACK-KNIFE DIVE

somersaults. The third group (fig. 6), the forward motion and reverse spin dows is commonly called the gainer group. In this form of diving the diver can rotate in reverse from  $\frac{1}{2}$  a turn to  $\frac{1}{2}$  turns. The fourth group is that of cutaway dives (fig. 7). In this category, the diver studies on the outer edge of the platform and jumps backward with a forward rotation from  $\frac{1}{2}$  a turn to  $\frac{1}{2}$  somersaults. The fifth and last classification is that of twarting (fig. 8). In this movement the diver rotates the body on the long axis, from  $\frac{1}{2}$  a twist to  $\frac{1}{2}$  twists, while evolving on the short x axis from  $\frac{1}{2}$  turns to  $\frac{1}{2}$  somersaults. With the possibilities of combining all groups with twisting, it, can easily be seen why the last grouping offers more dives than any other from which the diver

can choose his optional dives The majority of dives which are included in the present roster may be executed in three distinct positions, namely, straight, pike or tuck. In the first position (straight), the body must be held extended, and no flexion at the hips or knees shall be allowed. In the second position (pike), there may be a bend at the hips, with no knee flexion. In the third position (tuck), both the knees and hips are flexed and the position of the body resembles a ball. In all positions the feet must be pointed.

The surfaces of diving boards, whether firm or flexible, must be covered with cocoa matting or some other nonskid material the full length of the run. Spring-boards may be made of wood, aluminum, steel or other resilient material. Standard equipment for springboards is the adjustable fulerum. Such a fulcrum enables the diver to adjust the flexibility of the control of the control of the control of the control of the control of the control of the country of the control of the control of the control of the control of the control of the control of the country of the control of the contro

the diver to adjust the flexhility but (Rubning) of the board to his liking.

Surface diving is the act of descending below the surface of the water while swimning. It is most easily executed by forcing the head and upper body downward by a quick bend at the hips, followed by aligning the less with the descending torso. It is a most

useful technique in lifesaving work.

With very httle effort the swimmer may descend to 10 ft. The
return to the surface can be made by lifting the head backward,
eyes upward and the swimming with the breaststroke movement
of the arms and legs.

Bulloomarux—The literature on the subject of swimming is considerable; the most useful work of general reference is Ralph Thomas' (1704), which contains a bibliography from the earliest time. Other chief works on this technique of swimming that may be mentioned are: chief works on this technique of swimming that may be mentioned are: made of the swimming that the swimming the swimming that the swimming the swimming that the swimming the swimming that the swimming that the swimming that the swimming the swimming that the swimming the swimming that the swimming that the swimming the swimming that the swimming the swimming the swimming that the swimming the swimming that the swimming the swimming that the swimming the swimming the swimming that the swimming the swimming the swimming the swimming the swimming the s

SWINBURNE, ALGERNON CHARLES (1837-1909), English poet and critic, was born in London on April 5, 1837. He was the son of Admiral Charles Henry Swinburne (of an old Northumbrian family) and of Lady Jane Henrietta, a daughter



HILUSTRATIONS FROM OFFICIAL A A U SWIM
HIME HAMBBOOK BY COURTESY OF ANA
TICUE ATHLETIC UNION OF UNITED STATES
FIG. 8.—HALF-TWIST, FORWARD
DIVE (RUNNING)

of George, 3rd earl of Ashburnham It may almost be said to have been by accident that Swinburne owned London for his birthplace, since he was removed from it immediately, and always felt a cordial dislike for the surroundings and influences of life in the heart of a great city His own childhood was spent in a very different environment. His grandfather, Sir John Edward Swinburne, bart , owned an estate in Northumberland, and his father. the admiral, bought a beautiful spot between Ventnor and Niton in the Isle of Wight, called East Dene, together with a strip of undercliff known as the Landslip. The two homes were in a sense amalgamated Sir Edward used to spend half the year in the Isle of Wight, and the admiral's family shared his northern home for the other half, so that the poet's earliest recollections took the form of strangely contrasted emotions, inspired on the one hand by the bleak north, and on the other by the luxuriant and tepid south. Of the two, the influences of the island are, perhaps naturally, the stronger in his poetry, and many of his most beautiful pieces were actually written at the Orchard, an exquisite spot by Niton bay, which belonged to relatives of the poet, and at which he was a constant visitor.

After some years of private tuition, Swinburne was sent to Eton, where he remained for five years, proceeding to Balhol college, Oxford, in 1857. He was three years at the university, but eit without staking a degree. Clearly he must have cultivated while there his passionate and altogether unacademic love for the interature of Greece; but his undergraduate career was unattended by university successes, beyond the Taylorian prize for French and Italian, which he gamed in 1858. He contributed to the "Underground Papers," published during his first year, under the editorship of John Nichol, and he wrote a good deal of poetry from time to time, but his name was probably regarded without much favour by the college authorities. He took a second class in classical moderations in 1858, but his name does not occur in any of the "final" honour schools. Jowet was his firm friend after he left Oxford, and Swinburne visited him repeatedly at the seaside and in the country.

He left Oxford in 1860, and in the same year published the two dramas, The Queen Mother and Rosamond, a wonderful performance for so young a poet, fuller of dramatic energy than most of his later plays, and rich in harmonies of blank verse

After spending some time with the Bell Scotts at Newcastle, Swinburne came to London, and began the intimate friendship with D G. Rossetti which was to last for the next ten years. In 1861 he was introduced to Monckton Milnes (Lord Houghton, q.v.), who took an interest in his work and invited him to Fryston. There Swinburne created an unforgettable impression in the brilliant circle which gathered there, by his wide and varied acquaintance with ancient and modern literature and his astonishing memory In 1862 he met Meredith, and a review of one of Victor Hugo's books resulted in correspondence. In the autumn of that year he lived with Meredith and the Rossettis at 16 Cheyne Walk Swinburne showed symptoms of something approaching epilepsy, and it was thought better that he should be with friends. In 1864 he made a tour in France and Italy. At Florence he met Mrs. Gaskell and Walter Landor. For Landor he had a great admiration, but their meetings were few and short. On his return to London he took lodgings in Dorset street, where he made his home for many years.

In 1865, appeared the lyrical tragedy of Atalants in Calydon, followed by Chacsteard, and the famous Poems and Ballads in 1866. The Poems and Ballads were vehemently attacked, but Dolores and Resultsine were on everyone's lips: as a poet of the time has said, "We all went about chanting to one another these new, astonishing melodies" By the close of his 30th year, in spite of hostility and detraction, Swinburne had placed himself in the highest rank of contemporary poets, and had even established himself as leader of a choir of singers to whom he was at once master and prophet.

Meanwhile, his life was disturbed by domestic sorrow. A favourite sister died at East Dene, and was buried in the church-yard of Bonchurch. Her loss overwhelmed Admiral Swinburne with grief, and he could no longer tolerate the house that was so

full of tender memories. So the family moved to Holmwood, in house, The Pines, Putney, where the last 30 years of his life were the Thames Valley, near Reading Swinburne entered on a course of gasety in London which seriously aftected his health and alarmed his friends At the same time he saw much of the Pie-Ranhaelite movement, and for the next few years he was involved in a rush of fresh emotions and rapidly changing loyalties

Works .- It is indeed necessary to any appreciation of Swinburne's genius that one should understand that his inspiration was almost invariably derivative. His first book is deliberately Shakespearian in design and expression, the Atalanta, of course, is equally deliberate in its pursuit of the Hellenic spirit. Then, with a wider swing of the pendulum, he recedes, in Poems and Ballads, to the example of Baudelaire and of the Pre-Raphaelites themselves, with the Song of Italy (1867) he is drawing towards the revolt of Mazzini (whom he had met at the house of George Howard, afterwards earl of Carlisle); by the time Songs before Sunrise are completed (in 1871) he is altogether under the influence of Victor Hugo, while Rome has become to him "first name of the world's names" But, if Swinburne's inspiration was derivative, his manner was in no sense imitative; he brought to poetry a spirit entirely his own, and a method even more individual than his spirit. It is well to distinguish clearly between the influences which touched him and the original, personal fashion in which he assumed those influences, and made them his own The spirit of Swinburne's muse was always a spirit of revolution In Poems and Ballads the revolt is against moral conventions and restraints, in Songs before Sunrise the arena of the contest is no longer only the sensual sphere, but the political and the ecclesiastical The detestation of kings and priests, which marked so much of the work of his maturity, is now in full swing, and Swinburne's language is sometimes tinged with extravagance and an almost virulent animosity

With Bothwell (1874) he returned to drama and the story of Mary Stuart The play has fine scenes and is burning with poetry, but its length transcends all possibilities of harmonious unity, Erechtheus (1876) was a return to the Greek inspiration of Atalanta; and then in the second series of Poems and Ballads (1878) the French influence is seen to be at work, and Victor Hugo begins to hold alone the place possessed, at different times. by Baudelaire and Mazzini. At this time Swinburne's energy was at fever height; in 1879 he published his eloquent Study of Shakespeare and Poems and Ballads (second series) and in 1880 no fewer than three volumes, The Modern Heptalogia, a brilliant anonymous essay in parody, Songs of the Springtides, and Studies in Song It was shortly after this date that Swinburne's friendship for Theodore Watts-Dunton (then Theodore Watts) grew into one of brotherly intimacy After 1880 Swinburne's life remained without disturbing event, devoted entirely to the pursuit of literature in peace and leisure.

The conclusion of the Elizabethan trilogy, Mary Stuart, was published in 1881, and in the following year Tristram of Lyonesse, a wonderfully individual contribution to the modern treatment of the Arthurian legend, in which the heroic couplet is made to assume opulent, romantic cadences of which it had hitherto seemed incapable. Among the publications of the next few years must be mentioned A Century of Roundells, 1883; A Midsummer Holiday, 1884; and Miscellanies, 1886. The current of his poetry, indeed, continued unchecked; and though it would be vain to pretend that he added greatly either to the range of his subjects or to the fecundity of his versification, it is at least true that his melody was unbroken, and his resplendent torrent of words inexhaustible. His Marino Faliero (1885) and Locrine (1887) have passages of power and intensity unsurpassed in any of his earlier work, and the rich metrical effects of Astrophel (1894) and The Tale of Balin (1896) are inferior in music and range to none but his own masterpieces. In 1899 appeared his Rosamund, Queen of the Lombards; in 1903 his Duke of Gandia; and in 1904 was begun the publication of a collected edition of his poems and dramas in 11 volumes.

Later Years .- Meanwhile, in the autumn of 1879 the state of his health seriously alarmed his friends, and, with the consent of housing and local government to accept overspill population and Lady Jane Swinburne, Watts-Dunton took him to live at his industry from the Greater London area. Planning approval was

spent in complete retirement. He very rarely made the short journey into London, although his health was gradually restored The friends visited Paris in 1882 In 1888 a flash of his old excitability involved him in a quarrel with Whistler.

Besides this wealth of poetry, Swinburne was active as a critic, and several volumes of fine impassioned prose testify to the variety and fluctuation of his literary allegiances His Note on Charlotte Bronte (1877) must be read by every student of its subject, the Study of Shakespeare (1880)-followed in 1909 by The Age of Shakespeare-is full of vigorous and arresting thought, and many of his stattered essays are rich in suggestion and appreciation His studies of Elizabethan literature are, indeed, full of "the noble tribute of praise," and no contemporary critic did so much to revive an interest in that wonderful period of dramatic recrudescence, the side-issues of which have been generally somewhat obscured by the pervading and dominating genius of Shakespeare His prose work also includes an early novel in the form of letters. Love's Cross-currents, which had appeared serially in the Tatler and was revised for publication in 1005

Place in Literature.-The service which Swinburne rendered

to the English language as a vehicle for lyrical effect is simply incalculable. He revolutionized the entire scheme of English prosody Nor was his singular vogue due only to this extraordinary metrical ingenuity The effect of his artistic personality was in itself intoxicating, even delirious. He was the poet of youth insurgent against all the restraints of conventionality and custom The young lover of poetry, when first he encounters Swinburne's influence, is almost bound to be swept away by it; the wild, extravagant license, the apparent sincerity, the vigour and the verve, cry directly to the apparent sincerity, the vigour and the verve, ness. But, while this is mevitable, it is also true that the critical lover of poetry outgrows an unquestioning allegiance to the Swinburnian mood more quickly than any other of the diverse emotions aroused by the study of the great poets. It is impossible to acquit his poetry entirely of the charge of an animalism which wars against the higher issues of the spirit—an animalism sometimes of love, sometimes of hatred, but, in both extremes, out of centre and harmony.

Yet, when everything has been said that can be said against the unaesthetic violences of the poet's excesses, his service to contemporary poetry outweighed all disadvantages No one did more to free English literature from the shackles of formalism; no one, among his contemporaries, pursued the poetic calling with so sincere and resplendent an allegiance to the claims of absolute and unadulterated poetry Some English poets have turned preachers; others have been seduced by the attractions of philosophy; but Swinburne always remained an artist absorbed in a lyrical ecstasy. a singer and not a seer. His personality was among the most potent of his time, and his artistic influence was both inspiring and beneficent He died at Putney on April 10, 1909

and heneficent He died at Putney on April 1c, 1909
See R. H. Shephench, The Bibliography of Sumburne (1889); Theodore Wratnihaw, Algernon Choicie, Jamburne, a Shaby (1900). G. E.,
Blog, 2nd supp., 1903-11, Edward Thomas, Algernon Charles Swinburne, a Critical Study (1912); John Drinkwatter, Swinburne, an
Estimate (1923), Clars I, Watta-Dunton, The Rome Life of SwinBritante (1923), Clars I, Watta-Dunton, The Rome Life of SwinPaul Dottin, Swinburne et Les dieux (1925); J. W. Mackall, Studies
of English Poets (1926), H. Nicolson, Swinburne (English Mont Letters Series, 1926); G. Laiouvrade, Le Jeunesse de Swinburne,
1874-97 (1928); S. C. Chew, Swinburne (1929), (E. G. 3, 1874-1874).

SWINDON, a municipal borough and parliamentary division of north Wiltshire, England, 78 mi, W. of London by road. Pop. (1951) 68,932. Area 9.9 sq.mi. Until 1841 it was a small market town (now Old Swindon) with a population of less than 2,000, but after the Great Western railway had built its main engineering works to the north the population rapidly increased to 45,000, and in 1900 it received its charter. More than 21,000 people are employed in the railway works and other industries include engineering, clothing and tobacco. Under the Town Development act. 1952, provisional approval was obtained from the ministry of

given to expand the population to 92,000 within the existing borough boundaries and a 75-ac trading estate has been developed close to the Swindon-Gloucester railway In 1947 the first mu-nicipally owned arts centre in the country was opened, combining a small concert hall, a stage and an art gallery

SWINE, a name applied to the domestic pig, but also used to

include its wild relatives. The animals constitute the family Suidae (see Artionactyla). The swine are found only in the old world. They are characterized by elongated head and mobile snout, with an expanded, truncate, terminal surface in which the nostrils open, narrow feet with four toes, the outer pair not reaching the ground when walking canines in both jaws curve upward, forming large tusks, best developed in boars The hair is coarse and bristly, while the THE DENTITION OF THE skin is thick, underlaid by thick fat The BOAR 12 INCISORS, 4 tail is moderately long, generally tufted. The typical genus Sus is exemplified by



CANINES 16 PREMOLARS AND 12 MOLARS TOTAL 44

the domesticated pigs (see Pig) and the wild boar (See Boar ) Allied to these are the pygmy hog of Nepal (Porcula salvama), a little larger than a hare, and the African river hogs (q v) (Potamochoerus)

Linking these genera with the wart-hogs is the African Hylochoerus, a forest-dwelling form with a thick coat of coarse black

han. The remaining forms are the wart-hogs (q v.) (Phacochoerus, and the babirusa (q v) Extinct swine, some of gigantic size, are know from strata as far back as the Phocene of Europe and Asia, many of these belonged to the genus Sus SWINE FEVER (hog chol-



era) is a devastating acute general

infection of swine, caused by a filterable virus, in which high fever and prostration are outstanding symptoms. The disease has a wide distribution throughout Europe, North America and Africa It is not uncommon in the British Isles Canada controls the disease by slaughter of all hogs on infected premises, the cleansing and disinfection of premises, and the serum treatment of all hogs in the vicinity of an outbreak. In the United States the average annual loss from hog cholera from 1885 to 1952, including vaccination costs after 1914, was esti-

mated to be \$20,000,000-\$30,000,000. By mid-20th century it was still the cause of 90% of the deaths in swine, although an estimated 40% to 45% of all hogs raised were vaccinated

Natural infection results from immediate or mediate contagion The disease may be acquired by healthy herds by the introduction of infected pigs. Exposure of swine in markets in infected areas is a fertile source of infection, so are vehicles and trucks in which pigs are conveyed from place to place, dealers, castrators who journey from farm to farm, and attendants may serve as agencies whereby contagion is conveyed.

Outbreaks are likely to recur in premises where the disease has existed previously, as the virus appears to retain its vitality for fairly long periods outside the animal body. Within a space of time which rarely extends to three weeks after exposure to infection, and may not be more than four days, the disease is ushered in by fever, the subsequent symptoms varying somewhat with the form the disease assumes. The animal has no appetite, is depressed, ill and separates itself from its companions; the conjunctivae are reddened and congested and may secrete a mucopurulent discharge; vomiting is common, and constipation and diarrhoea are both met with; sometimes the faeces become dysenteric and the odour is peculiar and disagreeable.

In many cases a skin rash develops, the parts principally involved being the region of the ears, the axilla, groin and the skin covering the abdominal area. The mucous membrane lining the mouth, fauces and pharvnx may become inflamed: later ulcers form and become covered with a diphtheritic exudation. As a re-

sult the animal is unable to feed and respiration is difficult. The lungs may be the seat of pneumonic changes and the animal has then a short, dry and paroxysmal cough, a nasal discharge, difficulty in respiration, and the other symptoms characteristic of acute lung infection Gastritis and enteritis are common. The animal lies about and if compelled to move does so reluctantly and sometimes with a staggering gait and an arched back, later it is unable to use and becomes comatose

As in other acute septicaemic diseases, a hyperacute form may develop and death supervenes within a few days, or a less acute form may set in where one or more groups of organs become involved A chronic type is also encountered, life drags on over a considerable period and the animal becomes more debilitated and emaciated and remains a possible source of infection to other pigs Recovery occurs in some cases, the virulence and the mortality varying widely in different outbreaks

The great toll that hog cholera exacted in the United States stimulated efforts to develop vaccines The first active vaccination method used, dating from 1907, was the simultaneous method, using active virus simultaneously with hyperimmune serum By the 1950s, about 90% of all hog vaccinations in the United States were by the simultaneous method. The remaining were vaccinated with nonvirulent types, such as blood-origin vaccine attenuated by crystal violet, tissue-origin vaccine attenuated with crystal violet, virus modified by passage through rabbits and tissue culture modified virus The later types of vaccines offered hope that virulent virus might be discontinued as a commercial product, with the additional hope that eradication of hog cholera might eventually (A R S . NA BR)

SWINGING, a radio term denoting variation in intensity of a received radio signal resulting from changes in the frequency of the transmitted waves

SWINOUJSCIE (Ger. SWINEMUNDE), a fishing port and seaside resort in the province of Szczechin, Poland, at the east end of the island of Usedom, and on the Swine river which connects the Stettiner Haff with the Baltic Swinemunde, which was founded in 1748, was fortified and raised to the dignity of a town by Frederick the Great in 1765 It was an important German naval base during World War II About 70% of the city was destroyed during the war Its population declined from 30,056 in 1939 to 5,771 in 1946 It was transferred to Poland in 1945

SWINTON, 181 VISCOUNT, see CUNLIFFE-LISTER, PHILIP SWINTON, SIR ERNEST DUNLOP (1868-1951), British soldier, was born Oct 21, 1868, and commissioned in the royal engineers in 1888. In the South African War he was first adjutant and later commander of the 1st railway pioneer regiment. In 1904 he produced The Defence of Duffer's Drift, a tactical study which became an unofficial textbook in the British and Indian army and an official one in the US army In 1900, when an instructor at Woolwich, he wrote, under the pseudonym of Ole-Luk-Oie. The Green Curve, a book of short stories of great literary power and mulitary imagination Appointed secretary of the historical section. Committee of Imperial Defence, in 1910, he compiled the history of the Russo-Japanese War In 1914 he went to France as the official military correspondent ("Eyewitness"). His proposals in Oct 1914 became the first link in the evolution of the tank (see TANKS). In 1915 he became assistant secretary to the war committee of the cabinet Created K B E. in 1923, he was Chichele professor of military history at Oxford from 1925 to 1939 From 1034 to 1038 he was colonel commandant of the tank corps. Major General Swinton died at Oxford, Jan. 15, 1951.

SWINTON, an urban district in the West Riding of Yorkshire.

England, 104 mi N E. of Sheffield by road, at the junction of the Don navigation with the Dearne and Dove navigation Pop. (1951) 11,922. Area 2 7 sq mi. Formerly renowned for its Rockingham ware, it has coal mines, iron foundries, steel and glass

SWINTON AND PENDLEBURY, a municipal borough of Lancashire, England, 5 mi. NW of Manchester, contiguous with Salford. Pop. (1951) 41,294. Area 5.2 sq mi A great part of the Clifton rural area was added in 1933 Cotton spinning and weaving, coal mining, the manufacture of electric batteries, and

1038 Anciently parts of Swinton were held by the Knights of the Order of the Hospital of St John of Jerusalem Swinton and Pendlebury, incorporated in 1934, forms with Eccles the Eccles parliamentary division of Lancashire, leturning one member

SWISS LITERATURE. From the point of view of lanmage and literature the various nationalities of the Swiss confederation project into those of the neighbouring countries-Germany (Austria), France and Italy This unusual aspect becomes narticularly significant in relation to literary production before the existence or outside the boundaries of the Ewiger Bund (the Everlasting league) of 1201 Literatures produced exclusively in Switzerland are those written in the Raeto-Romance language or in one of the numerous varieties of local Swiss dialects Latin literature, of course, chronologically precedes all the others. In the following survey all these literatures are considered both on their own account and as parts of a Swiss literature in an over-all

Latin Swiss Literature.-The oldest document relating to what is now Switzerland was not produced within its territory, for the first notable description of Helvetia and the Helvetians is to be found in the first book of Caesar's Commentain, commonly referred to as Bellum Helvetscum After the humanists rediscovered this text, it gradually rose in the historical consciousness of the Swiss to the rank and dignity of a Great Charter Among the Latin chronicles of the middle ages the Casus Sancts Galls, written by Ekkehart IV in the 11th century, gives an impressive description of the highly developed culture of the abbey of St Gall, founded by Irish Benedictines Another chronicle, the Johannis Vitodurani Chronicon, contains the world picture as seen by a Franciscan of Winterthur in the first part of the 14th century The Swiss humanists who expressed themselves in Latin devoted most of their prose and verse to a description of their own country, eg, Albrecht von Bonstetten, dean of the abbey of Einsiedeln, in his Superioris Germanie Confoederationis descriptio (1479) and Heinrich Loriti Glareanus in his Helvetiae descriptio (1514). An important position in the history of general linguistics is taken up by the Zurich polyhistorian Konrad Gesner, who in his Mithridates (1555) undertook a survey of all languages known to him For three centuries to come the two volumes entitled De Republica Helvettorum (1576) by the Zurich clergyman Josias Simler remained the standard work in the constitutional law and politics of the older Swiss confederation

The final phase in Latin Swiss literature belongs to the Age of Reason and is largely connected with natural science An outstanding example of it is the description of Switzerland given by the city physician of Zurich, J J Scheuchzer, and entitled Uresiphoites helveticus sive itineia alpina tria (1708). It was printed in London as a publication of the Royal society with the imprimatur of Isaac Newton

German Swiss Literature,-In bulk, the most important literature of Switzerland is written in the German language. It first flourished in the age of the Minnesingers, of whom more than 30, se. practically one-fifth of the total number, lived on what is now Swiss territory The identity of the Codex Manesse with the famous manuscript of that name in Heidelberg has traditionally been accepted The Codex Manesse is an example of how specimens of prenational literature may be incorporated in a national literature in the 18th century J J. Bodmer was the first to have the Codex printed, and in the 19th century Gottfried Keller made it the subject of one of his Zuricher Novellen. In this way the poetry of the Minnesingers became part of the history of Swiss letters

The first literary productions with national characteristics were popular ballads and popular chronicles The popular ballads commemorate especially the great battles fought by the Swiss from the 14th to the 16th century and later on The most effective and influential of these is the ballad of William Tell, which through its moral and political aspects maintained an important position as a narrative and a play from the late 15th century onward The popular chronicles, occasionally written on behalf of some local authority and often illustrated, flourished especially in Berne, Lu-

engineering are the chief industries. The town hall was opened in cerne and Zunich. The most famous chronicle, however, was written by Giles (Aegidius) Tschudi, a leading magistrate of The contents of his Chroncon Helveticum was widely known after its completion in the 16th century, although it was only printed in the years 1732 and 1734 at Basel In it Johann von Schiller found the material for his drama Wilhelm Tell and Walter Scott the text for his translation of the ballad "The Battle of Sempach "

The reformation activities of Zwingli had only an indirect influence on literature Zwingli himself wrote mainly in Latin. The so-called Zurich Bible was soon replaced by the Luther Bible, which actually made for a closer connection between the writings produced in Switzerland and in Germany. One of the most important results of the work done by Zwingli was that the Protestant majority of German-speaking Switzerland established a permanent connection with the Protestant parts of western Switzerland and with Protestant countries abroad. Thus one of the earliest Swiss accounts of England was produced by the Zurich clergyman and lexicographer Josua Maler (c 1550), and in the 18th century the first German translations of Shakespeare were published in Zanich

The beginning of 18th-century literature in German-speaking Switzerland is marked by the works of a Bernese poet and the end by those of a historian from Schaffhausen. The poetry of Albrecht von Haller, especially Die Alben (1728), helped to bring about a new awareness in poetic experience in Germany and belongs to the earliest specimens of German poetry appreciated in France Iohannes von Muller's Geschichten schweizerischer Eidgenossenschaft (1786-1808), though a fragment, became the most representative piece of historical writing in German classicism and had a far-reaching influence on the style of historical writing in general Between these two cornerstones appears what is occasionally referred to as the Zurich school of criticism. Two members of the "Carolinum," J J Bodmer and J. J Breitinger opposing the critical views of French rationalism and classicism, strongly promoted the reception and appreciation of English literature from John Milton to Thomas Percy in Germany In this connection a revival of religious and national conceptions was prepared which had its special effect in the succeeding generations Salomon Gessner had a European success with his revival of the idyll, for predominantly moral reasons I K. Lavater turned to physiognomy and became one of its innovators, J C Hirzel surprised the reading public with the description of the village Socrates Kleinjogg In importance, however, they were surpassed by Johann Heinrich Pestalozzi, who not only wrote the first village story in German, entitled Lienhard und Gertrud (1781), but included in it the nucleus of his later meditations, covering the entire field of the nature and destiny of man It is indicative of the profound impression his ideas made on his contemporaries that his private institute of education at Yverdon was visited by philanthropists from all over Europe including, for instance, Robert Owen.

In the 19th century international fame and critical estimate at home did not always concur Thus The Swiss Family Robinson (1812-27) by Johann David Wyss, and Heids (1881) by Johanna Spyri are examples of a world-wide success though their purely literary merits were never considered very high at home From the first to the second half of the 19th century the significance of German Swiss literature gradually increased Berne produced its greatest novelist in the person of Jeremias Gotthelf (pseudonym for Albrecht Bitzius), whose epic power was combined with a profound knowledge of human nature. The series of his great novels, most of which describe village hie, opened with the Bauernspiegel oder Lebensgeschichte des Jeremias Gotthelf (1837) and ended in the year of his death (1854) with Erlebnisse eines Schuldenbauers. Fiction and poetry are the fields in which the Zurich writers Gottfried Keller and Conrad Ferdinand Meyer achieved fame. Both realized their own possibilities and destinies comparatively late, a phenomenon frequently observed in the history of Swiss thought. Gottfried Keller reached the first peak of his creative powers with Der grune Heinrich in 1854 when he was 35 and Meyer with his verse epic Huttens letzte Tage in 1871 when he was 46. Meyer drew moon the mountains and the princely courts of the past, and as a writer of fiction he succeeded in giving the Renaissance cult original expression. Keller in some of his best stories devoted himself to subjects corresponding to those of Cervantes and Shakespeare and brought the art of the Novelle to perfection The love he had for his country appears in all shades from hymns of praise to pungent social criticism. His understanding of the human soul is seen at its height in the description of odd characters of both sexes and of unforgettably charming young women. His prose is both homely and delicate and is matched by the quality of his fundamentally human attitude. Many of his admirers believe that his work is the one real contribution of Switzerland to would literature. The importance of this period is emphasized by the writings of the Basel historian Jakob Burckhardt, whose statements about the past, the present and even the future have since become increasingly impressive and valid. His greatest disciple was Heinrich Wolfflin, who continued and completed that work of his master which was interrelated with the history of fine arts The last poet of international repute was Carl Spitteler who was distinguished for epics in verse and prose

French Swiss Literature .- Though the French-speaking part of the Swiss population is only one-fifth of the total, the literature it has produced carries considerably more than the proportionate weight This is due partly to the immigration of a number of highly talented Huguenot families, partly, though to a lesser degree, to the fact that occasionally writers born in the Germanspeaking part of the country would decide to express themselves in the French idiom. This applies especially to the Bernese. The beginnings of French Swiss literature proper coincide with the Reformation. Jean Cauvin from northern France fashioned Geneva into the "csté de Calvin." From Geneva he exercised his influence on French literature through his diction and on the Anglo-Saxon world through his theology In this connection it is significant that one of the first important interpreters of England in France was the Bernese B. L. von Muralt, whose stay in England in 1694 resulted in his Lettres sur les Anglas et les Français (1725) His work was admired by J J. Rousseau, the father of continental romanticism. The formative influences at work on the Genevese philosopher have usually been connected with the comparatively narrow strip of country between the Alps and the Jura He was, however, not only a "citoyen d'un état libre," as he described himself in the opening chapter of the Contrat social, but obviously shared the political and psychological conceptions of all Switzerland to such a degree that one is tempted to consider him its most brilliant publicity agent (see, for example, his Considérations sur le gouvernement de Pologne) Obviously Swiss subject material was dealt with by H. B. de Saussure, one of the founders of modern geology, in his Voyages dans les Alpes (1779-96).

At the beginning of the 70th century, however, French Swiss literature om the whole preferred international themes and was largely connected with the militential circle of Mme. de Stall, who was born in Paris but was of German and Swiss extraction. Of her books setting forth the qualities of the various nations of Europe the one cnitited De I-Allemagne had the wides influence. Her friend Benjamin Constant, though less prolific, expressed himself all the more pointedly, his adaptation of Schiller's trilogy Wellenstein contains the memorable cessay Sur le théâtre allemand. Another member of the circle of Mme. de Stale, who in her manor house on the Lake of Geneva entertained a great many of the total contains the memorable cessay Sur le théâtre allemand. Another member of the circle of Mme. de Stale, who in her manor house on the Lake of Geneva entertained a great many of the Worker Mental and the Contained of Western Europe, was J. C. J. S. de Samondi. Who made an Law of western Europe, was J. C. J. S. de Samondi. Histories des républiques tablemand to Italian history with his Histories des républiques tablemand to Italian history with his Histories des républiques tablemand to Italian history with his Curpon and Cisaq.) Buropean in outlook, especially in his book L'homme dis midt et Phompe dis

To a later development belong the humorous tales and sketches of Rodolphe Toepfier, depicting a more homely world (Labibliothèque de mon onde, 1823), while the poems of Juste Oliver testify to a pronounced partiotism (Polmes sussess, 1830). The criticism of Alexandre Vinet, based on an essentially personal interpretation of Christianity, found an echo both in Switzerland and in France. Toward the end of the 19th century a powerful interpretation of Christianity, found and the Stance.

ternational influence was exercised by the posthumous publication of the fragments of H F Amel's Journal intime (1833), that caused Tolstoy to write a moving preface for 1st Russian translation. In his historical withings Philippe Monnier, in a manier reminiscent of Jakob Burckhardt, deals with Italy in the 15th and 13th centures (Le Quattrockin, 1901; Funsa aut 8 sidelo, 1907). C F Ramux wrote strongly imagnative novels about life amongst unerowers and Alonie herdsmen (Oscuws combibles, 1904).

Gonzague de Reynold, with a consistency hardly known before him, demonstrated the inward connection between German and French-speaking Switzerland in the 18th century and depicted the whole of his country in his Cités et pays surses

Italian Swiss Literature .- Only about 4% of the total population of Switzerland use Italian as their native language home is in the Ticino country and in some of the southern Grisons valleys It is thus unlikely that the literature of such a small group could exist without a strong and permanent relation to Italian literature proper Since the 18th century there have been a few nationally distinct features in what is now often referred to as the Swiss Italianità The themes of these minor writings devoted to poetry and fiction, natural science and history, economics and politics are fairly characteristic. As an exponent of the Age of Reason. Father Francesco Soave of Lugano translated John Locke and Salomon Gessner into Italian and, following the example of the latter. wrote his own Novelle Morah (1782), which since then have appeared in hundreds of editions and have also made the story of William Tell popular in Italy. A representative figure in the first half of the 19th century is Stefano Franscini, who in theory and practice helped to bring about the new unity of the Ticino country and to connect it with the spirit of the Swiss confederation. His main work. La Svizzera Italiana (1837-38), bears as a motto a quotation from Albrecht von Haller; "Alpibus quidem ad Italiam spectantibus ego plurimum boni spero" (The Alps looking toward Italy are my greatest hope). His Nuova statistica della Svizzera (1847) proved to be a particularly effective description of Switzerland in that neriod

So far, undensably the most outstanding poet and novelist of the Trino country has been Francesco Chiesa A convounced regionalist he combines a profound love of his country with an admiration for the great Lombard poets and thus creates the high treary standards necessary for the Italian-speaking part of Switzerland. His vast influence on his contemporaries has essentially contributed towards keeping the Italianità of his region intact (Calilope, 1907, I valid d'oro, 1911, Tempo di marzo, 1925) One of his disciples equally bent on exploring and interpreting his home country was Giuseppe Zoppi (Leggende ticenesi, 1928, and Presento d'un Trimo, 1933).

Raeto-Romance Literature,-The Raeto-Romance language was formerly spoken far beyond the boundaries of Switzerland, todav it is only used in a few Grisons valleys A treatise, published by the Grisons historian and philologist Joseph von Planta in the Philosophical Transactions of the Royal Society of 1776, made the existence of the language known to a wider public. Only recently, however, was it officially recognized. On Feb. 20, 1938, following a plebiscite of the whole country, Raeto-Romance, though represented by only 1% of the total population, was declared one of the four national languages of the Swiss confederation. Raeto-Romance literature was in its origins predominantly ecclesiastical and began in the middle ages. The Reformation gave it new impulses. There is a rich variety of popular songs, especially of the political kind. Owing to its geographical distribution Racto-Romance literature is essentially regional in character. Nevertheless the anthologist Caspar Decurtins and the poet Peider Lansel achieved decidedly more than mere local fame in the 20th century

Swiss Dialect Literature.—The fortunes of Swiss shiest hierature vary according to the language situation in each respective section of the country. In the Ticino country dalect literature is being produced with much devotion, but so far seems to have been of little consequence. In the French-speaking part of the country the local dialects are on the wane and, consequently, so are dialect writings. The maportant instances of this sort of literature belong to past centuries such as the different Genevee ballade. tional fame was achieved by the various Rang des vaches, melodies sung or played on the horn by herdsmen and in one case taken down by Rousseau in his Dictionnaire de musique (1768)

At present dialect literature flourishes mainly in the Germanspeaking part of the country, chiefly because there the population. regardless of social rank and education, consistently sticks to the use of the dialect for everyday purposes The existence of numerous local idioms might even produce an ever increasing variety of dialect writings This, however, would be at cross purposes with the accepted determination of the writers and their reading public to remain on common ground with German literature as a whole, which explains why some of the best poets express themselves both in high German and in their dialect. Thus Adolf Frey published a volume of poems in the dialect of the Aargau (Duss und underm Rafe, 1891 and 1921) and Meinrad Lienert one in the dialect of Schwyz ('s Henvili, 1908) There are vigorous novels in the Bernese dialect by Rudolf von Tavel, who began in 1007 with Ja gall, so gest's, and by Simon Gfeller, who depicted life among the peasants of the Emmenthal beginning with Heimisback (1011)

Patrimonium Helveticum .-- Without detriment to their connections with European civilization many Swiss consider the existence of a sixfold national literature with deep satisfaction. They are perfectly aware of the perplexing problems it inevitably involves and even look upon them as an asset Between the extremes of absolute diversity and absolute unity there is room for all aspects and expressions of thought and imagination. This is what the Swiss spirit of freedom fundamentally wills A representative cultural centre-such as Florence once was for Italy and Paris still is for France-is inconceivable for Switzerland Each group and even each individual expresses itself according to its character and region. Such a state of affairs may have its greatness, but it certainly also has its drawbacks and its dangers, which can only be overcome on the level of a vigorous national consciousness So far this consciousness has proved adequate for the solution of the problems involved. A deteriorating structural change could only occur if the minorities were estranged from the confederate whole or if the majority forces were tempted to exploit their position regardless of tradition. Although there is at present a trend for a slight shift in the numerical relationship of the different languages one cannot seriously speak of a peril to the wellestablished balance of the different cultures. On the contrary the fact that the underlying ideals are very much alive may produce further highlights of national integration A development of over 1.000 years is at the basis of the literary life of Switzerland and will continue to shape what might be called an ever-growing patrimonum Helveticum (F. E., H Sn.)

Contemporary Writers .- Swiss contemporary authors have found themselves inescapably confronted with two world wars, totalitarian revolutions, the triumphs of technical civilization and a growing disintegration of the great traditional values.

A considerable minority stick to the old values still current in the village and the small town, praising the good gifts of the earth (Hemrich Federer, 1866-1928; and Alfred Huggenberger), Others furnish antidotes to the conventional order of things and are alert to the stimuli of international modern thought After 1914 Albert Steffen, Jakob Schaffner (1875-1944), Robert Faesi and others opened broader and deeper vistas of the individual and of nations Marxist views are expressed by Hans Mühlestein and Jakob Buhrer On the other hand the complicated, highly strung modern individual preoccupies novelists like Monique Saint-Hélier and Kurt Guggenheim. A wave of irrationalism has set free new forces in Swiss poetry. In some writers, a refined sense of form (Siegfried Lang) and the bold use of intuitive imagery (Albin Zollinger, 1895-1941, Werner Zemp, Silja Walter) are reminders of the nearness of C. G. Jung, the Swiss explorer of the unconscious. Religious thought in this epoch has been greatly influenced by the theology of Karl Barth and Emil Brunner. A promising, provocative playwright is Friedrich Dürrenmatt,

With a few exceptions (e.g., the Zürich dramatist Max Frisch and the young Swiss Italian Felice Filippini) existentialism has had

commemorating the victory of the Escalade in 1602 Interna- little chance with Swiss writers so far, but many of the best believe that the truth lies in a sort of holism, an interpenetration both of the forces of the native soil and the world at large, eg, the novelists Gustav Keckeis and Cecile Ines Loos and the poet Urs Martin Strub, whereas the novelist Meinrad Inglin and the playwright Caesar von Arx (1895-1949) stress the native element A similar sense of many-sided relationships is an essential feature of the histone and literary essays of Gonzague de Reynold, Carl J. Burckhardt. Fritz Ernst and Max Rychner, representatives of a truly (A Bx) European Switzerland

European Switzelland
Bistiocastrii — R Feest, Anthologis Helvetica (Leipug, 1921) is
a collection in the six languages mentioned Anthologises bised on
each of the four national languages are E. Korrod, Gesteverbe der
Schweiz, and ed (Erlenbach-Zurich, 1943). C Clerc, Le ghein da hee
(Reuchâdel, 1939), Serition della Swizzeri adianda, 3 vol (Bellmonna,
1916), C Descurtins, Ratoromunische Christomathie, 11 vol (Edangen, 1896-1910).

eneral histories G de Reynold, Histoire litteraire de la Suisse au 18 stècle (Lausanne, 1909), E Jenny and V Rossel, Geschichte de schweizerichen Literatur, 2 vol (Bern, 1910), C Clerc et al, Littératures de la Suive (Paris, 1938) German Swiss literature: J Baechteratures de la Surve (Paras, 1918). German Swuss-literature: J Basch-104d, Grebuchte der deutschen Literatur und er Schueze (Praunfield, 1892). J. Miller, Literatur greichte der 1892 im 1892 im 1892 Schwerz (Munch, 1913). O von und Gretzethen der deutschen Schwerz (Munch, 1913). O von und Gretzet, Die Munderlackslung der deutschen Schwerz (Swiss German dahect Interature) (Leipzis, 1924). Prench Swess literature V. Rossel, Heistein Hirtharze de 1892

druitchen Schweit (Swiss Artinuos our Fritone Attherner de la Swisse Pennich Swiss Miterature Rose voi (Generowa 1858, 1851). Godet, Historie Miterative de la Swisse Proqueste, and ed (Paris, 1804). Godet, Historie Miterative de la Swisse Proqueste, and ed (Paris, 1804). Godet Historie Miterative de la Swisse Proqueste, and ed (Paris, 1904). Harvard, Historie de la Intérature proqueste, a voi 4, 31 de de (Paris, 1904). Malana Swisse Interature G. 200pp, interdebetton to Societion della

Racto-Romance literature Historisch-biographisches Lexikon der

Macto-Romance Interature Historical-mographisches Lexino der Schweiz, vol III, pp. 708 ff. (Neuenburg, 130-6).
Contemporary tiends A Bettes, Die Enteratur der deutsches Schweiz von heute (Olten, 130). See also F Baldensperger and W. P. Friederich, Bibliography of Componitive Literature (Chapel Hill, 150): H. Welsmann, Die wielsprachner Schweiz, (Basil, 1325); F. Ernst, Helvetia Mediatrix (Zurich, 1010) and European Switzerland

Historically Considered (Zurich, 1951)

SWISSVALE, a borough of Allegheny county, Pennsylvania,
U.S., 6 mi S.E. of Pittsburgh, on the Pennsylvania railroad The population in 1950 was 16,488, in 1940 it was 15 919, and in 16 020 It is a manufacturing centre

SWITHUN (or SWITHIN), ST. (d. 862), bishop of Winchester and patron saint of Winchester cathedral from the 10th to the 16th century. He is scarcely mentioned in any document of his own time. His death is entered in the Anglo-Saxon Chronicle under the year 861; and his signature is appended to several charters in Kemble's Codex diplomaticus. Of these charters three belong to 833, 838, 860-862. In the first the saint signs as "Swithunus presbyter regis Egberti," in the second as "Swithunus diaconus," and in the third as "Swithunus episcopus," Hence if the second charter be genuine the first must be spurious, and is so marked in Kemble More than 100 years later, when Dunstan and Ethelwold of Winchester were inaugurating their church reform. St Swithun was adopted as patron of the restored church at Winchester, formerly dedicated to St. Peter and St. Paul. His body was transferred from its almost forgotten grave to Ethelwold's new basilica on July 15, 971, and according to contemporary writers, miracles accompanied the translation.

The revival of St. Swithun's fame gave rise to a mass of legendary literature. The so-called Vitae Swithuni of Lantfred and Wulstan, written about AD 1000, hardly contain any germ of biographical fact; and the earliest detailed authority is a biography ascribed to Gotzelin (# 1058-78) From this writer, who has perhaps preserved some fragments of genuine tradition, it is learned that St. Swithun was appointed bishop of Winchester under Aethelwulf. At his request Aethelwulf gave the tenth of his royal lands to the church. He died on July 2, 862, saying that he was not to be buried within the church but outside in "a vile and unworthy place,"

William of Malmesbury adds that, as Bishop Alhstan of Sherborne was Aethelwulf's minister for temporal, so St. Swithun was for spiritual matters. The same chronicler uses a remarkable phrase in recording the bishop's prayer that his burial might be "ubi et pedibus praetereuntium et stillicidis ex alto rorantibus the well-known weather myth contained in the doggrel lines-

St Swithin's day if thou dost rain For forty days it will remain, St Swithin's day if thou be fair For forty days 'twill rain na mair-

had already, in the 12th century, crystallized around the name of St Swithun, but it is doubtful if the passage lends itself by any straining to this interpretation

straining to this interpretation

The so-called fives of S. Svatiend of the roth centry may be found in the Roth centry may be found in the Roth centry may be found in the Roth centry may be found in the Roth centry may be found in the Roth centre of the Roth of which refer to St Swithun in the body of the text, may be studied in Haddon and Stubbs's Councils, ii, 636-645

SWITZERLAND (Ger Schweiz; Fr Suisse, It Svizzera; Lat Helvetia) is a confederation or Esdgenossenschaft of 22 cantons (3 of which have half-cantons) with a republican and federal constitution It is situated in central Europe and bounded north by Germany, east by Austria and the principality of Liechtenstein (included since 1924 in the Swiss customs and monetary union), southeast and south by Italy, and southwest, west and northwest by France.

#### PHYSICAL GEOGRAPHY

Switzerland extends between 45° 49' and 47° 48' 30" N lat, and from 5° 58' to 10° 30' E long It forms an oval-shaped mass of which the greatest length (west-southwest to east-northeast) 18 226 mi, and the greatest breadth (north to south) 18 137 mi It has little or no physical unity, consisting as it does of numerous small districts, differing widely in language, religion, ethnology and customs, bound together in a political alliance, made originally for common defense

The nation consists of three great river valleys (Rhône, Rhine and Aar), lying to the north of the main chain of the Alps and including within their Swiss basins all the region between the Alps and the Jura In addition, the wedge-shaped canton of Ticino runs south from the St Gotthard massif and drains to the Po, while in the extreme east a tongue of the Grisons canton drains northeast via the Engadine, into the Danube The Rhône and Rhine valleys are shut off from that of the Aar by the great northern ridge of the Bernese Oberland and Todi Alps The Aar valley is wide and undulating, but the upper Rhine and Rhône have cut deep trenches in the structural depression which separates the great parallel chains. The main chain of the Alps provides the loftiest wholly-Swiss summit (15,200 ft.) in the crowning Dufourspitze of Monte Rosa, though the Dom (14,942 ft ) in the Mischabel range, immediately north of Monte Rosa, is the highest entirely Swiss mountain mass. The highest summit in the northern parallel ridge is the Finsteraarhorn (14,026 ft ) in the Bernese Oberland, while the lowest level within the confederation is on the Lago Maggiore (646 ft.)

The geological build of the Alps has been proved to be exceedingly complex; the contorted, folded, and even overfolded recent rocks have been fractured, exposing old crystalline cores to denudation; the Jura are much less complicated in their folding and in their exposures. Much of the central hummocky plain is covered with undisturbed very recent rocks of Oligocene and Miocene age, many of which are marine deposits formed at a period when an arm of the Mediterranean spread up the present Rhône course along the outer border of the Alps as far east as Austria. These deposits are concealed in many parts of the plain by the most recent glacial and alluvial accumulations.

The present confederation drains into the North sea, Mediterranean sea (direct), Adriatic sea and Black sea which, respectively, receive the Rhine, Rhône, Ticino-Po and Inn-Danube. The Swiss portions of their basins are approximately, in the order named: 11,160; 2,760; 1,360; and 660 sq.mi,

Many of its rivers, with their Alpine origin, tend to seasonal

esset obnoxius," This expression has been taken as indicating that overflows which have necessitated artificial embankment. The most important contiol scheme was that of Conrad Escher of Zurich (lates Conrad von der Linth) who in 1807-27 turned the turbulent Linth into Walensee, from which it emerges as a canal-1zed stream An earlier (1714) successful work was the diversion of the troublesome Kander into the Lake of Thun, where it is now placedly building an extensive fertile delta

The lakes of Switzerland are very numerous, the largest, Geneva (southwest) and Constance (northeast) are on the frontiers and are not wholly Swiss Neuchâtel (83 sq mi ) is the largest wholly Swiss lake. About 16 sq mi at the north end of Lago Maggiore (82 sq m1) belongs to Switzerland, next in order of size are Lucerne, Zurich, about half of the Swiss-Italian Lake of Lugano (19 sq mi.), Thun, Brienz, Morat, the Wallen and Sempach (55 sq m1), no others exceed 4 sq mi Eleven of these lakes are in the Aar basin, two (Maggiore and Lugano) are in the Po basin, and Geneva is the great Rhône filter. The lakes of the Swiss portion of the Inn basin are small; the largest are Sils (1 5 sq mi ), and the still smaller, slightly lower and adjacent Silvaplana Many small mountain lakes are of interest, such as the dreary Daubensee (7,264 ft alt) near to the Gemmi pass, the extremely beautiful Oeschinensee (5,223 ft alt) mirroring the snowy Blumlis Alp, and the remarkable, though sometimes empty Marielensee (7,766 ft alt) on which float miniature icebergs from the Great Aletsch glacier

Of the countless waterfalls in Switzerland those of the Rhine (near Schaffhausen), 100 ft high, inclusive of rapids, and 340 ft. wide, are the grandest, but the most beautiful are of less volume and greater height, such as those of the Lauterbrunnen valley and particularly the Staubbach, a mere veil of water hanging in front of a precipice 980 ft high

Switzerland contains many more glaciers than the combined total for adjacent lands, the number is estimated at more than 1.000, but no exact computations are possible on account of numerous detached ice masses which may or may not rank as glaciers Practically all of them are now in retreat, though they will long continue to feed all the important rivers and streams of Switzerland They probably occupy 700 sq mi, very unequally distributed; 11 of the cantons possess no glaciers The greatest area is found in the Valais (more than half of the total area), followed by the Grisons and Berne (about one-sixth each), then by Uri, Glarus and Ticino (the last about 13 sq mi), the remaining cantons-Unterwalden, Vaud, St. Gallen, Schwyz and Appenzell have, in aggregate, a glacier area little superior to that of Ticino alone. The longest glacier in the main Alpine chain is the Gorner (9.25 mi ), but it is exceeded by the Great Aletsch (16 5 mi ) and by the Fiescher and the Unteraar (10 mi. each) which run down from the high eastern mountains of the Bernese Oberland

Climate.-In an area such as Switzerland which extends through less than two degrees of latitude, climate will be influenced more particularly by differences of altitude, aspect and gradient, these show wide and surprisingly sudden variations, e.g., Monte Rosa (15,217 ft. high) is only 30 mi. distant in a "straight" line from Lago Maggiore, with waters in the same latitude, but only 646 ft. in altitude Great heights are characterized by (1) low barometer readings; Monte Rosa summit records about half sealevel pressure; hence the possibility of "mountain sickness", (2) usually more brilliant sunshine and dry air, particularly in winter, producing sunburning and ice-dazzle, which in some subjects amounts to snow blindness, (3) much lower temperatures, among the Alps the average fall in temperature is about 1.2° F on the south side and about 0.0° F, on the north side for each 330 ft of ascent. The height of the Alpine crest and its main direction also profoundly influence the winds. In addition to local winds of certain higher levels which show a daily change of direction, downhill in the morning and uphill in the evening, there are other characteristic winds which are much less localized in their effects, as the southerly föhn, warm, dry and oppressive, which affects considerable areas in east Switzerland, particularly during spring and autumn; and the northerly bise, a cold wind experienced especially in Geneva. Switzerland's many climates are important, not only in Europe's playground generally, but also in the "nests of

sanatoria." Hence, climate and weather statistics have been carefully compiled for many stations

January is the coldest month, the following averages in degrees F being recorded. Basle (909 ft alt ) 31 8, Altdorf (1,480 ft alt ) 32 4, Davos (5,121 ft alt) 18 7, St Gotthard (6,877 ft alt) 18 1, Santis (8,202 ft alt) 16 2, while an unusually low average is from Bevers (5,610 ft alt) with 14 2. Precipitation (either rain or melted snow) shows wide variations, eg, Basle has 32 5 in total annual precipitation, Altdorf, 49 o in , Davos, 35 7 in and Santis, 95 7 in At several stations much of this falls as snow On Santis the precipitation is as snow from November to April inclusive, and only July and August have more rain than snow Snow accumulates to a depth of 20 to 25 ft at Bevers and upward of 45 ft on Santis July is the hottest month, the average July records in degrees F being Basle 66 4, Altdorf 64 4, Davos 53 8, St Gotthard 46 2, Santis 41 o, Bevers 53 2 The range of 39 00 at Bevers tends to be extreme, Santis, though cold, is much more equable, 24 8°. The snow line, showing considerable local variations, is about 9,000 ft, high on the western Alps, and about 10,500 ft in the drier eastern mountains

Vegetation.—Though Swiss vegetation is mainly central

European in character, in some of the warm sheltered valleys Mediterranean types are found The true alpine flora (plants growing above the tree limit) is akin to that of the Pyrenees rather than to either of the other elements (see ALPS). Mediterranean species, found locally in the wide valley between the Jura and the Alps, in the Rhône valley in Valais, and on the southern slopes of the mountains running down to the Italian lakes, include vines. walnut trees, camelias, magnolias and palms. The lowlands and foothills are largely cultivated, and wherever possible land is farmed in the mountains. The natural climax vegetation of the mountain region, up to about 4,000 ft on the northern slones and 5,000 ft, or more on the southern, consists of deciduous trees such as oak, beech, ash and sycamore, but mixed forests of timber trees such as spruce, silver fir, larch and birch have been planted to a great extent in their place. The subalpine region covers the next 1,000 ft or so where the pure conferous forest (spruce, silver fir, larch and Scotch pine) are found These merge into the scrub of the alpine region which contains dwarf pines and willows, juniper, bilberry, creeping azalea, mezereon, white dryas, rhododendrons, etc. This is also the region of the alpine pastures Above about 6,500 ft. (where the summer lasts only five or six weeks) the flora is typically alpine, and cushion plants, mosses and lichens flourish among the bare rocks, screes and glaciers Finally, between 8,000 ft and 9,500 ft. comes the region of perpetual snow

The alpine meadows are transformed into brilliant gardens in May June and July Among the first to blossom are crocuses, anemones, Gentiana verna, Princula farinosa and pheasant's eye nacrosus, while on the higher sloopes the celelwess is in bloom. In June come St. Bruno's lity, orchids, campanulas, larkspurs and many others, followed by the martagon lity, oxeye dasay, etc. The alpine roses, Rhododendron ferrugnessim and R hiratistim (only found on limestone), clothe the sides of the Alps and Junt together with Saponaria oxymandss, Helanthensum alpistire, Gentiana muchis, the alpine lily and many more, As soon as the meadows have been cut for hay the autumn crocus (Colchicum autusnale) appears

Fauna.—In Switzenland the animals are protected and there is only a very short ahooting season. Many of them, for example the chamois that lives high up in the mountains and the marmot that is found near the snow line, are abline animals. Among the inhabitants of the forests are squirreds and foxes and woodpeckers, jusy, tits and many other birds. Hares and faled mice are common in the meadows. In the lakes and rivers there are trout and other fish, and salmon are found in the Aart, the Rhane and Lake Zürich. Among regitlist the viper is common Insects are numerous; butterflies and moths abound in the meadows when the flowers are in bloom and ants are pleintful in the woods.

See E. de Martonne, "La Suisse" in part I of Europe centrale, vol. iv of Géographie universelle, ed. by P. Vidai de la Blache and L. Gallois (Paris, 1931). (W. A. B. C.; X.)

#### HISTORY

For indications of the prehistory and ancient history of what is now Switzerland see Alamanni, Burgundy, Celt, Geneva, Helleviti, La Tener, Raria, Savoy, House or; Vinglicki, etc The following pages treat of the history of the Swiss confederation from its origin to the present day

The Swiss confederation forms a nation the patriotism of whose members is universally acknowledged, but Swiss history is very intricate and very local. A firm hold on a few guiding principles is therefore most desirable, and of these there are three which must always be borne in mind (1) The first is the connection of Swiss history with that of the empire. Swiss history is largely the history of the drawing together of bits of each of the imperial kingdoms (Germany, Italy and Burgundy) for common defense against the Habsburgs, and when this dynasty had secured to itself the permanent possession of the empire, the Swiss league little by little won its independence of the empire, practically in 1499, formally in 1648. (2) The second is the German origin and nature of the confederation Around a German nucleus (the three Forest districts or, as they are now called, cantons) there gradually gathered other German districts, and it was not until 1803 and 1815 that its French- and Italian-speaking cantons were raised to political equality with the German confederates (3) The third is that Swiss history is a study in federalism. Based on the defensive alliances of 1201 and 1315 between the three Forest cantons, the confederation was enlarged by the admission of other districts and towns, all leagued with the original three members, but not necessarily with each other. Hence great difficulties are encountered in looking after common interests; the diet was merely an assembly of ambassadors with powers very strictly limited by their instructions, and there was no central executive authority The whole constitutional history of the confederation is summed up in its transition to a federal state, which, while a single state in its foreign relations, in home matters maintains the more or less absolute independence of its members

The League of 195.—On Aug. 1, 1357, the men of the valley of Urt, the free community of the valley of Schwy, and the association of the men of the lower valley or Nidwalden—Obwalden or the upper valley is not mentioned in the text, though its name was afterward added to the attached seal of Nidwalden—formed the Everlasting league for the purpose of self-defense against all who should attack or trouble them, a league which was expressly stated to be a confirmation of a former one. This league was the foundation of the Swis confederation.

The legal and political conditions of each district were very different (1) In 853 Louis the German granted all his lands in the pagellus Uromae to the convent of SS. Felix and Regula in Zurich (the present Fraumunster) and exempted them from all jurisdiction save that of the king (Reschsfreshest), so that though locally within the Zurichgau they were not subject to its count, the king's deputy. The abbey thus became possessed of the greater part of the valley of the Reuss between the present Devil's Bridge and the Lake of Lucerne, for the upper valley (Urseren) belonged at that time to the abbey of Disentis in the Rhine valley and did not become permanently allied with Un until 1410. The privileged position of the abbey tenants gradually led the other men of the valley to "commend" themselves to the abbey. The important post of protector (advocabus or vogt) of the abbey was given to one family after another by the emperor, in 1218 the office was granted to the Habsburgs, but in 1231 the German king Henry VII bought it back in order to control the St. Gotthard pass, the valley thenceforward depending immediately on the king (2) In Schwyz (first mentioned in 972) it is necessary to distinguish between the districts west and east of Steinen. In the former the land was in, the hands of many nobles, among whom were the Habsburgs; in the latter there was, at the foot of the Mythen, a self-governing community of free men, both, however, were politically subject to the king's delegates, the counts of the Zünchgau, who after 1173 were the ever-advancing Habsburgs, But in 1240 the free community of Schwyz obtained from the emperor Frederick II a charter which removed them from the jurisdiction of the counts, placing them in immediate dependence

on the king, like the abbey men of Ur. In a few years, however, the Habbungs contrived to dispense with this charter in praetice. (3) In Unterwalden things were very different. The upper valley (Obwalden or Sarnen), like the lower (Nidwalden or Starse), tormed part of the Zurichgau, while in both the soil was owned by many lay and ecclesiastical lords, among them being the Habsungs and the Alsatian abbey or Murbach Hence in this district there were privileged tenants, but no free community and no entert of unity, this explains why Obwalden and Nidwalden won their way upward so nuch more slowly than their neighbours in Urn and Schwy

The Habsburgs had risen steadily from the position of an unimportant family in the Aargau to that of powerful landed proprietors in Swabia and Alsace and had attained political importance as counts of the Zurichgau and Aargau. In one or both qualities the cadet or Laufenburg line, to which the family estates in the Forest cantons around the Lake of Lucerne had fallen on the division of the inheritance in 1232, seems to have exercised its legal rights in a harsh manner In 1340 the free men of Schwyz obtained protection from the emperor. It was natural that when, after the excommunication and deposition of Frederick II by Innocent IV in 1245, the head of the cadet line of Habsburg sided with the pope, some of the men of the Forest cantons should rally around the emperor. Schwyz joined Sarnen and Lucerne (though Un and Obwalden supported the pope); and in 1247 the men of Schwyz, Sarnen and Lucerne were threatened by the pope with excommunication if they persisted in upholding the emperor and defying their hereditary lords the counts of Habsburg The rapid decline of Frederick's cause soon enabled the Habsburgs to regain their authority in these districts. These incidents are the only foundation in fact of the legendary stories of Habsburg oppression told of and by a later age. After this temporary check the power of the Habsburgs continued to increase rapidly. In 1273 the head of the cadet line sold all his lands and rights in the Forest cantons to the head of the elder or Alsatian line, Rudolph, who a few months later was elected German king. He recognized the privileges of Uri but not those of Schwyz; and as he united in his person the characters of German king, count of the Zurichgau and landowner in the Forest cantons, the union of offices might be expected to result in a confusion of rights. On April 16, 1201, Rudolph bought from the abbey of Murbach in Alsace (of which he was advocate) all its rights over the town of Lucerne and the abbey estates in Unterwalden. It thus seemed probable that the other Forest cantons would be shut off from their natural means of communication with the outer world by way of the lake. Rudolph's death, on July 15 of the same year, cleared the way, and a fortnight later (Aug 1) the Everlasting league was made between the men of Uri, Schwyz and Nidwalden for the purpose of self-defense against a common foe.

Morgarten and the League of 1315,-In the struggle for the empire, which extended over the years following the conclusion of the league of 1291, the confederates supported without exception the anti-Habsburg candidate. On Oct. 16, 1201. Ura and Schwyz alhed themselves with Zurich and joined the general rising in Swabia against Albert, the new head of the house of Habsburg. It soon failed, but hopes revived when in 1292 Adolph of Nassau was chosen German king. In 1297 he confirmed to the free men of Schwyz their charter of 1240 and, strangely enough, confirmed the same charter to Uri, instead of their own of 1231. It is in his reign that the first recorded meeting of the Landesgemende (or legislative assembly) of Schwyz (1294) occurred. But in 1298 Albert of Habsburg himself was elected German king, His rule was strict and severe, though not oppressive. He did not indeed confirm the charters of Uri or of Schwyz, but he did not attack the ancient rights of the former, and in the latter he exercised his rights as a landowner and did not abuse his political rights as king or as count. In Unterwalden the two valleys were joined together (1304) under a common administrator (the local deputy of the count)—a great step forward to permanent union. The stories of Albert's tyranny in the Forest cantons are not heard of until two centuries later. His successor, Henry of Luxemburg, confirmed, on June 3, 1300, to Uri and Schwyz their charters of 1393 and, for some unknown reason, confirmed to Unterwalden all the liberties granted by his predecessor, though as a matter of fact none had been granted. This charter and the nommanton of one royal bailift to administer the three distructs had the effect of plaung them all in an identical political position, and that the most privileged yet given to any of them—the freedom of the free community of Schwy 20 Jipure 13, 1311, Henry granted the request of Leopold I of Habsburg, who had accompanied him on his expedition to Rome, that Baron Eberhart of Burglen and Count Frederick of Toggenburg should inquire into, the precise rights of the Habsburgs in Alsace and in the Foest cantons with a view to restoring them. But no steps were taken to draw conclusions from this investigation.

On Henry's death in 1313 the men of Schwyz seized the opportunity for making a wanton attack on the great abbey of Einsiedeln, with which they had a long-standing quarrel as to rights of pasture The abbot caused them to be excommunicated, and Leopold's brother Frederick of Habsburg (chosen king, as Frederick III, by a minority of the electors), who was the hereditary advocate of the abbey, placed them under the ban of the empire His rival. Louis of Bayaria, to whom they appealed, removed the ban, whereupon Frederick issued a decree by which he restored to his family all their rights and possessions in the three valleys and Urseren and charged Leopold with the execution of this order The confederates hastily made arrangements with Glarus, Urseren, Arth and Interlaken to protect themselves from attack on every side. Leopold collected a brilliant army at the Austrian town of Zug in order to attack Schwyz, while a body of troops was to take Unterwalden in the rear by way of the Brunig pass. On Nov 15, 1315, Leopold moved forward along the shore of the Lake of Aegers, intending to assail the town of Schwyz by climbing the slopes of Morgarten above the southeastern end of the lake There they were awaited by the valiant band of the confederates, who utterly defeated them. Leopold fled in haste to Winterthur, and the attack by the Brunig was driven back by the men of Unterwalden On Dec q, 1315, representatives of the victorious highlanders met at Brunnen, on the Lake of Lucerne and renewed the Everlasting league of 1291. In their main lines the two documents are very similar, the later being chiefly an expansion of the earlier. That of 1315 is in German (in contrast with that of 1201. which is in Latin) and has one or two striking clauses largely indebted to a decree issued by Zurich on July 24, 1201. None of the three districts or their dependents was to recognize a new lord without the consent and counsel of the rest. Strict obedience in all lawful matters was to be rendered to the rightful lord in each case, unless he attacked or wronged any of the confederates, in which case they were to be free from all obligations No negotiations, so long as the "Lander" had no lord, were to be entered on with outside powers, save by common agreement of all. Louis solemnly recognized and confirmed the new league in 1316, and in 1318 a truce was concluded between the confederates and the Habsburgs. The lands and rights annexed belonging to the Habsburgs in the Forest cantons were fully recognized as they existed in the days of Henry of Luxemburg, and freedom of commerce was granted. But there was not one word about the political rights of the Habsburgs as counts of the Zurichgau and Aargau

The League of Eight Members—The name Switzerland (Swaez; derroyd from Schwyz, which had always been the leader in the struggle) applied to the three Forest cantons as early as 1320 and extended to the confederation as a whole in 1325. But it was not until after Sempach (1386) that it came into popular use, and it did not form the official name of the confederation until 1803. This is in itself a proof of the great renown which the league won by its victory at Morgarten Another is that as years passed other members were admitted to the provileges of the original alliance of the three Forest cantons. First to join the league (1332) was the neighbouring town of Lucerne, which had grown up around the monastery of St. Leodegar, Ludger or Leger (a cell of the great house of Murbach in Alsace) and had been sold to the Habsburgs in 129. It is accession brought a new element unto the pastoral association of the Forest cantons, which surrounded the entire Lake of Lucerne. Next came the ancient

town of Zurich in 1351, when it got the help of the Forest cantons and of Lucerne against the threat of an Austrian attack The league was then advanced from the hilly country to the plains, though the terms of the treaty with Zurich did not bind it so closely to the confederates as in the other cases and hence rendered it possible for Zurich now and again to incline toward Austria in a fashion which did great hurt to its allies. In June 1352 the league was enlarged by the admission of Glarus and Zug Glarus belonged to the monastery of Sackingen on the Rhine and the Habsburgs as advocates of the abbey claimed many rights over the valley, which, however, refused to admit them and joyfully received the confederates who came to its aid. However Glarus was placed on a lower footing than the other members of the league, being bound to obey their orders Three weeks later the town and district of Zug, attacked by the league and abandoned by their Habsburg masters, joined the confederation diate occasion of the union of these two districts had been a war begun by the Austrian duke Albert II against Zurich, and the peace of Sept 1352 restored Glarus and Zug to the Habsburgs. who also regained their rights over Lucerne Zug was won for good by a bold stroke of the men of Schwyz in 1364, but it was not until the day of Nafels (1388) that Glarus recovered its lost freedom These temporary losses were, however, far outweighed by the entrance into the league in 1353 of the famous town of Berne Founded in 1191 by Berchtold V of Zahringen, Berne had become a free imperial city in 1218 on the extinction of the Zahringen dynasty and made a treaty with the Forest cantons as early as 1323 In 1352 it had been forced to take part in the war against Zurich, but soon after the conclusion of peace entered the league as the ally of the three Forest cantons, being thus only indirectly joined to Lucerne and Zurich. The special importance of the accession of Berne was that the league began to spread to the west and so came into contact for the first time with the French-speaking land of Savoy The league thus by the end of the 14th century numbered eight members, the fruits of Morgarten, and no further members were admitted until 1481, after the Burgundian war. But while each of the five new members was allied with the original nucleus-the three Forest cantonsthese five were not directly allied to one another

Sempach and the Aargau.-Soon afterward, the quarrels with Austria broke out afresh Lucerne fretted much under the Austrian rule, received many Austrian subjects among its citizens and refused to pay custom duties to the Austrian bailiff at Rothenburg, on the ground that it had the right of free traffic. An attack on the customhouse at Rothenburg and the gift of the privileges of burghership to the discontented inhabitants of the little town of Sempach a short way off, so irritated Leopold III (who then held all the possessions of his house outside Austria) that he collected an army, with the intention of crushing his rebellious town. Lucerne meanwhile had summoned the other members of the league to its aid, and approximately 1,600 men of Uri, Schwyz, Unterwalden and Lucerne opposed the 6,000 which made up the Austrian army The decisive fight took place on July 9, 1386, near Sempach. Leopold, with a large number of his followers, was slain and the Habsburg power within the borders of the confederation finally broken. Glarus at once rose in arms, but it was not until the expiration of the truce made after Sempach that Leopold's brother, Albert III of Austria, brought an army against Glarus and was defeated at Näfels (not far from Glarus) on April 9, 1388, by a handful of Glarus and Schwyz men.

In 1380 a peace of seven years was made, the confederates being secured in all their conquests; and on July 16, 1394, the peace was prolonged for 20 years (and again in 1412 for 50 years), various stipulations being made by which the long struggle of the league against the Hinbsburgs was finally crowned with success. By the peace of 1394 Glains was freed on payment of \$200 annully; Zug too was released from Habsburg rule. Schwys was gwen the advocatia of the great abbey of Einstedelin; Lucenne got the Entlebuch (finally in 1405), Sempach and Rothenburg; Berne and its ally Solothuru were confirmed in their conquests. Above all, the confederation as a whole was relieved from the overlordship of the Habsburgs, to whom, however, all their rights and

dues as landed proprietors were expressly reserved, Berne, Zurch and Solothum guaranteeing the maintenance of these rights and dues with power in case of need to call on the other confederates to support them by arms. Though the house of Habsburg entertained hopes of secovering its former rights, so that technically the treates of 1389, 1394 and 1412 were but truces, it was finally to renounce forever all its feudal rights and privileges within the confederation by the Everhsting compact of 1424

The victory at Sempach enabled the league to extend both its influence and its territory. Both the league and its individual members were able to take the offensive. In the right century each member increased and rounded off its territory, though it usually withheld political rights from the men of the newly acquired lands. It was in the same century that Appenzell, St. Gallen and the Upper Valais first became associated with the league, though they did not become full members for a long time—Appenzell in 1731, St. Gallen in 1859, the Valais in 1854 Owner all, the 15th century saw the first attempt of the confederation to secure a footing south of the Alos.

In 1412 the treaty of 1394 between the league and the Habsburgs had been renewed for 50 years. When in 1415 the German king and future emperor Sigismund placed Duke Frederick IV of Austria under the ban of the empire, the league hesitated, because of their treaty of 1412, until Sigismund declared that this treaty did not release them from their obligations to the empire Sigismund's name, therefore, and by his special command, the different members of the league overran the extensive Habsburg possessions in the Aargau The chief share fell to Berne, but certain districts (known as the Frese Amter and the county of Baden) were joined together and governed as bailiwicks held in common by all members of the league (save Uri, busied in the south, and Berne, which had already secured the lion's share of the spoil for itself) This is the first case in which the league as a whole took up the position of rulers over districts which, though guaranteed in the enjoyment of their old rights, were nevertheless politically unfree

First Italian Conquests .- As the natural policy of Berne was to seek to enlarge its borders at the expense of Austria and later of Savoy, so Uri, shut off by physical causes from extension in other directions, as steadily turned its eyes toward the south. In 1410 the valley of Urseren was finally joined to Uri, an acquisition which gave to Uri complete command over the St. Gotthard pass, long commercially important and henceforth useful for purposes of war and conquest. Already in 1403 Urr and Obwalden had occupied the long narrow upper Ticino valley on the south of the pass called the Val Leventina or Livinental; in 1410 the men of the same two lands, exasperated by the insults of the local lords, called on the other members of the league, and all jointly (except Berne) occupied the Val d'Ossola (Eschental) on the south side of the Simplon pass Having lost this to Savoy in 1414, they obtained in 1416-17 the alliance of the men of the Upper Valais, then fighting for freedom, and thus regained the valley (1416). In 1419 Uri and Obwalden bought from its lord the town and district of Bellinzona This rapid advance, however, did not meet with the approval of the duke of Mılan, Filippo Maria Visconti; the confederates were not at one with regard to these southern conquests: Filippo Maria intrigued with them; and finally in 1426, by a payment of a large sum of money and the grant of certain commercial privileges, the Val Leventina, the Val d'Ossola and Bellinzona were formally restored to him,

The First Civil War.—The original contrasts between the scale condution of the different members of the league became more marked when the period of conquest began Quarrels and illefeling arose on the subject of the Aargau and the Italian conquests and a few years latter ripened into a civil war, brought about by the dispute as to the succession to the lands of Frederick VII, count of Toggenburg, the last male representative of his house. Count Frederick's predecessors had greatly extended their domains, so that they took in not only the Toggenburg or upper valley of the Thur, but Uranch, Sargans, the Rhine valley between Feldkirch and Sargans, the Prättigau and the Davos valley. He himself, the last great feudal 10rd on the left bank of the Rhine, had

managed to secure his vast possessions by making treaties with several members of the league His death (April 30, 1436) was the signal for the outbreak of strife The Prattigau and Davos valley formed the League of the Ten Jurisdictions in Raetia, while Frederick's widow took sides with Zurich against Schwyz for different portions of the great inheritance which had been promised them After being twice defeated, Zurich was forced in 1440 to buy peace by certain cessions to Schwyz, the general feeling of the confederates being opposed to Zurich, so that several of them went so far as to send men and aims to Schwyz Zurich, however, was bitterly disappointed at these defeats and had recourse to the policy which it had adopted in 1356 and 1393-an alliance with Austria (concluded in 1442), which now held the imperial throne in the person of Frederick III (Frederick IV as German king) Though permissible according to the terms of Zurich's joining the league in 1351, this act caused the greatest irritation in the confederation, and civil war broke out. In 1443 the Zurich troops were completely defeated at St Jakob on the Sihl, close under the walls of the city Next year the city itself was long besieged Frederick, unable to get help elsewhere, procured from Charles VII of France the dispatch of a body of Armagnac free lances (the Ecorcheurs), who came, 30,000 strong, under the dauphin Louis, plundering and harrying the land At the very gates of the free imperial city of Basle the desperate resistance of a small body of confederates (1,200 to 1,500), until cut to pieces, checked the advance of the freebooters, who then returned whence they had come Several small engagements ensued, Zurich dechning to make peace because the confederates required, as the result of a solemn arbitration, the abandonment of the Austrian alliance At length peace was concluded in 1450, the confederates restoring almost all the lands they had won from Zurich

(W A B C; H. Nz.) Waldshut and the Burgundian War.-Various communities such as the abbey and the city of St Gallen (1451), Appenzell (1452), Schaffhausen (1454), Rottweil (1463) and Mulhouse (1466) now became allies or associates of the eight cantons, while a successful war secured Thurgau as a common lordship, administered by all the states, except Berne, in agreement (1461) In 1467 and 1468 Berne used various pretexts to secure control of the Aargau, and war followed in 1468, partly in order to maintain the continued independence of Mulhouse against Sigismund of Tirol, the emperor Frederick III's cousin, who had succeeded to the Habsburg lands on the Rhine and in Alsace on his father's death in 1439 (in the years immediately following Frederick had been acting as his guardian) The war was hurriedly ended in Aug 1468 by the treaty of Waldshut, by which Sigismund was obliged to pay an indemnity of 10,000 gulden within a year, failing which he was to forfeit Waldshut and his possessions in the Black forest. Sigismund had no ready cash and his efforts to secure a loan led to an even greater was.

Louis XI of France refused to advance any money; but by the treaty of Sain-form (May 14,6) Charles the Bidd, duke of Burgundy, was willing to offer 50,000 guiden in cash in return for a pledge of the Austrian lands m Upper Alsace, Perrette, the Black forest and the Rhemsh towns of Waldehut, Sackingen, Rheinfelden and Laufenburg Skiffully interpreting some permissive clauses of the treaty favourably to his own expansionst ambitions, Charles proceeded to occupy the whole of Upper Alsace. He appointed Peter von Hagenbach as his agent with instructions to redeem mortgages, repair fortifications and improve administration in a way that would permanently unite Alsace with the Burgundian territories. This threatened the empire, and Fredrick III declared the treaty void; it also greatly perturbed Berne, whose prospects of espansion were greatly reduced. Further, Charles the Bold entered into an alliance with Savoy and with Milan and also threatened to occupy Mulbious, closely associated with Berne.

One result was the formation of the Lower union in 473 by Basle, Colmar, Mulhouse, Seisatt and Strasbourg; another, the Perpetual understanding of 1474 between Sigismund of Tirol and the Swiss, by which the former renounced any further territorial claims in Switzerland in return for promises of money to pay off its debts. Hagenbach was illegally arrested and executed in the

spring of 1474-a deliberate act of defiance of Chailes the Bold, who seemed to be fully occupied elsewhere The Lower union, supported by Berne, attacked Héricourt (Nov 1474) and Blamont (1475), Louis XI promising cash subsidies while the war continued Inspired by Niklaus von Diesbach, this western and southern movement continued all through 1475, much of the Vaud and part of Savoy, including Grandson, Orbe, Echallens, Jougne, Morat, Avenches, Estavayer and Yverdon being occupied by the end of the year, the inhabitants of the Valus acting in collaboration with Berne to prevent any interference from the side of Milan Enraged and even a little alarmed. Charles the Bold came south in person in 1476, occupying Grandson at the end of February and hanging its Beinese garrison Beine had gathered a considerable force from many states of the confederation and from the Lower union for the rehef of the castle too late to effect this, they oftered battle on March 2 at Grandson Charles' faulty generalship in the face of a disciplined force of pikemen, whom he mistakenly despised as ignorant peasants, led to the rout but not to the destruction of the Burgundian army The duke regrouped his forces at Lausanne and again advanced against Berne in June. His way was blocked by the castle of Morat, held by Adrian von Bubenberg and 2,000 Bernese The threat to this position was sufficient to bring 20,000 Swiss to its defense, and the battle of Morat (June 22, 1476) ended in a complete Swiss victory Charles was forced to fall back on Lorraine, whose ruler, René, had turned against him At Nancy (Jan 5, 1477) the duke was defeated and killed The Burgundian lands devolved upon his daughter Mary, Louis XI of France secured the duchy of Burgundy, Savoy regained, with French help, a good deal of the Vaud, and a Swiss incursion into Franche-Comté failed to consolidate itself into a permanent occupation.

Fribourg and Solothurn Admitted.-Such unity as the Swiss had so far enjoyed had been based almost entirely on successful defense against external enemies They had been, in fact, poor and apparently insignificant communities co-operating with difficulty for self-preservation Their military prowess, nurtured by necessity, had made them potentially great the latter part of the 15th century was the golden age of the mercenary soldies, and the Swiss had proved themselves the best available recruits There was much money to be made by military service and, for the first time, prospects of lucrative employment opened to young men of valour But the cessation of danger from outside and the lure of foreign gold were almost sufficient to turn friendly states into competitors. There was no constitution to hold them together, no common officers, seal, law courts, comage or flag, there was a growing divergence of interest between the cities and the mountaindwellers, as well as between east and west, there were numerous family feuds and endless local realousies, culminating in disputes about the distribution of the booty taken in the Burgundian war and about the administration of the territories held in common, particularly the Thurgau Fribourg and Solothurn were anxious to come within the circle of the confederation, but neither Zurich not Lucerne was very anxious for their support, while the country districts were anxious to maintain their predominance over the cities By 1481 these differences had become so exacerbated that all common purpose seemed at an end and civil war threatened It was averted by the intervention at Stans of the mysterious and self-effacing hermit Nicholas Lowenbrugger (Nicholas von der Flue or Bruder Klaus), who arranged the compromise which held the confederation together. By this Stanser Verkommus the full sovereignty of the component states was maintained and reasserted, but each agreed to abstain from attempts to foment internal discord or separatist activity among the subjects of any other state, the confederate oath of union was to be renewed every five years; loot captured in war was to be divided proportionately among the actual participants in the campaign, but lands occupied were to be shared equally by the states involved. The ancient guarantees of mutual aid and assistance in time of war were renewed, and Fribourg and Solothurn were admitted as full sovereign members of the confederation.

Zürich and the Swabian War.—Zurich had grown steadily in power and influence after its readmission to full confederate

status in 1446 Its textile manufactures had increased and with them the influence of the guilds, the effective authority within the city was shared by the ancient aristocracy, the Constajel Hans Waldmann (1436-80) was recruited to the one by apprenticeshin and to the other by marriage, he took part in a number of cam-paigns, including the battle of Morat, and was equally successful in war, business, diplomacy and politics Burgomaster in 1482. he became virtual dictator of the city, upholding the interests of the citizens against the peasants and turning the city itself into a community whose welfare, amusements, food and clothing were subjected to regulation and supervision In 1480, however, Waldmann had to face an armed peasants' revolt, which led to a constitutional revolution and to his execution The aristociacy of birth and of labour joined hands, and the possibility of Zurich's dictatorship extending to the confederation was averted. The struggle between the government and the peasants, however, was repeated with local variations in Schwyz, Unterwalden, Zug, Lucerne and St Gallen, although in no instance did the country people secure all their hopes

The temporary eclapse of Zunch was followed by the last attack from the north. The emperor Maximilian I, uniting in his own person Habsburg and Burgundian traditions, sought to extend alike the imperal prerogatives and the possessions of his house. In tags the imperal allet of Worms had put forth a revested constitution for the empire ensuring internal peace and common taxation and setting up an impernal chamber (Rechaksmine genchl) as a final court of appeal. The Swiss communities were technically imperial subjects and had teasin to fear renewed Habsburg aggression. They were therefore anxious to renew the understanding with France—Charles VIII was opposing Maximilian in Italy and was ready to hire Swiss mercenaries—and unwilling to join the South German Sewabana league for the maintenance of peace

South of the ten states of which the confedention was now composed by the Grosons. In Raetu many small separate communities had united into an Upper league, a League of God's House and a League of the Ten Jurusdictions, and the two former were in alliance with the Swass confederation. In 499 a boundary dispute between Triol and the League of God's House had led to a Trioles incursion into the Engadine and the Munsterthal and thus to war with Maximilan, the Swass came to the help of their ally, the emperor took up the implied challenge and in 1499 there was fighting from Basle to Bornio Basties raged at Hard, Bruderholz, from Baste to Bornio Basties raged at Hard, Bruderholz, brown as the state of t

Basle, Schaffhausen and Appenzell Admitted.-Basle as a member of the Lower union had taken part in the Burgundian war with the Swiss and had learned the value of such co-operation, as an imperial city it evaded with difficulty an obligation to support Maximilian in the Swabian war, while the confederates obviously needed security in the northwest. The bishop of Basle was politically much less influential than he had formerly been, and on July 13, 1501, the state was admitted to the confederation It was a notable addition, for the city was well fortified, strong, relatively wealthy, a home of scholarship with an active university and with an industrious and busy population. Schaffhausen, although smaller, was in much the same position it had had much difficulty with local knightly landlords, it had sent men to help its Swiss neighbours since 1453 and been accepted by most as an ally; and it had firmly refused to join the Swabian league. It received the reward of full admission to the confederation on Aug 10, 1501, Pinally, on Dec 17, 1513, a little reluctantly, Appenzell, which had been an ally rather especially closely associated with the confederation, was admitted to full membership and partnership. It was the last addition to the whole body, now 13 independent states, until the French Revolution, and it was accepted only because it helped to redress the balance of the "country" as against the "city" states.

The Milanese Campaigns.—The northern frontiers of the Italian states especially Milan, were exceedingly ill-defined. The southern route through Uri over the St. Gotthard was of growing

importance for trade and much used by the mercenaries hired for service in the Italian wars The inhabitants of the Val Leventina renounced Milanese allegiance in 1475 and were upheld in 1478 by armed men from U11 and other Swiss states Bellinzona was besieged but not taken, and at Giornico a small Swiss force defeated a much larger Milanese one But Berne and the western states were not interested in this southward expansion and refused to support any further advances, and it was with some difficulty that in April 1503 Bellinzona and the Blemo valley were secured by Uri, Schwyz and Nidwalden from Louis XII (as duke of Milan) in return for help against Ludovico il Moro. There was, however, growing resentment felt at the expenditure of Swiss lives in fighting on behalf of strangers, and opinion was markedly divided about the continued value of the French alliance, especially when France controlled Milan The greatest man in the Valais was Matthaus Schiner, bishop of Sion and a cardinal, who had turned against the French In 1510 Schiner arranged for Swiss support of the Holy league formed by the masterful pope Julius II for the expulsion of the foreigner from Italy After the death of Gaston de Foix at Ravenna in 1512 Swiss, papal and Venetian forces in co-operation were able to secure the removal of the French from the plains of Genoa regained a transitory independence, Maximilian Sforza, son of Ludovico il Moro, returned as duke of Milan and acquiesced in the occupation of Locarno, Lugano, Mendrisio and the Val d'Ossola by the confederates, while the Grisons secured the Valtellina, Bormio and Chiavenna. At Novara (1513) a fresh French army under Louis de La Trémoille was almost annihilated in a hard-fought battle, after which the Swiss penetrated into the duchy of Burgundy as far as Dijon but jeturned home when promused a substantial sum of money Francis I renewed the French invasion of northern Italy in 1515. The division of interests between the eastern cantons (who were reluctant to leave the St Gotthard route uncovered) and Berne (traditionally well-disposed to France), together with a growing dislike of mercenary service and an equally strong distrust of Cardinal Schiner, led to a division of forces Berne, Fribourg, Solothurn and the Valais were bought off at Gallarate, and a truncated Swiss army, with Milanese and papal support, was defeated on Sept 14, 1515, at Marignan (q v ) with heavy losses Francis I willingly agreed to easy terms in 1516 retaining the duchy of Milan but acknowledging all that the confederates and the Grisons had gained in the Bellinzona area except Domodossola and paying a considerable sum as well

The Reformation.-Five dioceses-Basle, Lausanne, Sion, Chur and Constance-provided the spiritual framework for the ministrations of the church to the Swiss people Neither the institutions nor the men were suited to the changing needs of the 16th century. The bishops were sometimes nonresident, sometimes incompetent, often, as absentee landlords, disliked The parish priests were frequently ignorant and sometimes lazy or immoral While there were no territorial princes, as in Germany, to benefit by a redistribution of church property, the considerable monastic lands were coveted by certain cities, and if there was little active opposition to the indulgence system which so enraged Martin Luther, there was little popular support for it either. Humanism could hardly impinge upon the lives and thoughts of peasant mountain dwellers, but contacts with Italy were easy and Basle became the home of Erasmus and Joannes Froben's printing press. All these things affected the career of Huldreich Zwingh (o.v.) (1484-1531) who became the most influential figure in the Swiss Reformation A musical, intelligent boy of good peasant stock from the Toggenburg district he had taught classics at the University of Basle and had been parish priest at Glarus (1506) and at Einstedeln (1516) and people's priest (Leutpitest) in the Zurich minster in 1518. He had been to Rome and with Swiss armies in the field, had studied widely in the Fathers and read the Bible in the original Hebrew and Greek. Experience had convinced him that mercenary service was harmful to his countrymen, and his Bible study and reading of the works of Erasmus had made him critical of the pope and opposed to indulgences.

In the all-important city of Zurich the pulpit, properly used, could be most influential, and on Jan. 2, 1519, Zwingh started a course of sermons on St. Matthew's Gospel such as had not been

Lutheran although it was, in fact, the independent outcome of his own thought and studies. In the same year there was plague in Zurich which caused a revivalist movement. Next, in 1520, Zwingli was denouncing the compulsory payment of tithe to the canons The city council then permitted the public preaching of the gospel, and in 1522 Zwingli formally challenged ecclesiastical authority by eating meat (sausage) during Lent He also denounced clerical celibacy and married Anna Reinhard, setting out his convictions and theological standpoint in 67 conclusions, which were publicly debated in Zurich in 1523 Appealing to the Bible, he convinced his hearers; the Great minster was reformed, monks and nuns began to leave the cloister, the clergy to marry and the communion to be administered in both kinds, the income from church property being diverted to education or poor relief Images were discountenanced, preaching encouraged, relics hidden or destroyed, monasteries dissolved and finally, in April 1525, the mass was superseded by a simple commemorative service. Zurich had thus by steady stages accepted the Reformation, and Zwingli was lett almost as head of the state as well as religious leader He set out his religious teaching in writing, issued a vernacular translation of the Bible, rejected the teaching of the Anabaptists (who were proscribed) and secured a permanent majority of supporters in the city council

The Catholic states were by then seriously alarmed and made every effort to isolate the new teaching in Zurich and to prevent its extension even to the common lordships over which Zurich shared jurisdiction. It soon became apparent that religious and economic interests were likely to coincide, the strongly Catholic cantons were, generally, the rural mountainous areas, U11, Schwyz, Zug, Unterwalden, Lucerne, Solothurn and Fribourg, while the city-dominated communities, Basie, Beine and Schaffhausen in particular, were lost to the old faith. The coherence of the confederation had been difficult to maintain in 1480, it proved almost impossible in 1529. In February of that year the Catholic communities, encouraged by pope and emperor, formed a separatist group known as the Chustian union; Zurich then tried to force the pace by an armed campaign in June, but the western states, particularly Berne, were not interested, and the antagonists were singularly loath to kill one another. The first armistice at Kappel (June 24) was followed by an agreement to dissolve the Christian union, to allow treedom of worship in the common lordships and to decline further foreign pensions. But neither side kept the spirit of the agreement. Then, in Oct 1529, the efforts of Philip of Hesse to unite the Protestants by bringing Luther and Zwingli together at Mathure conspicuously failed By 1531, when an Italian adventurer attacked the Grisons, the Forest cantons could refuse to come to the help of a non-Catholic state and could complain that the evangelical faith was being forced on the Thurgau, Choosing time and place with great skill, the five Catholic cantons declared war on Zurich at Lucerne on Oct. 4, 1531, and sent a force north to Kappel, where they met a hurriedly raised detachment of volunteers from Zurich led by Jorg Goldli and with Zwingh in person among them, The battle of Kappel (Oct. 11, 1531) resulted in a Catholic victory and in Zwingh's death.

Zurich thus lost the effective leadership of the confederation, which devolved, not very satisfactorily, upon Berne; the Catholics regained an appreciable amount of ground, so that when the Jesuits came they were in a strong position. For almost three centuries after 1531 religion so divided the Swiss people that co-operation was hardly possible. The rare diets of the whole confederation, necessary only for the administration of commonly owned territories, were brief and formal; the Protestant cities entered into cordial relations with England, Scotland, northern Germany and Scandinavia; the Catholic states were the willing agents of France, Spain and Austria on the rare occasions when these powers were found acting together. The wonder is that the confederation survived at all.

Geneva was not to be admitted as anything other than an allied state until 1815. Important strategically, it had entered into a pact of co-citizenship with Berne and Fribourg in 1526 in order to throw off the rule of its bishop and to prevent its absorption

heard in the minster before his teaching was inevitably called unto the expanding and ambitious duchy of Savoy The Protestant faith was brought into the Vaud from France and preached by Guillaume Farel and Pierre Viret under the protection of Berne, which had already taken various parts of the Vaud into a kind of protective custody The Reformers were successful in 1535, after the usual public disputation, in inducing the independent city council of Geneva to forbid the public celebration of the mass Threatened by their former bishop and by Savoy, the Genevans appealed to Berne, and a Bernese force under Hans Franz Nageli overran the Vaud, occupied Lausanne and brought temporary se-curity to Geneva At this juncture John Calvin, who in 1536 had published at Basle his definitive Christianae Religious Institutio came to Geneva and, not without some setbacks, soon made that city the centre of an active and independent religious teaching Calvinist doctrine was explicit and logical, the duties of the Christian household were clearly prescribed, attendance at church, particularly at seimons, was enforced, sumptuary laws were enacted by the city, an excellent system of schools established and ministers of religion were chosen with the greatest care for their character and capacity By the agreement of Zurich (Consensus Tigurinus), made with Heinrich Bullinger in 1549, Calvinism became the creed of the whole of Protestant Switzerland The Catholic cantons would not agree to the inclusion of Geneva in the confederation so that the city had to rely upon the alliance with Berne, upon the desire of the communities of the Valais that Savoyard aggression should be restrained, and upon the obvious interest of France in a friendly neutral at such a strategically important point Savoy was to make a last attempt to capture Geneva by surprise in 1602; this failed, and the city was never again in serious danger until it was annexed to France in 1798

The Counter-Reformation and the Valtellina,-Carlo Borromeo (a v ) became archbishop of Milan in 1565, and much of southern Switzerland lay within his province He was determined to stamp out the new faith wherever possible even if this meant straining the law and peace-agreements, he set a personal example of piety and of activity, visiting Einsiedeln and encouraging active Catholic conversion wherever possible. From the Swiss college at Milan, which he founded, and from the Jesuit houses missionaries came north, but the Protestants expelled from Locarno found a place of refuge in Zurich, and the Inquisition found little support even in the Catholic cantons However, the nomination of a permanent papal nuncio was welcomed, and Lucerne and Fribourg gladly received Jesuit colleges The historian Giles Tschudi, by a well-managed war, the so-called Tschudikrieg (1559-64), and through French and papal mediation, got the decrees of the Council of Trent enforced in Glarus, with the ultimate elimination of the Zwinglians, and Appenzell between 1579 and 1507 was subjected to an intensive process of reconversion which was so successful that the canton split into the two halves, Ausser Rhoden and Inner Rhoden (it thus remained politically impotent until 1848, and the division is still operative) Lucerne not only became the centre of Catholic Switzerland but it was also represented in France, during the Wars of Religion, by Ludwig Pfyffer (d, 1594) and it was the chief component of the Golden league which supported Philip II of Spain. Melchior Lussy (d 1606) of Nidwalden not only advanced this cause by his skilful diplomacy, making himself very wealthy in the process, but he also secured the confidence of the pope and averted the threatened entire dissolution of the confederation.

The loosely united communities (Giev league, League of the Ten Jurisdictions, League of God's House) known as the Grisons, two-thirds Reformed, one-third Catholic, controlled the important eastern passes, which were of interest alike to Milan and to Venice. Milan was under Spanish control and jealous of its ancient commercial and territorial rival Venice, which in 1603 had secured the friendship of the Grisons partly through the powerful Planta family. The Valte'lina (q.v.) was governed by the Grisons and inhabited by Catholics; its roads formed the most convenient link between Milan and Austria, Habsburg allies whose co-operation was unwelcome to France. A revolt in the Valtellina in 1620 led to Spanish support for the inhabitants against their northern masters and to successful Austrian intervention. The treaty of Monzon (1626) called in the pope as a third party and led to further disputes, formented by the local patriot, pastor, politician and pervert Georg Jenatsch (q v ) and ended by a return to the status quo in 1639, with the Valtellina restored to Grisons sovereignty but

with the Catholic rights markedly reinforced The Thirty Years' War .-- All Switzerland was interested in the Bohemian war of 1618, which grew to a conflict that involved every great power on the continent, but the religious division in the confederation effectually prevented any corporate action This was advantageous, for a Habsburg victory might have meant a renewal of Habsburg claims or an enforcement of the Edict of Restitution (whereby the Catholics recovered lost ecclesiastical lands), while a decisive Swedish triumph must have altered the balance of power in the confederation decisively. Many Swiss soldiers were hired by either side, and much material was sold to the combatants at a profit, while the necessities of frontier defense caused all the 13 states to come to a rare agreement in the Defensionale of Wil (1647) The frontiers would be defended against any aggressor and a mixed council of war of Protestant and Catholics would direct a force recruited from all parts of the confederation and its subjects and allies. The Defensionale was to be revised in 1668 and certain details were challenged later. but the acceptance of the principle of defense of neutrality was significant. The negotiation of the peace of Westphalia (1648) owed much to the indefatigable labours of Johann Rudolf Wettstein, burgomaster of Basle, and it was appropriate that this European instrument should take notice of the explicit renunciation by

the emperor Ferdinand III of all imperial claims over Basle and

the former Habsburg territories in Switzerland, an act followed by

the abrogation of any claim by the Reichskammergericht to exer-

cise appellate jurisdiction there The Villmergen Wars and Louis XIV.—The soil of Switzerland, however carefully cultivated, could not support its growing population, and the temporary prosperity caused by the wars gave way to a depression in the latter part of the 17th century Exports were necessary, and for this an industry was required which should use as little heat as possible and make the maximum use of human ingenuity and activity. Home industries were popular, partly because conditions in the valleys restricted outdoor work, particularly in the winter. Hence wood carving, spinning, frame-work knitting and embroidery were popular; water power made textile manufacture (silk, cotton and linen) profitable, particularly around the lake of Zurich and in St. Gallen; and in western Switzerland the construction of clocks and watches and of musical instruments, at first luxury trades allied to the art of the goldsmith and the jeweller, centred in Geneva, spread to Neuchâtel, Olten, La Chaux-de-Fonds and Le Locle. Basle was a commercial city, where stockings and silk ribbon and the preparation of tobacco and snuff occupied many; Berne remained primarily the capital of a great agricultural state, where the real or imaginary virtues of the peasant received an exaggerated recognition which was later to become a kind of intellectual cult (popularized by Hans Caspar Hirzel in his Wirthschaft emes philosophischen Bauers, 1761). Mercenary service, particularly with the French army, was a popular form of employment, and returning soldiers brought

news of foreign markets and fashions that was often valuable, The government of a number of states, Berne, Lucerne, Fribourg and Solothurn in particular, was in the hands of a patrician aristocracy, exclusive and splendid. Difficult economic conditions after the Thirty Years' War led to a rising in 1653 of the peasants of the Entlebuch against Lucerne. With the help of neighbouring governments it was suppressed, but it was followed by similar trouble in the Bernese Oberland and in the rural territories of Basle. The peasants seemed united, and the cities in alarm cooperated for the defense of their privileges, irrespective of religious differences. A battle at Herzogenbuchsee established their superiority, and harsh punishments were meted out (followed by some belated reforms). Zürich tried to make the confederation more of a reality, but the attempt broke on the rock of religious prejudice. The Catholic states reinstituted the Golden league in 1655, and the expulsion of some Protestant families from Arth led to a split between Schwyz and Zürich which developed into no common language, coinage, system of weights and measures,

civil war between the five inner states and Zurich allied with Berne At Villmergen (Jan 24, 1656) the Catholics under Christopher Pfyffer defeated their opponents and reasserted to the full the favourable position secured at Kappel and the complete individual sovereignty of the cantons.

In the age of Louis XIV the Swiss could hardly escape the allpervading influence of Versailles If the Protestant states were not very eager to help the persecutor of the Huguenots, and the Catholic states looked to Spain for help, both could be influenced by the appeal of Jean de La Barde, the French ambassador, to renew the Perpetual understanding with France In 1663 an embassy confirmed this renewal by a spectacular public oath in Notre Dame at Paris and for the next half-century French influence was paramount in such external relations as the confederation had Louis XIV's aggressive policy was in many respects at the expense of ancient Swiss interests. At the end of the 15th century Swiss influence had been almost paramount in the Franche-Comté and in Alsace, and these were exactly the areas against which Louis proceeded most successfully In 1667-68 the Habsburgs succeeded in retaining possession of the Franche-Comté, but the French threat to it alarmed the confederates Its final annexation to France in 1678 brought France to the Bernese fronties and caused fears for the future of the French-speaking Vaud, while the French occupation of Strasbourg meant that Mulhouse and Rottweil could not hope to remain permanently linked with the confederation, Basle, too, recognized how serious French pressure could be when a French battery at Huningen confronted its defenses The confederation remained discreetly neutral during the War of the Spanish Succession, but politically its independence was the safer because of the victories of the duke of Marlborough and Prince Eugene One other setback to France occurred in Neuchâtel on the extinction of the ruling French family of Orléans-Longueville in 1707, a struggle ensued between the French candidate François Louis de Bourbon, prince of Conti, and the Prussian king Frederick I, in which the latter won the principality for the Hohenzollerns.

The religious question in the common lordships, particularly the Thurgau and the Rheintal, was a delicate one, as the populations of both creeds were ruled by nominally co-operating states of similarly divergent faiths Questions of mixed marriages and the education of children were urgent ones and roused strong feelings, which were accentuated by the attempt of the prince-abbot of St Gallen to dictate to his mainly Protestant subjects in the Toggenburg district A road entirely under Catholic control was being constructed from Schwyz into imperial territory, and the abbot Leodegar Burgisser was determined that the Toggenburgers should contribute labour and materials to its construction. They demurred and appealed successfully for support to Berne and to Zurich, and in 1712 an armed conflict broke out. The abbot had the support of the emperor Charles VI, which made France willing to mediate; moreover, the French representative, Charles François de Vintimille, comte du Luc, was well-disposed to the Protestant cause. Berne and Zürich co-operated well, while Lucerne was unable to co-ordinate effectively the forces of the Forest cantons, The abbot fled, the Protestants won a victory at Bremgarten, besieged Baden and blockaded their enemies elsewhere. A final battle (July 25, 1712) at Villmergen settled the issue in their favour; and the peace of Aarau (Aug. 11, 1712) established real equality of treatment for both sides in the common lordships, increased decisively the influence of Berne and Zurich in the confederation and entirely superseded the second peace of Kappel,

The Bighteenth Century .- Every form of government existed side by side: a patrician aristocracy, proud, exclusive and competent, ruled in Berne, Fribourg, Lucerne and Solothurn; Zürich, Basle and Schaffhausen were governed by their craft guilds and trading corporations; in the oldest states, Zug, Uri, Unterwalden, Schwyz, Glarus and Appenzell, the primitive democracy of the Landesgemeinde assured the participation in the government of every adult male citizen; in Neuchâtel and St. Gallen autocratic princes were in power. Every state, individually or collectively. ruled subject territories; there was little sense of nationality and army or law courts There was a general arr of contentment, prosperity and industry and determination not to change. A vigorous and varied intellectual life was evidenced by the work of Johann Jakob Bodmer, Johann Kaspar Lavater, the Bernouilli family at Basle, Albrecht von Haller and Johann Heinrich Pestalozzi (qq v.), as well as the philosopher Isaac Iselin (1728-82) The country was increasingly visited by foreigners Edward Gibbon wrote much of the History of the Decline and Fall of the Roman Empire in Lausanne, Voltaire was to be found on the frontier at Ferney Jean Jacques Rousseau was proud to describe himself as a citizen of Geneva, and his thought was profoundly influenced by Swiss conditions The general complacency was disturbed by several manifestations of discontent John Daniel Davel attempted to free Lausanne and part of the Vaud from the domination of Berne in 1723; he was quite unsuccessful and was exe-cuted, but not forgotten There was trouble in Appenzell raised by Lorenz Zellweger in 1733 Geneva unwillingly acquiesced in a greater degree of democratic government in 1738 A serious conspiracy against Berne headed by Samuel Henzi was decisively dealt There were demonstrations against the authority of with in 1740 Uri in the Val Leventina in 1755 and armed opposition to the patricians of Fribourg, led by Nicolas Chenaux, in 1781, but neither these, nor somewhat similar explosions in Schwyz, Lucerne and Geneva, presented any real challenge to constituted authority All the time a consciousness that something more than mere defense and self-interest held the Swiss states together was growing, and this found public expression in the formation of the Swiss society (Helvetische Gesellschaft) in 1761.

The French Revolution and Napoleon .- The ideas of "enlightenment," rationalism and general improvement which became widespread in 18th-century Europe were eagerly absorbed in Switzerland The writings of Montesquieu, Voltaire, Denis Diderot, Jean Le Rond d'Alembert and the Encyclopédistes, as well as the almost home-bred solvent thought of Rousseau, powerfully influenced the intellectual circles, many talked of liberty and equality in societies in which there was little practical application of either Some of the more advanced thinkers had found life more congenial in France than at home in 1789, and in 1790 a "club of Swiss patriots" was founded in Paris by Jean Castellaz and supported by a number of Vaudois refugees, by Henri Monod, by Jean Jacques Cart and, most notably, by Frédéric César La Harpe who had been employed by Catherine the Great in Russia to teach her grandson Alexander In 1791 F C La Harpe was urging the French people to support the malcontents in the Vaud and the Valais while, as in Great Britain, the conservatives in Switzerland were in strong opposition to Jacobinism. Feeling was roused to violent heights by the massacre of the Swiss guards of Louis XVI in the Tuileries (Aug 6, 1792), but neither this event nor the invasion of the lands of the bishop of Basle by a French army nor even the formation of the First Coalition led to war In Paris Robespierre urged correctly that the interests of France called for a friendship with the Swiss people; and the war party in Switzerland, led by Niklaus von Steiger, was able to secure only an agreement that the allies might recruit Swiss mercenaries. There was, however, a good deal of anti-French activity in Switzerland, including the collection of war material for use against France and a spy service in the pay of William Pitt's representative, Sir William Wickham,

The successful invasion of Italy by Napoleon Bonaparte in 1796 and the peace of Campo Formio (1797) was soon followed by the annexation to the Cisalpine Republic of the three provinces ruled by the Grisons, the Valtellina, Chiavenna and Bormio, and the Swiss could do nothing but accept the accomplished fact. In Paris, La Harpe and Peter Ochs of Basle were urging a French invasion of Switzerland in the name of liberty, using the separatist movement in the Vaud as an excuse for intervention. There were inspired riots in the Liestal near Basle and elsewhere, culminating in the proclamation of a "Republique Lémanique" in Jan. 1798. The French Directory at once sent soldiers to the help of the insurgents: Berne resisted, but received no help from the diet of the confederation, which debated fruitlessly at Aarau. A French contingent was driven back at Neuenegg (March 5) but at the same

time the main Bernese force capitulated at Grauholz and the city of Berne was occupied. Great quantities of supplies and bullion were carried off to France by Bonaparte's agent Guillaume Brune, while Peter Ochs drafted a new constitution for a unitary Helvetian republic. The common lordships and the associated districts were abolished, the number of cantons was enlarged from 13 to 23, a bicameral legislature (great council and senate), chosen indirectly by manhood suffrage, was to be responsible for law-making, and a directory of five members was constituted the executive The rights of the individual citizen were written into the constitution, including freedom of worship, of meeting, of petition and of the press A national militia was embodied, and local government was controlled by centrally appointed prefects

The new constitution was not imposed without resistance. In Nidwalden a revolt was savagely put down by Gen Balthasar de Schauenbourg, but discontent continued to manifest itself in the east, especially when the country was marched over by opposing armies A compulsory alliance with France gave that country the right to use Swiss roads for military purposes, and the French guarantee of the Helvetian republic offered easy opportunities for intervention. The allies regarded the republic as a satellite of France, and in May 1799 Austrian and Russian forces under Suvorov met a French army under André Masséna near Zurich before making a classic retirement into the Vorarlberg. The campaign had devastated the countryside, the price of provisions rose alarmingly, and a bad harvest made the winter of 1800 one that was long to be remembered for misery and unemployment. The cost of the new centralized government was relatively high, although the burden was more equally distributed, direct taxation being introduced for the first time and feudal dues, corvées, tithes and ground rents abolished without compensation. Some money was spent on education, and an elaborate scheme of free or cheap public instruction (culminating in a national university as in France) was adumbrated, but little could be done in a short time, J H Pestalozzi, however, was given a free hand to proceed with his innovations, which attracted much notice, although his adventures in journalism, as editor of the Helvetisches Volksblatt, were less satisfactory. The first constitution barely outlived the Directory in France. Then, after violent struggles between the protagonists of greater centralization and those who stood for more cantonal authority, the Malmaison constitution was established in May 1801, and Aloys Reding was chosen as the first Landammann or head of the state of 15 cantons. He had to meet political and financial difficulties, culminating in a rebellion in the Vaud and a kind of counter-revolutionary movement in Aargau and Berne

Napoleon promptly intervened to dictate the Act of Mediation from Saint-Cloud (Sept 30, 1802, amplified on Feb 19, 1803). The cantons were again defined with boundaries substantially as they have remained ever since Berne lost most, Aargau and Vaud becoming separate entities at its expense; the Grisons became part of the confederation, with Ticino, St Gallen and Thurgau. There were now 19 cantons, the new ones, where representative democratic institutions were accepted, the old Landesgemesinde cantons, where popular open-air voting continued but was limited to men of 20 years or more; and the city cantons Zurich, Berne, Fribourg, Solothurn, Basle and Schaffhausen, where the old aristocracy regained some of its ancient influence under new forms. With Lucerne substituted for Schaffhausen, these latter became the directing cantons, having seniority in turn, the chief magistrate for the year having custody of the seal of the republic and presiding over the assembly. The sovereign rights of the cantons, the issue of money, control over customs, education, monasteries and the posts, were restored, but freedom before the law, of settlement and of occupation was guaranteed to all citizens.

Napoleon was at first a relatively popular protector until the war with England obliged him to demand the 16,000 men promised him by the military capitulation. British recruiting of mercenaries was stopped and Switzerland forced to participate in the continental system with very great harm to its own commerce and industry, particularly in cotton. The Swiss frontiers were violated by armed forces. Thousands of Swiss took part in the Russian campaign, distinguishing themselves in the crossing of the Beresina

during the retreat but losing most of the effectives. The Valuis which had remained aloof from the Swiss republic was united with France as the département of the Simplen in 1810, nominally to put an end to anarchy, Ticino was occupied by French-commanded Italian troops in order to stop smuggling, and Neuchâtel was banded over to Marshal P. A. Berthier as a kind of feudal fief When therefore it became appaient in 1813 that the Napoleonic empire was crumbling after the battle of Leinzig, the Landanianian for the year, Hans Reinhard, called a special assembly at Zurich which voted for a policy of armed neutrality Prince Metternich soon saw this to be on the whole to the advantage of France and encouraged certain discontented elements, who desired a restoration of pierevolutionary conditions, to apply for military help A force marched through northern Switzerland on its way into France at the beginning of 1814, while the Napoleonic Act of Mediation was formally denounced

The Restoration.—The congress of Vienna devoted comparatively little time to the Swiss question, but certain of its decisions were none the less of far-reaching importance Swiss affairs were left largely to the competent advice of Baron Heinrich vom Stein, Baron Wilhelm von Humboldt, Count Capo d'Istria and Stratford Canning, who made as few boundary alterations as possible The most serious loss was to Austria, which annexed from the Grisons the three districts of Chiavenna, Bormio and the Valtellina, On the other hand, partly as a result of the efforts of Charles Pictet de Rochemont, Geneva was at last united to the confederation with reasonable boundaries, as too was Valais Neuchâtel, part of the dominions of the king of Prussia, also came in, and the independent existence of the Vaud as a separate canton was accepted Berne received the city of Biel and the former prince-bishopric of Basle The northern part of Savoy, on the southern shore of the lake of Geneva, was declared neutral, as was, permanently, the whole Swiss state. This declaration and a guarantee of Swiss integrity was reinforced by the second peace of Paris (Nov 20, 1815) The return of Napoleon from Elba made no substantial difference. Swiss soldiers in the service of France did not join him. a Swiss contingent marched with the allies, who were allowed to cross Swiss territory, into Upper Burgundy There was a small modification of the frontier of the Vaud and the creation of a free zone in Gex and its neighbourhood under the treaty of Tunn (March 16, 1816). Mulhouse remained in French hands and the Swiss confederation now consisted of 22 contiguous cantons Its constitution, after a conservative patrician restoration in Berne and some rioting elsewhere, had been settled at the "Long diet" of Zurich in 1814. Its keynote was the full restoration of the sovereignty of the cantons, almost the only federal institution being the army, for the defense of the frontiers, and for the unkeep of which a special fund was voted. Each canton was equally represented in the diet. Lucerne, Zurich and Beine acting as chief city for two years in turn. The possessions of the monasteries were placed under federal protection, but the earlier general freedom of worship, as of settlement and occupation, were not retained. Each canton continued to collect its own customs, coin its own money and manage its own affairs by the customary machinery, The franchise was everywhere limited so as to favour the old ruling families and the property owners, and any alteration of the federal

status quo was made constitutionally impossible. Military service with foreign powers again became possible. Louis XVIII gladly enlisting a number of men. Reserving its neutrality, the confederation declared its adhesion to the Holy alhance in 1817, thereby pleasing the tsar. Refugees in some numbers (including the future Napoleon III) obtained asylum within its borders, so that Metternich complained that the country was a focus of revolutionary plots and in a state of anarchy. The diet even agreed to place limitations on the freedom of the press from the rigid tariff restrictions of its neighbours. France and Austria in particular, from the decline in European purchasing power after the Napoleonic wars, from successful British competition in world textile markets and from its own constitutional inability to have any common policy on imports. Apart from some

more substantial signs of a religious revival, the Swiss states showed little activity in the 1820s

News of the July revolution in Paris in 1830 caused a good deal of excitement among the politically minded young men of certain Swiss cities Clubs, societies, even athletic associations began to demand larger measures of cantonal democracy, more popular education and some protection of women and children against industrial exploitation. A number of mass demonstrations led to the introduction of more liberal legislation in 11 of the larger cantons in 1831, implying the acceptance of the principle of popular sovereignty and the expansion of the franchise. More schools and training colleges for teachers were opened and universities were founded at Zurich and Berne There were, however, exceptions and the surge forward was followed by a reaction In Schwyz the opposition of reformers and conservatives was so violent that only the intervention of federal troops saved the state from civil war or self-partition In Basle long-standing differences between the relatively wealthy city, with great external interests, and the predominantly agricultural countryside came to a head in 1831 adoption of a democratic constitution for the state would give political preponderance to the country people and this the citizens were determined to resist. After violent demonstrations in 1831 the canton was divided in 1833 into two halves. Basel-Stadt and Basel-Land, which have remained permanent. Frederick William III of Prussia in 1831 most reluctantly abandoned a small part of his absolute rights in his principality of Neuchâtel (eg, that of nominating the whole of the cantonal council), but there were clashes between the republicans and the monarchists, neither of which was long satisfied with the compromise agreed to by the monarch One result of these differences was the formation in 1832 of the Siebnerkonkordat (Zunch, Berne, Lucerne, Solothurn, St Gallen, Aargau and Thurgau) opposed by the conservatives united in the Sarnenbund (Basel-Stadt, Uri, Unterwalden, Schwyz and Neuchâtel) None of these internal changes affected the traditional willingness of the country to shelter political refugees Poles were welcomed in considerable numbers in the north, while the harbouring of Prince Louis Napoleon (particularly after his attempted coup at Strasbourg) and the notonous use of Swiss bases by Giuseppe Mazzini almost brought about war.

The Sonderbund War .- The 1830s were years of considerable literary activity and of much thought about the future of the confederation Strictly constitutional revision was difficult, if not impossible, but the changing needs of the times and the general modification of opinion toward more liberal forms of government clearly suggested change With a growth of national feeling went a growing conviction that there were certain minimum individual rights of the citizens that ought to be secured to all, and some were prepared to enforce this point of view, others were impressed by the expense and dislocation caused by each canton's having its own tariff and customs barriers. There were several local mamfestations of discontent but they remained localized and ineffective, The bond of union was found in religion How was the principle of religious freedom to be enforced? The Articles of Baden (1834), condemned by Pope Gregory XVI but upheld by the liberal cantons, called for a general diminution of ecclesiastical privileges and exclusive claims, the mass demonstration against the appointment of D. F. Strauss to a chair of theology at Zürich in 1839 indicated the depth of passion aroused. Matters came to a head in Aargau There in 1835 the monks of Muri had objected to taking an oath of loyalty, and in 1841 the Catholic minority demonstrated in arms against a liberal revision of the constitution, The government then dissolved the Aargau monasteries, which were held to have fomented the revolt. The federal pact of 1815. however, had expressly guaranteed the property of the monasteries against secularization, and the Aargau Catholics appealed to their friends in the south The chief Catholic canton was Lucerne, and there Joseph Leu had taken advantage of the situation to secure the recall of the Jesuits, invited by Eutych Kopp, to undertake the teaching of theology and the control of the clerical seminary. This action was lawfully done and lay within the proper province of the canton, but was highly provocative. A demonstration against it in slight manifestations of embryonic nationalism and some rather Lucerne itself was severely punished, and a general popular demand for the expulsion of the Tesuits from the confederation was ignored. The Radicals passed from argument to violence, Joseph Leu was found shot, and from most of the Protestant cantons bands of volunteers (Freischarler) marched on Lucerne under the command of Ulrich Ochsenbein, a Bernese staff officer. The expedition was mismanaged, and in a fight at Malters more than 100 men were killed and more than 1.800 made prisoner (April 1, 1845)

The battle was followed by the union of the Catholic cantons, Luceme, Uri, Schwyz, Unterwalden, Fribourg and Valais into a separatist confederation, the Sonderbund The primary purpose was to prevent any alteration of the weak federal act of 1815, even if this were the declared will of the majority of the people, and foreign alliances were welcomed to this end Through 1846 opposition grew Berne, Solothurn, Zurich, Vaud and finally Geneva (under Tames Fazy) elected radical governments, determined to declare the Sonderbund an unlawful pact. In May 1847 St. Gallen joined the liberal cantons, and 12 votes out of 22 were certain. The diet met in Beine in July 1847 under the presidency of Ochsenbein and by a majority declared the Sonderbund to be dissolved A commission was appointed to draft a new federal pact, and the expulsion of the Jesuits from Lucerne, Fribourg, Schwyz and Valais was ordered, together with their exclusion from the whole confederation. In the name of religion and of state rights the minority determined to resist by force. Their leader, Constantin Stegwart-Muller, purchased arms, collected an army under the command of Johann Ulrich von Salis-Soglio and looked for support from Louis Philippe and Metternich This, partly because Lord Palmerston openly sympathized with the opposite side, was slow in coming. The Sonderbund War was soon over While at Lucerne there were divided counsels and uncertainty of purpose, the Radical cantons entrusted their men and fortunes unreservedly to Guillaume Henri Dufour of Geneva, a somewhat conservative professional soldier, simple, upright and unselfish. Dufour had more men than his opponents, and these better trained and equipped, with better guns and superior economic advantages. All these he used to decisive effect Fribourg capitulated on Nov. 14, 1847, almost without fighting, and the ring closed relentlessly in on Lucerne. Zug surrendered on Nov 21, and two days later the decisive battles were fought at Meierskappel and Gislikon. Luceine was entered, officers, Jesuits and nuns fleeing by steamer to Fluelen and then over the St. Gotthard to exile. Valais was the last canton to submit, on Nov. 28. Somewhat more than 100 men on both sides had been killed. The costs of the war were charged to the losers, and Appenzell Inner Rhoden and Neuchâtel had to pay fines for their neutrality. A collective note from the powers, unsupported by Palmerston (who sent Stratford Canning with sympathetic instructions to Berne), could be and was ignored until the greater troubles of 1848 left Switzerland free to work out its own destiny

The New Federal State, From 1848 .- The revision commission had a new constitution ready for submission to the cantons in June 1848, and it was adopted with little change by 151 cantons (1,897,887 votes) against 61 (293,371 votes). The central authority of the confederation was strengthened, particularly in regard to defense, law and order and the promotion of the common welfare. There was to be a cabinet or executive (Bundesrat) of seven. a supreme federal court (Bundesgericht), a senate or council of states (Ständerat) consisting of two representatives from each canton and a national council (Nationalrat) representing the county as a whole. Foreign affairs became the concern of the federation only, although separate cantons might, with federal approval, make agreements not of a political nature with one another and with neighbouring countries. The posts, currency, weights and measures and customs duties became the province of the federation, which thus acquired an independent revenue, cantonal expenses being met by local levies, taxes on salt, an excise on wine and stamp duties. Universal military service in a federal force was accepted; very small cantonal armies were approved, and the cantons controlled infantry training but not the cavalry or artillery. Service with foreign armies, military capitulations and the acceptance of foreign pensions or decorations were prohibited. Freedom of the press, of worship, of association and of settlement and equality before the law were secured to all, but these were somewhat narrowly interpreted in some cantons-the Jews remained under special disabilities and the Jesuits were excluded Berne became the seat of the government, Lausanne of the high court and Zurich of the federal institute of technology. It had been the hope of many that a great federal university at Zurich would unite the higher education of the country, the ordinary teaching of children being left to the cantons; but the existing academies at Geneva, Lausanne and Neuchâtel and the universities of Berne and Basle were not prepared to accept this measure of academic unification, and in the end only technology was thus centralized Similarly it was only after considerable differences of opinion that the French franc and the metric system of weights and measures were fully adopted

Foreign Affairs .- Neuchâtel, part of the dominions of Frederick William IV of Piussia, had in 1848 adopted a republican form of constitution, which had been accepted as that of a federal canton This was partly the work of the industrial region of Le Locle and La Chaux-de-Fonds and was resisted by the older ruling families, who proclaimed their loyalty to their monarch. The last of several attempts at counterrevolution took place in Sept 1856, when the lovalists under Comte Frédéric de Pourtalès-Steiger gained possession of the castle of Neuchâtel and had to be ejected by force The king of Prussia threatened to intervene on behalf of his "subjects" and mobilized his men; the federal army was placed on a war footing and sent to the northern frontier. British good offices and diplomatic pressure on Prussia by Lord Palmerston were followed by the mediation of Napoleon III, and in 1857 the king gave way, renounced all sovereign rights and secured an am-

nesty for his supporters.

More serious was the question of refugees. Switzerland, like Great Britain, was a home for political exiles from many countries, and Giuseppe Gambaldi and Mazzini now found safety from the Austrian police there Mazzini continued to plot the violent overthrow of the lawful rulers of Lombardy and Venetia and attempted to gain recruits for his secret associations until he left the country. In 1850 some measures were taken to prevent Switzerland from becoming too obvious a base for revolutionary propaganda but the law on this subject was never very strictly enforced In the Ticino the sympathy of the population for Italian nationalism combined with provocative anticlerical actions led to Austrian reprisals in the form of the expulsion of Ticinese from Lombardy and of an economic boycott which caused much suffering. Perhaps only Austrian preoccupation elsewhere prevented matters from being pushed to extremities. During the war of 1859 federal troops prevented Swiss sympathizers from crossing the frontier to join the insurgents and secured the interpment of belligerents who fled north. The war was followed in 1860 by the cession of Nice and Savoy to France and the reopening of the question of the neutral zone of Chablais, Faucigny and the Genevois. A federal councillor, Jacob Stampfli, threatened to readjust matters by a Swiss occupation of this area, a threat impossible to carry into effect as the easy repulse of a Genevan force that attacked Thonon in March 1860 clearly showed. In the end the neutral zone was enlarged a little, arrangements made about the collection of customs and the issue shelved until 1919 (when full French sovereignty over the area was to be asserted and accepted). The war had further been responsible, indirectly, for the establishment of the International Red Cross organization, a widely read pamphlet by Henri Dunant having drawn attention to the unnecessary sufferings of the wounded at the battle of Solferino (1859) In 1864, after much local activity, the Convention of Geneva regulated the care of wounded in war and arranged for the neutralization of the medical and ambulance services, distinguished by the federal cross in reverse colour

Economic Development.-The Swiss people did not at first welcome the advent of the railway; it was believed to be aesthetically and technically unsuited to mountainous country and it threatened the prosperity of the roadside hotels. The interests of Basie and Zurich conflicted and cantonal state-rights were a serious obstacle. It was therefore not until 1847 that an experimental line was opened between Baden and Zurich. After a report from Robcit Stephenson the federal council accepted the necessity for planned railway construction, and a conflict between Alfred Escher on the side of private enterprise and Jacob Stampfli on that of state ownership and control resulted in the victory of the former There was soon a manua for railway speculation, and lines were built with little or no co-ordination, sometimes in conscious rivalry. In 1853 the North Eastern railway linked Zurich with the Rhine and the lake of Constance, and in the same year the route Morges-Lausanne-Yverdon was opened, by 1850 the Central railway joined Basic with Olten and thus to Lucerne on the cast and to Solothurn. Beine and Thun on the south Finance, politics, personalities, cantonal rivalries and strategic considerations soon caused difficulties The construction of a railway through the St Gotthard tunnel was not completed until 1882, after much negotiating with Baden and Wurttemberg and with the Italian government. Escher was chairman of the company responsible, the confederation refusing to accept any financial obligations The estimates proved maccurate, and Escher was forced to resign, some part of the excess cost being borne by public funds. There were difficulties about gauge, locomotives and differential rates, and in 1883 a suggestion of unification by public ownership was rejected by a small majority A similar suggestion was rejected by a referendum in 1801, but in 1808 nationalization of the main lines was accepted by a popular vote, and the principle was extended in 1903 and 1909

The existence of ample water power and an industrious population gave Swiss industry a good start, but the absence of coal made further developments difficult until the progress of hydroelectric schemes supplied an alternative source of heat and energy. Swiss textile manufactures, including cotton goods, largely held their own in a predominantly free-trade world but declined in face of growing protection and large-scale competition. Embrodiery of good quality, however, was to maintain a wide market until about 1020, as did the Basle silk-ribbon industry Dyeing led to a considerable development of the chemical industry; and the traditional localized watchmaking and clockmaking was supplemented by large-scale factory production, which met with considerable success and led to the making of a wide range of machines and locomotives The home production of grain decreased in the 1880s, when it became much cheaper to import foreign wheat; the farmers turned to stock breeding and dairy farming Cheese making, the export of milk products of all kinds and the chocolate industry became widespread. Better communications with the outside heightened the flow of the valued tourist traffic.

Constitutional Revision and Internal Politics, 1860-1914. -The German Kulturkampf had its repercussions in Switzerland. The issue of the Syllabus errorum by Pius IX in 1864 attracted a good deal of attention and helped to make the Radicals also to some degree anticlerical, and the definition of papal infallibility in 1870 and the emergence of the Old Catholics in Germany, with many sympathizers in Switzerland, created difficulties. The Catholics of the diocese of Basle, in particular, refused to follow their bishop, Eugène Lachat, in accepting papal infallibility and declared him deposed. In this they were upheld by the cantonal governments, particularly Berne, but a majority of the clergy stood by their bishop, refused to accept his removal and protested against the secularization of his property. Berne now required that parish priests should be chosen by their parishioners from among those who were approved by the government and had undergone a state examination. In Geneva the action of the pope in appointing Gaspard Mermillod to an apostolic vicariate there without any prior consultations led to Mermillod's being expelled from Switzerland (1873), to the recall of the papal nuncio and to the prohibition of the activities of religious associations in schools.

The feeling thus aroused helped forward the growing demand for a general revision of the constitution of 1848. The introduction of the "initiative" (i.e., the right of the people to propose legislation) into the canton of Zürich in 1869 was a victory of the leftiwing democrats over Escher and his followers. The freedom of the press was extended, the principle of payments to councillors was accepted, and the example of Zürich was largely copied by

Berne, Lucerne and Solothurn. In 1866 the Jews, who had been denied freedom of settlement on commercial grounds, were admitted to full civic lights In 1874, partly as a result of the Franco-German War, a revision of the conditions of military service was generally demanded The division between those demanding greater centralization and increased federal authority and those upholding the rights of the cantons was focused on the rivalry of Emil Welti of Aargau and Louis Ruchonnet of the Vaud Radicals were only partially successful, but a revised federal constitution was accepted by popular vote in 1874 Direct popular control over the government was further extended by the principle of the referendum, by which a national verdict on an issue could be sought if properly demanded by 30,000 votes or eight captons In 1801 it was agreed that a demand by 50,000 votes (the initiative) could bring similar machinery directly into operation The army was more directly centralized, discipline and military education. the provision of arms and the collection of exemption-payments were to be federal matters, the force being based on the cantons (which also promoted some of the officers). Freedom of trade and choice of occupation within any canton was secured to all, and each canton was obliged to make provision for full primary education. Teaching was to be secular, civil marriages were made compulsory and the foundation of new monasteries was forbidden Certain other anticlerical regulations were made. The authority and appellate jurisdiction of the federal court at Lausanne was upheld and extended, and federal laws dealing with factories, bank notes and the railways were made more comprehensive money needed to meet the additional expenditure was secured by the extension and raising of duties on imports.

The opening of the St. Gotthard route attracted some attention to the Ticino; an increasing number of immigrants heightened party rivalries, Radicals and Conservatives being almost precisely equally balanced Religious feeling made matters worse, the Conservatives were accused of manipulating the elections so that they would remain permanently in power, and rioting in 1800 ended in the formation of a provisional government. Armed federal intervention became necessary, a revised electoral law introduced proportional representation, and an increased electorate was followed by a Radical and peaceable administration. Growing industrialization and an increase in the size of the urban populations were accompanied by the spread of socialism. The Social Democratic party formed in 1870 avowedly existed to forward the claims of the manual workers and, under Otto Lang, began to demand social reforms and positive opposition to large-scale capitalist enterprise A notable piece of practical socialism was the slow nationalization of the railways. Some action was necessary to prevent important sections of the railways from passing under foreign control, and in 1801 the federal council negotiated the purchase of the Central railway; but the proposal was negated by a popular referendum. Seven years of discussion followed, accompanied by an occasional strike. Then in 1898 agreement was secured for the public purchase of certain main lines. The principle was extended in 1903 and 1909 and was to make much easier the later electrification of the federal lines.

Political refuges, their numbers increased by German antisocialist legislation, continued to be a source of difficulty. In 1889 a German police inspector, August Wohlgemuth, arrested as a ppy, was expelled from the country only after an acrid exchange of notes between the Swiss government, represented by Numa Droz, and Bismarck. Anarchists were more difficult to central or eliminate. In 1898 the Austrian empress Elizabeth was asassinated in Geneva; and in 1902, after the murder of King Humbert of Italy, the Italian government demanded that action should be taken against Guillo Silvistrelli for provocative newspaper articles. A temporary breaking-off of diplomatic relations between Switzerland and Italy followed, but normal inercourse was soon restored. The principle of permanent neutrality had become firmly accepted by the people when World War I began in Aug.

World War I.—Attention in 1914 in Berne was soon transferred from the Swiss national exhibition to the needs of defense. The wisdom and the value of the policy of neutrality, imposed

alike by public instruments, by national interest and by tradition, was never in doubt. The citizen-army was rapidly mobilized and sent to guard the frontiers There was a momentary controversy over the choice of a supreme commander, the parliamentary representatives voting for Theophil Sprecher von Bernegg, the federal council (supported by a decisive popular vote) choosing Ulrich Wille Fortunately a neutral Switzerland had certain advantages both for France and for Germany, and no attack upon its frontiers was ever seriously considered. Universal military service, the rigours of campaign conditions without an enemy to fight and the use of soldiers for public works were less resented than the economic conditions imposed on a country which could neither entirely feed itself nor supply all its own raw materials. The tourist traffic, which the 20th-century enthusiasm for mountaineering and allied pursuits had rendered especially active, came to an end, a run on the banks was with difficulty averted, and the large number of resident foreigners added certain difficulties. But it was soon apparent that Swiss services could be of value alike to both belligerent groups and a certain amount of trade became possible For certain purposes Cette became an open port for Switzerland Heavy taxation and a good deal of borrowing were necessary, there was a violent controversy when two officers, Col K Egh and Col. M von Wattenwyl, were discovered to have given military information to the Germans (Feb 1916), sympathy with the Allied war aims was most prominently expressed by the French-speaking Swiss The factory workers in the cities were discontented at the lapidly rising prices and at political and industrial conditions unfavourable to them, and the Social Democratic party became a vehicle for the teaching of Lenin, resident in Zurich until his transference to Russia by the Germans The constitution, however, made political action slow and ineffective, and in Nov. 1918 a general strike was called. The workers demanded a 48-hr week, oldage pensions, national health insurance, female suffrage, the election of a new national council by proportional representation, conscription of labour and a capital levy Prompt action by the administration, the hurried expulsion of the Soviet legation, the arrest of strike leaders and the use of some show of military force ended the general strike quickly, after which a number of the de-manded reforms were enacted. Concurrently with the general strike the serious influenza epidemic that affected so much of Europe wrought considerable havoc.

Swiss agencies, governmental and private, including the Red Cross, were much used by the belligerents, but the expression of Swiss opinion had little effect on the course of the war or on the peace negotiations in Paris The collapse and partition of the Habsburg empire decisively altered conditions on the Swiss eastern frontier, where the inhabitants of the Vorarlbeig wished to form themselves into a new canton of the confederation The decision about this rested with the Allies, who declined to detach the territory in question from the new Austrian state and ignored the principle of self-determination, so that the treaty of Saint-Germain-en-Laye left the frontier there unchanged Switzerland was affected in several ways by the treaty of Versaillesthe international control of shipping on the Rhine thereby became very much a concern of France; the agreement with Germany about the regulation of the St Gotthard line was revised; and the neutralized "free" zone of Gex and Upper Savoy became an undifferentiated part of the French republ

The League of Nations.—The Covenant of the League of Nations, an space of the flattering choice of Genova as the headquarters of the organization, was not regarded with satisfaction in Svitzerland. The guarantees for the maintenance of peace in Europe were less adequate than the Swiss project had suggested, and it was obviously difficult for a permanently neutral state to be associated with the enforcement of collective security and with active resistance to aggression. But Swiss idealizing welcomed the general implications of the League, and outstanding difficulties were solved when, by the Declaration of London (Feb. 13, 1920), the council of the League recognized the special position of Switzerland as permanently neutral and agreed that no military assistance, direct or indirect, could be required from it in the event of a breach of the covenant, although "economic sanctions" would

become applicable The issue was long debated; the federal council advised entry into the League, which was accepted by the Nationalrat by 115 votes to 50, by the Standerat by 30 to 6 The necessary referendum on May 16, 1920, revealed even greater caution 112 states were for, 101 against, and the final figures revealed a favourable majority of 90,000 in a total vote of 700,000 On the social, economic, intellectual, industrial and medical committees of the League of Nations Swiss help was prominent. The country readily accepted the Kellogg pact abolishing war as an instrument of policy, and it advocated the early admission of Germany into the League The passage of foreign armed forces across Switzerland, even on the most direct and manifest League missions, was strenuously and successfully resisted Relations with the USSR, embittered by the murder of the Soviet representative Vorovsky at Lausanne in 1923, remained unsatisfactory, and Switzerland opposed the admission of that country into the League in 1934 In 1935 trade relations with Italy were not broken off when Italian forces invaded Abyssinia, although an embargo was placed on the export of arms to both sides The Sino-Japanese War, the failure of the Disarmament conference, the war in Spain and the successful Anschluss between Germany and Austria caused a national reaction, and in May 1938 Switzerland publicly refused to participate in future sanctions

World War II and After .- Switzerland had foreseen the outbreak of a general conflict and was militarily prepared against World War II On Aug 30, 1939, Henri Guisan was elected general (commander in chief) by a large majority. The army was mobilized, the frontiers guarded and conscription of labour enacted The tourist traffic and with it the hotel industry, already affected by European conditions, suffered greatly while both imports and exports were exposed to severe and immediate limitations There were many expensive diplomatic and Red Cross activities, and with the fall of France in 1940 a large number of French and Polish troops crossed the frontier and were interned Belligerent aeroplanes flew high over Swiss territory and were seldom shot down, certain towns, notably Schaffhausen, were ac-cidentally bombed Defense measures were deliberately concentrated upon the mountainous interior, and these were not put to the test. War materials were supplied to both sides and conveyed by rail between Germany and Italy Home agriculture, corn-growing in particular, received all possible encouragement, and the country emerged from the war less impoverished than might have been expected. A careful censorship was exercised over the press, incitement was avoided, as dislike for German National Socialist activities increased and the Communist party was proscribed. Diplomatic relations with the U.S.S.R. were reopened in 1945, and every effort was made to co-operate with international organizations which were consistent with the maintenance of the increasingly difficult principle of permanent neutrahty A number of wartime restrictions were removed by popular vote in 1949 when a return to direct democracy was accepted. The growing financial and economic difficulties of Europe in the 1050s, in spite of Swiss currency stability, were reflected in a number of individual trade agreements and efforts to secure markets and supplies of scarce raw materials. Some action against Communists at home and increased defense expenditure reflected Swiss reluctant acceptance of the consequences of world tension and anxieties.

Characteristically the Swiss government accepted an important and limited responsibility for the Korean truce in 1953.

and ammet regionality for the Access there is 1952; in Suinc, Suinc, Valle, Vall (Lausanne, 1937), E. Galdiard, Getcheket der Schwerz, 3 vol (Zürich, 1934-97); E. Dürr, R. Feller, I. von Murait and H. Nabhotz, vol. (Lausanne, 1937), W. Cherner, Christ, 1930); W. Ochieket der Schwerz, 1930; W. Ochieket, 1930; P. O. Bessie, Historie de keeple susset; Orrentury, 1940–1). For mediaval sources: Aligaments Geschichtsforschende Gesellschaft was stated for the Christ of the Schwerz (Schwerz (Schwerz)). Gesellschaft Schwerzensch (B. K. P.)

# POPULATION AND SOCIAL CONDITIONS

Switzerland has an area of 41,295 sq.km. or 15,944 sq.mi. of which 22.6% is "unproductive" (i.e., bare mountains, plateau

slopes, lakes and rivers), 24.8% is occupied by forests, 243% consists of alpine pastures and only 28 3% is agricultural land.

Well-organized census returns were made at ten-year intervals from 1850 on, except that censuses were taken in 1888 and not in 1890, and in 1941 and not in 1940 The total population by the census of Dec 1, 1950, was 4,714,992. This represented an increase of 449,289 or 10.5% over the figure for 1941 and was almost double that for 1850 (2,392,740) Three-quarters of the increase since 1941 was due to natural causes and the remainder to immigration. The gains were the industrial ones of

cantons registering the greatest Zurich, Zug, Basle and Geneva (See Table I ) There was a steady increase in density of population from 150 per square mile

mile) and Uri (69) The Jura cantons are much better populated Vaud (305) and Neuchâtel (415) The densest of all are the cantons of Geneva (1,861) and Zurich (1,163).

The non-Swiss element of the population increased from 3% in 1850 to 11 6% in 1900, but fell to 8.8% in 1930 its total increased from 71,570 in 1850 to 355,522 in 1930. By 1941 there were only 223,554 aliens in the country (5 2%), the most numerous being Italians (96,018), next in order came Germans (68,622), French (24,396) and Austrians (9,652). In 1950 there were 283,367 foreigners

From 1800 to 1940 about 683,000 Swiss emigrated, mainly beyond the seas The annual average of emigrants was 6,800 in the decade 1871-80, reached 11,500 in the years 1881-88, fell to 4,400 in the years 1889-1900, reached the peak of 11,800 in the years 1910-20 and was about 6,000 in the decade 1931-40 The number of Swiss-born residents in the United States rose steadily from 13,358 in 1850 to 124,848 in 1910; by 1940 the number was

Language -- By the federal constitution of 1874, German, French and Italian are recognized as national languages for the purposes of debates in the federal parliament and for the public notification of federal laws and decrees. The recognition on July 8, 1937, of Romansh (See Rhaeto-Romance Languages) as a fourth national language did not affect the constitution German predominates in 16 cantons, including even the Grisons (where, however, one-third of the people speak Romansh in the

TABLE II ... Distribution of Population by Language

Year		German	French	Italian	Romansh		
	1880 . 1910 1941	2,030,702 (71,3%) 2,594,186 (69 1%) 3,097,060 (72 6%)	608,007 (21 4%) 703,264 (21.1%) 884,669 (20 7%)	161,923 (5 7%) 302,578 (8 1%) 220,530 (5 2%)	38,705 (1 4%) 40,234 (1 1%) 46,456 (1 1%)		

form known as Ladin and about one-fifth Italian): French prevails in Vaud, Neuchâtel, Geneva, Fribourg and Valais; Ticino is Italian-speaking Detailed census returns as to language had revealed a small amount of shifting (See Table II.)

Religion .- The constitution of 1874, while recognizing no established Swiss church, guarantees full religious liberty and freedom of worship, as well as exemption from any compulsory church rates. It repeats the constitution of 1848 in forbidding the settlement of Jesuits and their affiliated societies in Switzerland; the interdiction can be extended to any other religious orders that may endanger the safety of the state or interfere with the peace of other creeds. Protestants outnumber the Catholics in

Table I - Area and Population of Systerland by Cantons, 1041-50

Cantons*	Area in	Popu	lation	Inc	ease	Pop per sq
Cantons	sq mı	1941	1950	Number	Per cent	mi 1950
Zürich (Zurich), 1351 Bern (Berne), 1353	668	674,505 728,010	77/,002 801,013	73,027	15 2	1,163
Luzern (Lucerne), 1112	576	200,008	223,249	16,641	81	388 60
U11, 1291 Schwy4, 1291	415 351	27,302 66,555	28,556 71,082	1,254 4,527	4 6 6 8 8 8	203
Obwalden (Unterwald-le-Haut) 1201	100	20,340	22,125	1,785	8.8	116
Nidwalden (Unterwald-le-Bas), 1291 Glarus (Glaris), 1352	106 264	17,348 34.771	19,389 37,663	2,011	8 3	183 143
Zug (Zoug), 1352	9.3	36,643	42,230	5,596 6,642	153	454
Fribourg (Freiburg), 1181 Solothurn (Soleure), 1181	645 306	152,053	158,695	15,561	44	246 557
Basel Stadt (Bills, Vills), 1501	14	160,061	196,498	26,537	15 6	652
Basel Land (Bale-Campagne), 1501 Schaffhausen (Schnifhouse), 1501	165	91,459 \$3,772	107,549 57,515	3,743	13 0	500
Appenzell Ausser Rhoden (Appenzell Rhodes Extérieures) 1513,				3,182	7 1	510
Appenzell Inner Rhoden (Appenzell	94	44,756	47,938	3,102		
Rhodes Interseures), 1513 St Gallen (Saint-Gall), 1803	67	13,383	13,427 300,106	22,905	8.0	200 398
Graubtinden (Grisons), 1803	2,746	128,247	137,100	8,853	60	50
Aargau (Argovic), 1803	542 388	270,463 138,122	300,782 149,738	30,310	11 2 8 4	555 386
Thurgau (Thurgovie), 1803 Ticino (Tessin), 1803	1,086	161.882	175,055	13,173	8 2	163
Vaud (Waadt), 1803 Valas (Walhs), 1815	1,239	343,398 148,319	377,585 150,178	34,187	10 0	395 79
Neuchatel (Neuenburg), 1815	300	117,000	128,152	10,252	7 3 8 8	415
Genève (Genf, Geneva), 1815 Total	15,944	174,855	4,714,992	28,063 449,289	16 0	1,861 206

\*The cantons are given in the official order with the year of the entrance of each into the confederation Source: Statistisches Jahrbuch der Schweiz 1951 (Basle, 1952)

13 cantons, of which 9 are German-speaking and 3 (Geneva, Vaud mile in 1930 to 296 per square mile in 1930 to 296 per square mile in 1930 to 296 per square mile in 1930 to 296 per square mile in 1930 to 296 per square populated cantons are the Alpine ones, e g. Genoms (50 per square Protestains in 1 coantons, including 7 German-speaking, 2 French-speaking in Coantons, in Coantons speaking (Fribourg and Valais) and the Italian-speaking Ticino

The Roman Catholic priests are much more numerous than the Protestant clergy and comprise more than 6,000 regular and secular priests under five diocesan bishops viz, those of Basle and Lugano (resident at Solothurn), of Lausanne and Geneva (resident at Fribourg), of St Gallen, of Sion (Sitten) and of Coire (Chur). (See Table III )

Table III -Distribution of Population by Religion

Year	Protestant	Catholic	Jewish	Others		
1880	1,667,107 (58 6%)	1,160,782 (408%)	7,373 (0 2%)	10,838 (0.4%)		
1910 .	2,107,814 (56 2%)	1,593,538 (42.4%)	18,462 (0 1%)	33,479 (0.0%)		
1941	2,457,242 (57 6%)	1,724,205 (41.4%)	19,429 (0 5%)	64,827*(0.8%)		

\*Including 20,000 "Christian Catholics"

Cities -In 1950, ten towns had a population exceeding 30,000. (See Table IV.)

Table IV -Cities With Population of More Than 30,000 in 1950

	City	1850	1900	1950	City	1850	1900	1950
-	Zürich Basle . Berne Geneva Lausanne	41,585 27,844 29,670 37,724	57,550 97,350	183,543 146,499 145,473	St Gallen Wantherthur Lucerne Bienne (Biel)	13,651	20,255	68,011 66,925 60,526 48,342

Education -- Under the constitution of 1848 each canton or half-canton is sovereign in education The constitution stipulates. however, that elementary education is compulsory and free: that all public schools must be under the direction of the state; and that freedom of religion and conscience must be guaranteed. The confederation financially supports public elementary schools and vocational training in all its branches. By regulating examinations for the professions, the confederation also influences the curriculum of the higher middle schools The only institution of higher education maintained by the confederation is the Federal Institute of Technology at Zurich (Eudgenössische Technische Hochschule). The ministry of the interior in Berne is in charge of education on behalf of the confederation; there is an educational department in every canton,

Children enter the primary school at the age of 6 or 7 and leave it at 14 or 15. Secondary and lower middle schools form a link between primary and higher or vocational schools. Pupils enter between the ages of 11 and 13, remaining for two to five years; they are grouped in language-history and mathematics-science branches. The technical or vocational schools serve pupils under-

going an apprenticeship between the ages of 15 and 19. The higher middle schools either take their pupils from the senior classes of a primary school or themselves provide the preparatory schooling, in the latter case the course lasts 121 years They prepare their pupils for the higher school certificate in three types of schools: classical (with compulsory Latin and Greek), modern language and science, there are boys', girls' and coeducational institutions

In addition to the Federal Institute of Technology at Zurich (founded 1855), there are seven cantonal universities, viz., Basle (1460), Lausanne (1537), Geneva (1559), Zurich (1833), Berne (1834), Neuchâtel (1838) and Fribourg (1889). The commercial college of St Gallen (1808) ranks also as an institution of higher education. At Lausanne, Geneva and Neuchâtel instruction is given only in French, at Basle, Zurich and St. Gallen only in German Fribourg and Neuchâtel have no medical faculties Swiss universities are lay (laigues), but all, except Fribourg, are in cantons of Protestant tradition At Basle, Geneva, Lausanne, Neuchâtel and Zurich the theological faculties are Protestant at Berne there are Protestant and Catholic faculties, at Fribourg only a Catholic one Of the 16.501 students in 1950-51 nearly a quarter were foreigners, at Lausanne one in three students is a foreigner, at Geneva one in two. (See Table V.) (K. Sm.)

TABLE V - Education

m	•	↑ Pupils			
Type of school	Boys	Girls	Total	staff	
Primary schools (1948-19)	220,125	214,373	434,498	14,136	
Secondary schools (1048-40)	27,866	27,107	54,073	2,305	
Lower middle schools (1048-40)	14,455	0,150	23,614	979	
Higher middle schools (1948-40)				1	
Classical and modern	6,281	2,277	8,558 2,675	1,195	
Mathematics sciences	2,595	110	2,675	1,195	
Vecational training schools (ros7-48)	85,744	75,7×9	101,463		
Commercial colleges (1947-18)	2,172	1,549	3,721	I 57	
Teachers training colleges (1047-48)	1,143	1,245	2,388	257	
Universitles (1950-51)				1,371	
			3,251	380	
St. Gallen Commercial college (1950-51)	1		408	82	

## GOVERNMENT

The Cantons.-The political divisions are the communes (of which there are now about 3,000), districts (198), and cantons (22). Of the cantons, 19 are undivided In 1831 the rural districts of Basle revolted against the undemocratic rule of the urban trade guild; the latter were twice defeated in the field before they agreed (in 1833) to the subdivision of the canton into Basle-Stadt and Basle-Land Unterwalden, from before 1291, was divided into Obwalden and Nidwalden, representing two distinct physical divisions in different river valleys. In 1291, Nidwalden accepted alliance with Urı and Schwyz; Obwalden did not join until later The Reformation led to a division (1597) of Appenzell into the Inner Rhoden, mainly Roman Catholic and pastoral, and Ausser Rhoden, largely Protestant and industrial,

Each of the 22 cantons has its own legislature, executive and judiciary. The older cantons have in some instances (Unterwalden, Appenzell and Glarus) preserved their ancient democratic assemblies (Landesgemeinden), in which all male citizens of full age meet, usually annually during April or May, in the open air for the purpose of legislation and the selection of an annual administrative council. In the remaining cantons the legislature (Grosser Rat or grand conseil) is composed of representatives chosen by universal male suffrage and usually by proportional representation. These councils exercise all the functions of the Landesgemeinden. The executive also in most of the newer cantons is elected by a popular vote and not as hitherto by the cantonal legislature. All the cantons have the referendum and the popular initiative, the application of which varies in the different cantons,

The cantons are build up of two main types of communes, or Gemeinden. These are the real units. The burgher communes (communes bourgeoises or Bürgergemeinden) are now principally of historical interest, having for the most part been gradually absorbed by the second class of political communes. Initially burgher communes were groupings of the people to manage the 'lands subject to common user' (mainly summer pastures and canton or one from each half-canton; i.e. 44 in all. The mode

forests). Later, by purchase or otherwise, the burghers became possessors of manorial rights. But when the federal diet imposed the care of the poor on the several communes (1551) these naturally gided only their own burgher members nonburgher settlers, were excluded from any share in the enjoyment of the common lands, or in their management, though they paid local rates Increased communication facilities, together with a shifting industrial population, made such restrictions invidious and unfait, particularly after the introduction, under the Helvetic republic (1798-1801) of a federal citizenship, superior to cantonal citizenship. Later, the increase of communal public duties meant financial obligations exceeding the sums produced by the common lands To avoid some of these inconveniences, political communes (municipalités or Einwohnergemeinden) were set up. The duties of these communes were largely increased after the liberal movement of 1830, the care of the highways, the police, the schools, the administration of the poor law being successively handed over to them Swiss citizens belonging to cantons other than those in which they resided were, by the federal constitution of 1848, given rights of voting there in cantonal and federal matters, but not in those relating exclusively to the commune itself, but the federal constitution of 1874 gave to permanent Swiss settlers communal voting rights, subject to three months' residence

In most cantons a number of communes are grouped together to form a district (Amtsbezirke) under a prefect who represents the cantonal government Minor communes are controlled by a small council. In the larger communes an executive council is chosen by a general assembly of all male Swiss citizens over 20 vears of age, of good conduct and with three months' communal residence. A maire (Gemeindebrasident) is elected by the larger body to preside over the council which has the management of all local affairs, including the carrying out of cantonal and federal laws or decrees, save and except matters relating to the pastures and forests held in common

The Confederation .- On the cessation of the federal pact in 1848 a new constitution was accepted by general consent. This is fundamentally the constitution in operation today, but sundry revisions were made in 1874 and 1931, and the amended constitution is the one now in force. Any subsequent revision can be made by normal federal legislation with a compulsory referendum on the demand of 50,000 franchised citizens, or by popular instiative. Changes require a favourable majority in total votes and total number of cantons.

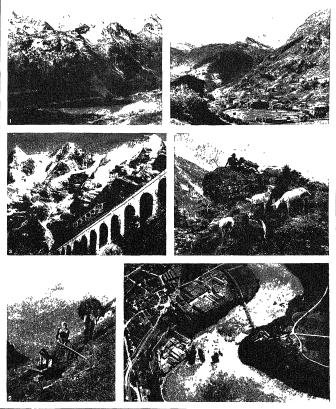
Federal sovereignty is exercised by the legislative federal assembly (Bundesversammlung) and by the executive federal council (Bundesrat), both meeting at Berne. The assembly consists of two chambers; the national council (Nationalrat) and the

council of the states (Standerat),

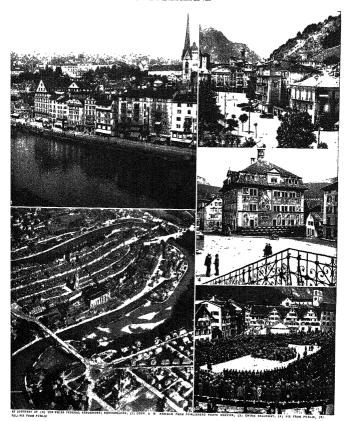
Every whole canton is represented in the national council, on the basis (from 1950) of one member for every 24,000 people in the canton, with an additional deputy for any remainder exceeding 12,000. On the census returns of 1050 there were thus 196 representatives varying from 33 for Berne and 32 for Zürich to 1 for Uri. The deputies receive attendance pay and travelling expenses from federal funds; neither allowance is lavish. (See Table VI.)

TABLE VI,-Elections to the National Council

Party	1919	1922	1925	1928	1931	1955	1939	1943	1947	1951
Liberal Democratic. Catholic Conserva-	0	10	7	6	6	6	6	8	7	5
tive. Peasants, Artisans	4X	44	42	46	44	42	43	43	44	48
and Middle Class. Radical Liberal	30	34 60	30	31 58	30 : 52	21 48	22 50	22 47	21 52	23 51
Independents'	=		-5	3	- 2	7	9	5	30	10
Social Democratic Labour (Commu-	41	43	49	50	49	50	45	56	48	49
nists)	-	2	3	2 2	2	2	4		7	5
Total	189	198	198	198	187	187	187	194	194	196



BY COURTEST OF (1, 6) THE SWISS FEDERAL AERODROME, (2, 3, 4, 5) THE SWISS FEDERAL BAILWAYS



VIEWS OF SWISS CITIES

- 1 Limat Qual and part of Zurich. This city is the educational capital of will be substituted in the magnificant university buildings are seen in the back-buildings are seen in the back-b
- 2. Are represented in Someway.

  2. Are represented in Someway.

  3. Are represented in Someway.

  4. In a retained in Someway.

  5. Are popular assembly by led on the public square in Glanus Bory have a principle of the public square in Glanus Bor
- 4. The Ratheus in Sohwyz

of their election, term of membership and rate of pay are entirely cantonal matters and vary accordingly. Their average financial allowance is less than that for a deputy to the national council

A general election of representatives to both chambers takes place every four years, voting is by proportional representation with universal male franchise for persons of 20 years of age or more, and any voter other than a clergyman, may be elected a deputy Laws passed by the federal assembly, though this represents both people and canton, can be vetoed as a result of a majority-supported referendum based on a popular initiative demand by 30,000 enfranchised citizens

The seven members of the federal council or government are elected for four years by the federal assembly and are responsible for the following departments foreign affairs, justice and police; interior, defense, finance and customs; public economy, and railways and post office. No canton may have more than one representative in the federal council, but according to custom it should always include a Bernese, a Zurichese and a Vaudois Usually four members are German-speaking, two French-speaking and one Italian-speaking. The president of the confederation (who is titular president of the federal council) and the vicepresident of the federal council (who is one of its seven members) are elected for one year only (Jan 1—Dec 31) by the federal assembly and cannot be immediately re-elected Federal councillors cannot hold a plurality of office, either federal or cantonal, and must not engage in any profession or trade The federal government (assembly and council) is being increasingly entrusted with matters formerly considered to be purely cantonal

Justice .- Each canton elects, controls and pays (often merely a nominal sum, even if the posts are not entirely honorary) its own magistracy for ordinary civil and criminal trials. There are cantonal variations in the penal code, e.g., capital punishment exists only in nine cantons and one half-canton

The federal supreme court (Bundesgericht) sits at Lausanne. There are 26-28 full members (plus 9 supplementary judges), elected by the federal assembly to hold office for six years with eligibility for re-election. The federal assembly also elects every two years the president and vice-president who, as such, cannot The original and final jurisdiction of the Bundesbe re-elected gericht extends to disputes between the confederation, the cantons, corporations, and private individuals, so far as these differences refer to federal matters and involve more than 4,000 Fr in financial suits It is a court of appeal against cantonal authorities in the application of federal laws and also against decisions of other federal departments. It is a court of trial for persons accused of treason, or other offenses against the confederation. The four courts of the Bundesgericht are: the court of accusation, the criminal court (with paid jurors elected by the people), the federal penal court and the court ot cassation (W. E. WH.; X.)

### DEFENSE

The Militia System .- Being composed of militia, the Swiss army contains no forces maintained permanently with the colours except a corps of 327 instructors a system which is unique in Europe. The total number of men physically fit and trained for military duty was

total number of men physicany in and trilines no minus? was year approximately reacted in 1953. In approximately reacted in 1953, approximately reacted in 1953, and the year in which their 20th birthday fails until the year of their aght birthday. Service may be rendered either personally or by the payment of a military tax. Volunteering before the legal age is permitted. The military is as payable up to the age of 48. Bollstennet takes place in the year of the 19th birthday. Personal service includes attendance in the year of the 1911 birtheay. reasonal service because for training, active service at home or abroad in defense of the country, and maintenance of public order and security. Men passed fit for auxiliary service pay a tax in lieu of military training for the years in auxiliary service pay a tax in lieu of military training for the years in which it would otherwise be performed. After physical training for boys, provided by the cantons under the supervision of the federal gov-

boys, provided by the cantons under the supervasion of the federal government, the training is carried out under the military department. The army consists of a first line (Atsizing or élite!) for ages from to 31 inclusive, Londoueler for ages from 33 to 40 inclusive, and Landoueler for ages from 35 to 40 inclusive, and Landoueler from 51 to 118 days according to the arm of their course varying from 51 to 118 days according to the arm of their course varying the state of the state

As the militia keep their rifles in their own houses, the whole army

can be mobilized in 48 hr In 1939 about 500,000 were mobilized, but after the collapse of France in 1940 the number under arms was reduced

10 55,000 O'rdet of Battle.—The country is divided into nine divisional distinct. There are use four independent monattan bigades and three areas of the country of the

105-mm guns and 105-mm and 150-mm howitzers. There is a small aut force, which by 1931 had 179 left lighter auteraft in the first line.

In 1950 Switzerland started an extraordinary rearmament program, the total cost of which amounted to about 1,400,000,000 Fin 1950 the total military expenditure amounted to 480,000,000 Fi, four times The military estimates for 1952 amounted to as much as in 1938

Higher Command.—In peacetime the Swiss aimy has no general, colonel being the highest rank. One of the seven federal councillors is head of the military department, the central authority in peacetime for national defense If troops are mobilized on a large scale the is need of the means of the month of the means of the mea Gen Henri Guisan was appointed There is a general staff under the military department and a national defense committee, with the head of the military department as chairman and the chief of the general staff and with four aimy colps commanders and the officer commanding infantry as members The committee ceases to function when a commander in chief is appointed

### ECONOMIC CONDITIONS

According to the census of 1941, the economically active popula-According to the census of 1941, the economically active popula-tion was employed as follows 4, 50% in the nanulacturing industry, handscrifts, building, mining and quarying, 20 8% in agriculture and ministration and the professions, 4,7% in the hold industry, 38% in tansport and communications, and the rest in domestic and other services. As these proportions clearly show, Switzelland is preponder-antly an industrial country, depending for its existence and prosperity on the export of machinety, apparatus and instruments. This is all the more supprising as the country has practically no useful mineral resources except salt and is entirely landlocked, without direct access to overseas markets. Apparently condemned by nature to a meagre

Table VII - Economically Active Population, 1941

		Male	Female	Total
Agriculture, forestry, fishing		384,799	30,137	414,936
Mining and quarrying Manufacturing industry and handicrafts	:	7,344 520,388	202,557	7,467
Building Transport and communications	: '	70,425	6,310	137,583
Commerce, banking, insurance . Hotels	: :	117,952	70,520 58,779	198,472 84,969
Public administration and professions . Domestic service and day labourers	•	101,105	40 288 114,935	147,453 120,813
Institutions with resident staff Unspecified	: :	5,878 18,783 23,767	34,485	53,268 27,840
Total	: :	1,422,272	570,215	1,992,487

pastoral economy, the Swiss by hard work, inventiveness and persever

pastoral economy, the Swiss by hard work, inventiveness and peasever-ance have succeeded in developing other industries but their hold is always precurous. (See Table VII) Switzenland, the high average altitude, the excessive rannial and the prevailing system of small holdings all combine to prevent the country from being preponderantly agricultural From the middle of the roth century the rural population has declined: in 1888 the proportion of the economically active population engaged in agriculture was 37% as compared with so 8% in 1941. At the same time the country has be-come necessingly dependent on imports for its food supply, especially come increasingly dependent on imports for its food supply, especially for its bread grain. By 1850 the grain production was sufficient to food the grain production was sufficient to the proportion of the grain production was reduced to one-third. Softwarend its many state of the proportion was reduced to one-third. Softwarend its many proportion was reduced to one-third. Softwarend its many proportion was reduced to one-third. Softwarend its many proportion was reduced to one-third. Softwarend its many proportion was reduced to one-third proportion with proportion was reduced to one-third proportion. Softwarend its many proportion was reduced to one-third was reduced by the softwarend w

TABLE VIII -Agricultural Production

Crop	1934-38	1947	1948	1949	1930	1951	1952
Wheat Barley Rye Oats Potatoes Sugar beets	160 8 33 22 736 74	187 55 25 78 1,230 161	195 54 27 65 1,141 x85	254 05 30 88 764 204	228 44 38 52 1,132 235	234 48 37 05 968 209	220 50 34 61 1,075 216

heavy transport charges, Swiss manufacturers cannot indulge in mass production. They can thrive only by producing wates which will find

TABLE IX -Livestock (in eeo head, date of estimate April)

Туре	1039	1946	1948	1950	1952
Cattle Pigs	1,711 880	1,472 054	767	1,530	1,682
Sheep Horses	176*	105	183	180	190 130

\*April 1936

purchasers even if expensive and which present a very high value in a reduced volume. That is the case with intricate producers' goods such

TABLE X -Swiss Production and Net Import of Major Foods (In ooo metric tous, Jr934-38 annual average

Γood			Production	Net Import	Total
Meat Fish and poultry Fish and poultry Eggs (200,000 units) Fluid cow milk Cheese Butter Other animal fats Vegetable fats and oils Sugar Bread grains Potatoes Citrus fruit, etc Wine (200,000 1)	: : :	:	190 3 5 8 42 1 2 1,016 8 50 7 26 3 11 7 9 4 203 9 334 4	7 6 (4%) 9 7 (63%) 238 2 (30%) 9 2 (1%) 10 6* 9 9 (1%) 3 5 (23%) 148 0 (94%) 421 1 (57%) 45 2 (100%) 45 2 (100%)	197 9 15 5 661 4 1,026 0 34 1 27 2 15.2 28 1 157 4 625 0 365 0 45 2 157 9

\*Net export Source I Rosen, Wartime Food Developments in Switserland (1947)

as complicated machinery, durable consumers' goods such as watches or boots and shoes, and luxury products such as fine salks, embroideries, perfumes and other articles of interest mainly to the feminine world As industrial technique progresses and as fashions vary, all production involving the use of intricate machinery and destined to satisfy luxury tastes is inevitably subject to extreme fluctuations. Thus, while the first of these two factors has favoured the development of the chemical, mechanical, aluminum and artificial silk industries, the second has crippled the silk and silk ribbon industries and in combination with the construction, export and establishment abroad of very high-grade embroidery machinery, all but killed what, at the beginning of the century, was the second branch of Swiss manufactures

Foreign Trade,-The importance of foreign trade for Switzerland is reflected in the annual value per head of the population of imports and exports together. In 1938 that figure, in Swiss francs, was 464; of 564 for Belgium, 523 for the Netherlands and, on the other hand, 430 for Great Britain. Imports, consisting of such necessities as raw

TABLE XI .- Foreign Trade

(in 600,000 FT)									
Турс	1913	1938	1946	1947	1948	1949	1950	1951	1952
Imports Exports	1,919	1,317	2,070	3,208	3,435	3,457	3,911	5,011 4,000	4,748

materials, fuel and food, surpass exports in value, but the resulting deficit is generally covered by the tourist trade (See Table XI.)
Watches, clocks and parts were both before and after World War II

third (13%).

Transport and Communications—In 1950 Switzerland had 10,550 mi. of reads, 146,098 inotor cars, 41,574 buses and lorries and 26,4487 motorcycles. There were 3,345 mi. of railways, of which 7,513 mi. were state-owned. (35e also Albes for the principal passad tunnes). In 1932 the mouthly average of railway goods traffic and tunnes.) In 1932 the mouthly average of railway goods traffic. and tunnels.) In 1935 the monthly average of rainway goods traine amounted to £6,000,000 ton-Am. (as compared with 131,000,000 ton-km, in 1938); that of passenger traffic £12,000,000 pass-km. (as compared with 23,000,000 pass-km in 1938). The monthly averages for traffic on the national air lines (Swissair) in 1932 amounted to 24,464, cranic on the national air lines (Swissair) in 1932 amounted to 24,464, 'coop pass.-kin. (as compared with 1,159,000 pass.-kim in 1938) and, for rargo, 726,000 ton-km. (as compared with 65,000 ton-km in 1938). Federal Finances.—The principal expenditure of the confederation under the heads of defense, social insurance, contributions toward under the heads of defense, social insurance, contributions toward.

the promotion of economy and administration. Until World War I the main revenue of the confederation was from indirect taxes (customs duties and stamp duty), while direct taxes were levied only by cantons

TABLE XII -Federal Finance (In oco,coo Fr , actual)

				-			
Type	1913	1938	1946	1947	1948	1949	1950
Revenue Expenditure	101	73T 772	2,949	2,682	2,207 2,367	2.049 1,900	2,071 1,734

and commune. In 1915 federal taxes on property and income were introduced (See Table XII)

The unit of currency is the func of 100 Rappen or centimes. The acknings rate of the func on Dec. 21, 1953, was 4.28 FF, per US tional bank, founded in 1907, is the central bank of issue. On Dec. 31, 1953, that day off regards of 100 Feb. 31, 1953, that day off regards of 100 Feb. 31, 1953, that day off regards of 100 Feb. 31, 1953, that day off regards of 100 Feb. 31, 1953, that day off regards of 100 Feb. 31, 1953, that day off regards of 100 Feb. 31, 1953, 195

1953, 11 had gold reserves of U.S. \$11,38,000,000 and foreign exchanige to the amount of U.S. \$11,200,000,000, compared with a note issue of \$415,000,000 Fr. and deposit morey of 6241,000,000 Fr. and the second of 6321,000,000 Fr. and foreign of 6241,000,000 Fr. and foreign of 6321,000,000 Fr. and foreign of 6321,000 Fr. and foreign of 6321,000,000 Fr. and foreign of 6321,000 Fr. and foreign of 6321,000,000 Fr.

SWOLD, BATTLE OF: see OLAF I TRYGGVESSON SWORD, a general term for a hand weapon of metal, characterized by a longish blade, and thus distinct from all missile weapons on the one hand, and on the other hand from staff weaponsthe pike, bill, halberd, and the like-in which the metal head or blade occupies only a fraction of the effective length The handle of a sword provides a grip for the hand that wields it, or sometimes for two hands; it may add protection, and in most patterns does so to a greater or less extent.

Early Forms .-- Of the actual origin of swords we have no direct evidence. Neither does the English word nor any of the equivalent words in other languages, Aryan or otherwise, throw any light on the matter. Daggers shaped from reindeer antiers occur among the earliest relics of man, and there are flint daggers of the Neolithic period, which may be supposed to have been the model for the first hand weapons made of copper Bronze took the place of copper about 2000 B C., and the transition from bronze to iron in Europe is assigned to the period 1000 to 700 B.C Whatever the further discoveries of archaeologists, we know that swords are found from the earliest times of which we have any record among all people who have acquired any skill in metal-work There are two very ancient types, which we may call the straightedged and the leaf-shaped. Assyrian monuments represent a straight and narrow sword, better fitted for thrusting than cutting Bronze swords of this form have been found in many parts of Europe, at Mycenae, side by side with leaf-shaped specimens, and more lately in Crete. We have also from Mycenae some very curious and elaborately wrought blades, so broad and short that they must be called ornamental daggers rather than swords. The leafshaped blade is common everywhere among the remains of men in the "Bronze Period" of civilization, and this was the shape used by the Greeks in historical times, and is the shape familiar to us in Greek works of art. It is impossible, however, to say whether the Homeric heroes were conceived by the poet as wearing the leafshaped sword, as we see it, for example, on the Mausoleum sculptures, or a narrow straight-edged blade of the Minoan and Mycenaean pattern. In any case, the sword holds a quite inferior position with Greek warmors of all times. Strange as it is to a modern swordsman, representations m Minoan art seem to show that not only the bronze daggers but the long swords were used with an overhand stabbing action like a modern Asiatic dagger. The handles are too short for any but a rigid grip without finger-play. Before about 1500 B.C. the rapier type was the prevailing one, but there is no evidence of historical connection between the Assyrian and the Minoan rapiers It is thought that the leaf-shaped blade came to the Mediterranean countries from the north So far as we know from works of art, it was mostly used with a downright cutting blow, regardless of the consequent exposure of the swords-

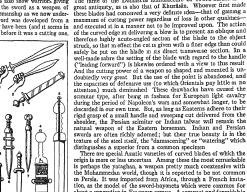
man's body, this, however, matters little when defence is left to a shield or armour, or both. Attic vases also show warriors giving point, though less often The use of the sword as a weapon of combined offence and defence—swordsmanship as we now understand it—is quite modern. If the sword was developed from a spearhead or dagger, it would naturally have been (and it seems in fact to have been) a thrusting weapon before it was a cutting one.

But when we come to historical times we find that uncivilized people use only the edge, and that the effective use of the point is a mark of advanced skill and superior civilization The Romans paid special attention to it, and Tacitus tells us how Agricola's legionaries made short work of the clumsy and pointless arms of the Britons when battle was fairly joined. Asiatics to this day treat the sword merely as a cutting weapon, and most Asiatic swords cannot be handled in any other

Historical Types,-The normal types of swords which we meet with in historical times, and from which all forms now in use among civilized nations are derived, may be broadly classified as straight-edged or curved. In the straight-edged type, in itself a very ancient one, either thrusting or cutting qualities may predominate, and the blade may be double-edged or singleedged. The double-edged form was prevalent in Europe down to the 17th century The single-edged blade, or back-sword as it was called in England, is well exemplified among the Scottish weapons commonly but improperly known as claymores (the real claymore, i.e. great sword, claid-Ligands mdg, is an earlier mediac Fie 1—GREE AND INDARA SWOWLES and I form), and is now all but e. 2–3. Great, et the classical types classically employed for military weapons. But these, with few experiences of the company of the influenced by the curved Oriental sabre. Among early double-edged swords the Roman pat-

Cavairy (monument at Worms)
From Trajan's column. 10. &
Sword handles (Kiel and Mainz) tern (gladius, the thrusting sword, contrasted with the barbarian ensis) stands out as a workmanlike and formidable weapon for close fight. In the middle ages the Roman tradition disappeared, and a new start was made from the clumsy barbarian arm which the Romans had despised. Gradually, the broad and all but pointless blade was lightened and tapered, and the thrust, although its real power was unknown, was more or less practised from the 12th century onwards. St. Louis anticipated Napoleon in calling on his men to use the point; and the heroes of dismounted combats in the Morte d'Arthur are described as "foining" at one another. In the first half of the 16th century a well-proportioned and well-mounted cut-and-thrust sword was in general use, and great artistic ingenuity was expended, for those who could afford it, on the mounting and adornment The growth and variations of the different parts of the hilt would alone be matter enough for an archaeological study. One peculiar form, that of the Scottish basket-hilt, derived from the Venetian pattern known as schiavone, has persisted without material change.

Quite different from the European models is the crescent-shaped Asiatic sabre, commonly called scimitar. We are not acquainted



origin is more or less uncertain. Among these the most remarkable is perhaps the yataghan, a weapon pretty much coextensive with the Mohammedan world, though it is reported to be not common in Persia. It was imported from Africa, through a French imitation, as the model of the sword-bayonets which were common for about a generation in European armies A compact and formidable hand weapon was thus turned into a clumsy and top-heavy pike. The double curve of the yataghan is substantially identical with that of the Gurkha knife (kukri), though the latter is so much

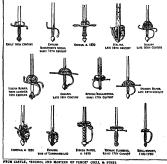


FIG. 2.-TYPICAL EUROPEAN SWORDS, 16TH AND 17TH CENTURIES

broader as to be more like a woodman's than a soldier's instrument. It is doubtful, however, whether there is any historical connection. Similar needs are often capable of giving rise to similar inventions without imitation or communication. There are yet other varieties which have acquired a strong individuality Such are the swords of Japan, which are the highly perfected working out of a general Indo-Chinese type; they are powerful weapons and often beautifully made, but a European swordsman would find them ill-balanced, and the Japanese style of sword-play, being

SWORD 694

two-handed, has little to teach us

Other sorts of weapons, again, are so peculiar in form or historical derivation, or both, as to refuse to be referred to any of the normal divisions The long straight gauntlet-hilted sword (patá) found both among the Mahiattas in the south of India and among the Sikhs and Rajputs in the north, is an elongated form of the broad-bladed dagger with a cross-bar handle (katår), as shown by a transitional form, much resembling in its shape and the size of blade the mediaeval English anlace and furnished with a guard for the back of the hand When once the combination of a long blade with the gauntlet hilt was arrived at, any straight blade might be so mounted; and many appear on examination to be of European workmanship-German, Spanish or Itahan There are various other Oriental arms, notably in the Malay group, as to which it is not easy to say whether they are properly swords or not. The Malay "parang latok" is a kind of elongated chopper sharpened by being bevelled off to an edge on one side, and thus capable of cutting only in one direction The anlace incidentally mentioned above seems to be merely an overgrown dagger; the name occurs only in English and Welsh; in which language first, or whence the name or thing came, is un-

Later European Developments.—In the course of the 16th century the straight two-edged sword of all work was lengthened, narrowed, and more finely pointed, till it became the Italian and Spanish rapier, a weapon still furnished with cutting edges, but used chiefly for thrusting We cannot say how far this transition was influenced by the estot or Panzerstecher, a late mediaeval thrusting weapon carried by horsemen rather as an auxiliary lance than as a sword The Roman preference for the point was rediscovered under new conditions, and fencing became an art Its progress was from pedantic complication to lucidity and simplicity

and the fashion of the weapon was simplified also Early in the 18th century, the use of the edge having been finally abandoned in rapier-play, the two-edged blade was supplanted by the bayonet-shaped French duelling sword, on which no improvement has since been made except in giving it a still simpler guard. The name of rapier was often but wrongly given to this by English writers. About the same time, or a little earlier, the primacy of the art passed from Italy to France. There is still a distinct Italian school, but the rest of the world learns from French masters It is unnecessary here to consider the history of fencing (q v).

Meanwhile a stouter and broader pattern, with sundry minor varieties, continued in use for military purposes, and gradually the single-edged form or broadsword prevailed. The wellknown name of Ferrara, peculiarly associated with Scottish blades, appears to have originally

belonged to a Venetian maker, or family of makers, towards the end of the 16th century. The Spanish blades made at Toledo had by that time acquired a renown which still continues. Somewhat later Oriental examples, imported probably by way of Hungary, induced the curvature found in most recent military sabres, which, however, is such as not to interfere with the effective use of the point. An eccentric specialized variety of the sabre is the narrow and flexible "Schläger" with which German students used to fight their duels, under highly conventional rules almost identical with those of the old English "back-swording" practised within living

FIG. 3,-ORIENTAL SWORDS

ris, 3.—URINTAL SWORDS 1, 2. becorated Persian Arms, 5. Gauntiet Sword, 4. Common type of taiwar (North West Provinces), 5. Yataghan type, 6. Persian talwar-8, Kukri (Nepal), 7, 9 & 10. Mar-hatta, showing transition to gauntiet

memory, in which, however, the swords were represented by

Modern Swords .- The present military swords are descended from the straight "back-sword" and the Eastern scimitar or talwar The difference between the curved "sabre" and straight "sword" has been preserved in some languages (eg, in German, Degen stands for the straight, and Sabel for the curved, sword), though in English the single word



4 --- TYPES OF GERMAN AND BRITISH SWORDS

BRITISM SWUNDS, 18 and 18 sword (men) pattern, 1889, 351, long. 2 British cavality sword (officers) 35½ in long 3. British infantry sword (officers), 32½ in. long. 4 British general officer's sword, 32½ in long

"sword" covers both varieties The shape of the sword has varied considerably at different times; this is due to the fact that it is practically impossible to decide by trial whether a straight or a curved sword is the better under all circumstances The trooper can use his sword in three different ways-to cut, to guard and to point, and his success depends upon the training of his horse, his skill in horsemanship, and, above all, upon the dexterity and methods of his adversary. The result is that changes have often been made in cavalry armament under the erroneous impression that the arm used has been the main cause of

success The Ottoman cavalry up to the end of the 18th century was regarded as one of the best in Europe The curved European cavalry sabre so long in use may undoubtedly be traced to this cause, the superiority of the Turks being put down to their curved scimitars, though horsemanship and dash were really the dominating factors.

The shape of the sword to be chosen depends obviously on the purpose for which it is mainly intended. In this much-debated matter the facts appear to be as follows A determined thrust, especially when delivered by a horseman at full speed, is difficult to parry if it gets home, it will probably kill the recipient outright or disable him for the rest of the campaign. That this is the case is borne out by the very large proportion of killed as compared with wounded in the British cavalry when engaged with that of the French in the Peninsular War, the French making much use of the point, and their heavy cavalry being armed with a long straight sword On the other hand, to deliver a bold thrust, while disregarding the uplifted sword of the adversary, and leaving one's own body and head open to an impending blow, demands complete confidence that the thrust will get home before the blow can descend Such confidence can only be the fruit of long training, especially as it is the natural tendency of all men to cut when excited, therefore, in view of the excitement of the mêlée, it is considered by many unwise to adopt a sword with which a powerful cut cannot be delivered as well as an effective thrust, The swords adopted by most nations in recent times have represented a compromise. They have blades which are nearly straight, but of sufficient weight towards their points to enable an efficient cut to be delivered with them. France, however, in 1898 decided on a long straight sword designed wholly for thrusting practically identical with that which was in use about a century ago. The following year Great Britain introduced a slightly curved weapon, but in 1908 a new sword was adopted which has a long straight blade and is intended to be used chiefly for thrust-

mg. BBLIGGRAFUX—Archaeology and General History J. Naue, Die Vorramischen Schwerter aus Kupper, Bronze und Bien, a standard work for the prehistoric perposis (with map of illustrations, Municla, 1993), R. Forier, "Der Wertegang von Dolch und Schwert," hinzellic tion to Die Schwerter und Schweithnauß der Sommlung Confession Schwerzenbach the best monograph (Lepzig, 1905). Neither of these authors has been able to use the Cretan materials. See also R F. Bur-

authors has been able to use the Cream materials. See also K. F. Bulton, The Book of the Swood (1884).

Special Regions and Periods: For the overlapping of the bronze and iron age in the Homeric poems see R. M. Burrows, The Discoveries in Crete, p. 214 (1907). As to Britain, see H. S. Cowper, The Art of

Athens, vol xix, p 44 (1912-13) The development from Mediter-lanean copper and bronze daggers under northern influence is stated janean copper and bronze daggivs under northein influence is stated by Peake, from . 1500 B c. p. d. r. p. 81, and in moie detail by W. Pulke Brews, "The Bronze Sword in Great Britain" in Archaeologia, vol. lvcin, p. 235 (1932). For the Iberana sword, see S. Ranach, "L'épée de Brennus" in Culter, mythes, et religions, vol. in, p. 14. (1905-08), and H. Sanders, "Wespons of the Iberana" in Archaeologia, vol. law. p. 265 (1933). As the spear still was in Instorical Imms, see A. Petrvaengle and B. Rechhold, Grenchsche Varnmülere times, see A Purtwaengle and B Reichhold, Greechasche Vaenumalres, Sen III, p. 128 (Muntch, 1010) For seimiting, act, see Col Belowe, Sen III, p. 128 (Muntch, 1010) For seimiting, etc., see Col Belowe, of the Rey Soc of Arts (Nov 4, 1921), as to the history of the macharist 'type in Europs er R Sandres, op c.i. For hand-weapons of the Indo-Chinese and Malby types (see of which can be properly Museum, Bulletin No 137 The Collection of Premitive Weapons and Armor of the Philippine Islands in the US National Museum (Walshington, 1930) See also I Dirummond and J Anderson, Ancest Solvenson, 1981 (See 1982) (See 1982) (See 1983) (See 1984) (See 19

Armor of the enurpher Samuel is not of Jandson, as a second migton, 1940. See also J Drummond and J Anderson, Anews Scot-tath Wespons (1881)

Armour The general treatises and handbooks on arms and armour, such as Grose, Meyrick, Hewitt, Lacombe, and Deminin, may be cashed with advantage, but with caution in details The same may be said of published catalogues of museums and collections The following said of published catalogues of museums and collections. The following works are trustworthy W. Boehem, Handbuck der Wolfenhunde (Lepug, 1900), T. Lindenschmit, Tracht und Bewaffung der romstehen Heers wahrend der Koherent (Brunswick, 1882), Lord Egerton of Tatton, Indian and Oriental Armour (1896), R. C. Clephan, The Defensive Armour, and the Wagons and the Englines of War of The Defensive Armour and the Weapons and the Engines of War of Mediaeval Times and the Renaissance (1900), C H Ashdown, British and Foreign Arms and Armour (1909), Sir Guy Laking, The Armour of Windsor Castle (1904), and Record of European Arms and Armour (1020-22)

(1920-21) Regution Castle, Schools and Masters of Fence from Swordsmanship: Egetton Castle, Schools and Masters of Fence from the Stiddle Ages to the Diplement Century (with a critical bibl.), Technology H. Williamson, Regume of War (1841), G. S. Marey Monge, Memorre sur tea orner blanches (Strasburg, Lit, trans by Lt-Co. Maxwell, 1860). For the technique of Japanese swords, see A Dobrée, "Japanese Sword Blades" in the Archaeological Journal, vol lxii, pp 1-18 and pp 218-255 (1905), and for the export of European blades to India see Lord Dillon, ibid, p 67 and pp. 69-72.

SWORDFISH (Xiphias gladius), a large fish, widely dis-tributed in warm seas, dark purplish in colour, and with the snout prolonged to form a long, flat "sword" As in the mackerels, to which it is related, the caudal peduncle is slender and the caudal fin is widely forked. It reaches a weight of about 1,000 lb. It swims swiftly at the surface and feeds on other fishes, especially mackerel, and is said to dash into a school, killing a num-ber with slashes of its sword. The flesh is red and oily and is valued as food, fisheries exist in the Mediterranean and off the Atlantic coast of America, the usual method being harpooning The record swordfish taken with rod and reel was 13 ft. 9 in, long and weighed 860 lb

Related to the swordfish are the spearfishes (Tetrapturus), marlins (Makaira) and sailfishes (Istiophorus) in these the rostrum is not flattened, but is spear-like, rounded in transverse section. Each genus has two or three species, all large fishes of warm seas. Istrophorus americanus of the Atlantic is a beautiful fish, silvery and blue-backed, with the very large sail-like dorsal fin deep blue, with numerous round black spots. The members of this group are said to attack whales, and whereas this is doubtful, it is certain that they frequently strike ships, possibly mistaking them for whales. The sword or spear may be driven into a wooden ship with such force that the fish, in order to get free, has to break it off short. In the Natural History museum in London is a piece of timber, less than a foot square, containing the broken ends of three spears.

Attack (Ulverston, 1906), and O. Montelius, "Chionology of the Bittsh Bronze Age" in Arrhaeologia, vol. bit, pp. 155-6 (1909). For the substitution of boronze for copper, 2000 nct, and the transition from substitution of boronze for copper, 2000 nct, and the transition from control of the state of the substitution of boronze for copper, 2000 nct, and the state century cartier—vr. H. Pecks, The Boronze Age and the Cettier World (1923). For easily more also also seen a Askalohom in Crete "in the Annual of the Bittsh School at Cene at Arkalohom in Crete "in the Annual of the Bittsh School at Cene at Arkalohom in Crete "in the Annual of the Bittsh School at Cene at Arkalohom in Crete "in the Annual of the Bittsh School at Cene at Arkalohom in Crete "in the Annual of the Bittsh School at Cene at Arkalohom in Crete "in the Annual of the Bittsh School at Cene at Arkalohom in Crete "in the Annual of the Bittsh School at Cene at Arkalohom in Crete "in the Annual of the Bittsh School at Cene at Arkalohom in Crete "in the Annual of the Bittsh School at Cene at Arkalohom in Crete" in the Annual of the Bittsh School at Cene at Arkalohom in Crete" in the Annual of the Bittsh School at Cene at Arkalohom in Crete" in the Annual of the Bittsh School at Cene at Arkalohom in Crete" in the Annual of the Bittsh School at Cene at Arkalohom in Crete" in the Annual of the Bittsh School at Cene at Arkalohom in Crete" in the Annual of the Bittsh School at Cene at Arkalohom in Crete" in the Annual of the Bittsh School at Cene at Arkalohom in Crete" in the Annual of the Bittsh School at Cene at Arkalohom in Crete" in the Annual of the Bittsh School at Cene at Arkalohom in Crete "in the Annual of the Bittsh School at Cene at Arkalohom in Crete "in the Annual of the Bittsh School at Cene at Arkalohom in Crete "in the Annual of the Bittsh School at Cene at Arkalohom in Crete "in the Annual of the Bittsh School at Cene at Arkalohom in Crete "in the Annual of the Bittsh School at Cene at Arkalohom in Crete "in the Annual of the Bittsh School a John of Gaunt Catherine had four children, all of whom were boin before their marriage. They were declared legitimate in 1397 and took the name of Beaufort from one of their father's SYAGRIUS (d 487), the last of the independent Roman

administrators of Gaul, was the son of Aegidius, who had seized Gaul while Ricimer was master of Italy Defeated in 486 by Syagrius fled, leaving his land at the mercy of the Franks He sought refuge with Alaric II, king of the Visigoths, at Toulouse, but Alanc imprisoned him instead of granting him refuge, and delivered him up to Clovis. He was executed in 487, secretly

and by the sword, according to Gregory of Tours

SYBARIS, a city of Magna Graecia, on the Gulf of Tarentum, between the rivers Crathis (Crati) and Sybaris (Coscile), which now meet 3 m from the sea, but in ancient times had independent mouths, was the oldest Greek colony in this region. It was an Achaean colony founded by Isus of Helice (about 720 BC), but had among its settlers many Troezenians, who were ultimately expelled Placed in a very feitile, though now most unhealthy, region, and following a liberal policy in the admission of citizens from all quarters, the city became great and opulent, with a vast subject territory and daughter colonies even on the Tyrrhenian sea (Posidonia, Laus, Scidrus) For magnificence and luxury the Sybarites were proverbial throughout Greece, and in the 6th century no Hellenic city could compare with its wealth and splendour. At length contests between the democrats and oligarchs in which many of the latter were expelled and took refuge at Crotona, led to a war with that city, and the Crotoniats, with very inferior forces, were victorious. They razed Sybaris to the ground and turned the waters of the Crathis over its ruins (510 B.C.) Explorations have so far failed to lead to a precise knowledge of the site. The only discoveries have been (1) that of an extensive necropolis, some 8 m to the west of the confluence of the two rivers, of the end of the first Iron age, known as that of Torre Mordillo, the contents of which are now preserved at Potenza, (2) that of a necropolis of about 400 BC-the period of the greatest prosperity of Thuris (q v )-consisting of tombs covered by tumuli, in some of which were found fine gold plates with mystic inscriptions in Greek characters.

SYBEL, HEINRICH VON (1817-1895), German historian, was born on Dec. 2, 1817, at Dusseldorf Sybel was educated at the gymnasium of his native town, and then at the University of Berlin, where he came under the influence of Savigny and of Ranke, whose most distinguished pupil he was to become In 1841 he settled at Bonn as Privatdozent in Instory. He was already known by his Geschichte des ersten Kreuzzuges (Dusseldorf, 1841; new ed, Leipzig, 1881; Eng. trans by Lady Duff-Gordon, 1861) This was followed by a study on the growth of German kingship (Die Entstehung des deutschen Königtums, Frankfurt, 1844, and again 1881), after which he was appointed professor. In the same year (1844) Sybel came forward as an opponent of the Ultramontane party In 1846 he was appointed professor at Marburg, while a seat in the Hessian Landtag gave him his first experience of political affairs. In 1848 he was present at Frankfurt, but did not sit in the National Assembly His opposition to the revolutionary party made him unpopular with the mob, who broke his windows, as his liberalism made him suspected at court. He sat in the Erfurt parliament of 1850, and was attached to the Gotha party, which hoped for the regeneration of SWOYERVILLE, an anthracite-mining borough of Luzerne Germany through the ascendancy of Prussia. During the years of county, Pennsylvania, U.S.A., 3 mi. N. of the public square of reaction that followed all political activity was impossible, but he Wilkes-Barre. Pop. (1950) 7,793.

was fully occupied with his great work, Geschichte der Revo-SWYNFORD, CATHERINE (c 1350–1403), wife of John Mutomate 1750–1500, for which he had made prolonged studies of Gaunt, duke of Lancaster, was a daughter of Sir Payne Roelt. in the archives at Paris and neswhere. The lacet ceitions of the eather volumes are much enlarged and altered, and a new edition was published at Stuttgart in 1882. The first three volumes have been translated into English by W. C. Perry (1867–69) In this work he for the first time showed the connection between the

internal and external history of France

In 1856 Sybal accepted the post of professor at Munch Here he founded the Historische Zeitschrift, the original and model of numerous technical Instorical publications. In 1861 he accepted a professorship at Bonn, which he held till 1875. He was at once elected a member of the Prussian Lover Bouse, and during the next three years was an active member, opposing the policy of Bismarck, not only on financial but also on the Polish and Danish aflars. In 1864 he did not stand for re-election. He had a seat in the Constituent Assembly of 1867, and while he joined the National Liberials he distinguished himself by his opposition to the introduction of universal suffrage, the effects of which he, as did many other Liberials, much distrusted. In 1874 he again accepted a seat in the Prussian parlament. In 1886 he settined

In 1875 he had been appointed by Bismarck director of the Prusian archives. Under his superintendence was begun the great series of publications, besides that of the correspondence of Frederick the Great, in the editing of which he himself took part. His last yeass were occupied on his great work, Die Begrandung des deutschen Ruches durch Withelm I (Munich, 7 vols., 1889–94). He died at Marbug Aug. 1, 1895.

SYCAMORE, the name applied to American species of the genus *Platonus* which also embraces the European and Asiatic planes (see Plane). The eastern sycamore (Platanus occidentalis), also known in certain localities as buttonwood or American plane, is probably the largest hardwood species in the eastern United States Best development is attamed on rich alluvial bottomlands, where it often reaches a height of 150 ft. and a diameter of 8 to 12 ft. It is occasionally found in pure groves, but is much more common as an occasional tree in association with other bottomland hardwood species such as river birch, red and silver maples, American elm, cottonwood and willows. Sycamore features large, simple, shallowly 3- to 7-palmately-lobed leaves, each with a long petiole swollen at the base and enclosing next year's bud. A pair of large foliaceous stipules at each node is another conspicuous feature. The flowers are monoecious and are borne in solitary heads which appear in advance of the leaves. The fruit is a multiple head of obovoid achenes, each furnished at the base with a fringe of brown silken hairs. Winter characters are also distinctive. The stout, brown, conspicuously zigzag twigs feature alternately disposed conical buds that are capped with a single scale and nearly surrounded by a leaf scar. Above each leaf scar is a prominent stipule scar which encircles the twig. The bark on small branches is creamy white; that on larger limbs and the main bole (except near the base of large trees) is characterized by the annual exfoliation of the brown outer layers to expose the lighter yellowish to white layers immediately below.

The Arizona sycamore, P. wright, is one of the most abundant hardwoods of southwestern Unted States. This tree features deeply 5- to 7-lobed leaves and the multiple heads of achenes are borne in racenoes clusters of from two to four. The California sycamore, P racemost, a medium-sized tree of the coast ranges and lower Siera Nevada mountains of California, features 3- to 5lobed leaves, and fruit in racemose clusters of two to seven. (E. S. Ha.)

SYCOPHANT, in ancient Greece the counterpart of the Roman delator (a.n.), a public informer (Cr. arcospérrer). According to ancient authorities, the word (derived by them from else, "fig." and doutse, "its above?" meant one who informed against another for exporting figs (which was forbidden by law). This derivation is doubtful and the question is still contested. Any Athenian citizen was at liberty to accuse another of a public offence. Allusions to the sycophants are frequent in Aristo-phanes and the Attic orators. The word is now generally used in the sense of a cringing flatterer of the great.

Sid La Whibley Companion to Greek Studies (1916).

THOMSON, ist Baron (1799-1841), British statesman, was

born September 13, 1799 After some years spent in his father's busness an Russa and m London he was returned to the House of Commons for Dover in 1826 In 1830 he jouned Lord Grey's ministry as vice-presedent of the board of trade and treasured of the navy He was elected MP for Manchester in 1835, a seat which he occupied for many years In 1839, he accepted the governor-generaliship of Canada, where it fell to his lot to establishing the Canadian constitution were recognized in 1840 by a K C B, and a perage. He took the title of Basine Sydenham of Sydenham in Kent and Toronto in Canada He died unmarried September 4, 1841, when his perages because extinct

His Memons were published by his brother, G. J. Poulett Scrope, in 1843

SYDENHAM, GEORGE SYDENHAM CLARKE, IST BARON (1848-1933), British soldier and administrator, a leading authority on fortification, was boin in Lincolnshire on July 4. 1848. Educated at Haileybury and Wimbledon, and afterwards at the Royal Military Academy, in 1868 he entered the Royal Engineers. Having served in various expeditions abroad, he returned to England in 1885, and was employed at the War Office until 1802 From 1804 to 1001 he was superintendent of the royal carriage factory at Woolwich. On his retirement from Woolwich he was made a member of the committee on War Office reorganization In 1901 he was appointed governor of Victoria (Australia), and on his retirement in 1904 he became secretary to the Committee of Impenal Defence. From 1907 to 1913 he was governor of Bombay. He had been created GCMG. in 1905, and in 1913 was raised to the peerage. In addition to his classic work on Fortification (1896; 2nd ed. 1907), his publications include The Navy and the Nation (1897) and Studies of an Imperialist (1028)

SYDENHAM, THOMAS (1624-1689), English physician, was born on Sept. 10, 1624, at Wynford Eagle, Dorset, the son of a country gentleman He received his MB from Oxford in 1648, and about the same time became a fellow of All Souls After further study and a period of service in the Puritan army. Sydenham continued his researches at Montpellier In 1663 he passed the examinations of the College of Physicians and was thereby able to practise in London In 1676 he became M.D. of Cambridge. He died in London on Dec. 29, 1689. Sydenham's fame among his contemporaries rested on his successful cooling treatment of smallpox, on his laudanum (the first form of a tincture of opium), and on his use of Peruvian bark in quartan agues. But his more important contributions to medicine soon became recognized, and he himself regarded as the English Hippocrates He revived the Hippocratic idea of Epidemic Constitutions, and made an elaborate study of the variations in epidemics of different diseases according to different seasons, years and ages Further, rejecting the traditional dogmas of medicine and insisting that observation should have precedence over theory, Sydenham diligently studied the natural histories of diseases and contended that most forms of ill-health could be ranked in certain definite species His title of the founder of modern clinical medicine is warranted by his clear accounts of the diseases of his day, especially of malaria, plague, smallpox, hysteria and gout. Sydenham is also credited with the first diagnosis of scarletina and with the modern definition of cholera. Acute diseases, such as fevers and inflammations, he regarded as a wholesome effort of the organism to resist injurious influences operating from without. but chronic diseases he held to be due to a deprayed state of the humours arising from errors of diet and methods of life.

Sydenham's chief works are: Methodus curandi Jebres (1668), which appeared in a 3rd edition under the better-known title of Observationes: nedicae (1676); two Epitoles responsories (1680), one 'on Epidemice' and one 'on the Lues veneres'. Dissertatio epitolarist (1682), an account of hysteria, and Tractains de podage et hydroge (1683), his famous description of gout. His last completed work was Processus integri (1629).

SYDENHAM, a large residential district in the south of London, England, partly within the metropolitan borough of Lewisham (q,v). The Crystal Palace (q,v) was in this district. SYDNEY, a city situated in the Sydney Basin (County Cum-

us, bo

# SYDNEY

Sperland) is the capital of New South Wales, Australia, and hes (lat 33° 52' S, 151° 12' E) mainly on the south shore of Port Jackson somewhat south of the central east of the State The oval-shaped area which extends from about Broken Bay (Hawkeshury River estuary) on the north to a little beyond Port Hacking on the south, and from the coast east of Sydney c. 40 miles mland (near Glenbrook) forms the lower part of a geological and tectonic basin which is disposed fairly symmetrically about the line Botany Bay-Penrith.

The Sydney Basın is enclosed on three sides by flattish highlands which are, moreover, deeply dissected and seamed with gorges by streams which now, for the most part, form part of the Hawkesbury system but which formerly had different (westward and north-westward) courses and were dislocated by the late (Tentrary?) uplift which raised the plateaux. On the seaward side, also, recent earth-movements have resulted in the drowning of river valleys and created spacious mlets-Port Hacking, Botany Bay, Port Jackson, Broken Bay—but here also the basin-edge structure is apparent in the upstanding cliffs which form an outer tampart along the coast and give rise, at the entrance of Port Jackson, to the famous Sydney Heads, great sandstone cliffs which admit between them a deep (80 ft. low-water) sea passage of a minimum breadth of 2 mile.

The Sydney Basin is one of the largest coastal lowlands of the State, but its lack of easy land communications makes the presence and growth of Sydney seem somewhat surprising. The reasons are partly physical but more historical the superiority of the deep and sheltered harbour, defensible yet easily accessible from the sea, gave it an advantage over the shallower and more open Botany Bay and the semi-silted Port Hacking, and when Governor Phillip, in 1788, removed the early settlement from Botany Bay, he chose the small deep-water cove at the head of which now stands Circular Ouav, but where was then a fresh-

running stream (Tank Stream) now obliterated.

Port Jackson, sheltered from the southerly gales, covers an area of 22 sq miles and has a highly embayed coastline-a succession of romantic low bluffs and coves, still often densely wooded, giving a total shore-line of nearly 190 miles. It opens a way into the heart of the lowlands and upon its southern and lower shores (elevation 100 ft.) the original settlement grew. For some time it was, from the point of view of its founders, not only "the State," but "all Australia," and from it emanated, and upon it centred, much of the energy and initiative which built up the growing colony. Hence its triumph over physical obstacles, for the roads and the railways have had to cross the highlands at one of their most difficult sections, and, outside the basin, and apart from a few special areas—e g., mining centres, and also the tourist resorts (Katoomba, etc.) attracted by elevation and scenery the barren and rugged highlands at a distance of 50 miles are still almost unoccupied. The city expanded rapidly (pop. 1861, 97,061; 1901; 487,932; 1921, 906,103) until in 1933 the total metropolitan area contained 1,235,267 inhabitants, or 47.5% of the population of New South Wales. The metropolitan area includes the city proper (Sydney in 1933 with 88,312; North Sydney 49,749) and a group of suburbs organized into a total of 48 additional municipalities. Altogether in 1933 it covers an area of 244 sq. miles and has a density of 5,062.98 per sq. mile. But this concentration of a large portion of the citizens of a vast State into what is virtually the Sydney Basin is characteristic. The remarkable growth of large industrial cities, which in so many countries has drained the countryside during the last half century, has characterized Australian growth from almost the beginning and without the typical agrarian preliminary stage.

However, as the city grows, industrial and commercial occupation advances and the residential areas are pushed farther out. Thus the higher and less accessible northern shores of the harbour have developed mainly as residential areas (e.g., Ryde, pop. 27,861). Industries are expanding along the southern shore—Redfern (18,834), Paddington (24,674), Balmain (28,472)—and westwards—Granville (19,718), Parramatta (18,076), Lidcombe (17,379)—so that residential areas are now developing far afield. Along the southeast coast is Randwick (78,957) and in the Bot- Heads and close to the busine

any Bay (q v) area are Berdey ( ? ... mned Hurstville (22,663) and Canterbury (70 mally erally healthful and invigorating, coul mally winds in winter (May to September in his. cover unpleasantly humid in summer The provident was ber-April (inclusive) are from the north 6r). from 70 1° F in summer to 56 2° F in with anv thev F and 35 9° F. Sydney is a city of sunthing Rainfall is distributed throughout the year isted and winter maximum (Feb-July) and et : 4 gical besides its splendid site, has had the advantage that r un conlocal quarries The old town had win-hit part of the and enclosed streets. In spite of much record to any wear tenalong the water-fronts-some of these 167 the an old-world flavour. The public building ren notably fine, the two Cathedrals (Anglican at 1) bus the University, Post Office, several of the king of the king. besides some of the public galleries, etc. 1 gard face The main streets also offer excellent special and and out and substantial architecture, while it; .. ... (Government House, etc.) have historical at the late of the unusually well endowed with parks, recreated to get . and mine Domain, Hyde Park which commands man a product water in addition the Sydney Cricket Ground, the Hours, Salvall and Society's Ground where is held annually the it is the total made cultural show in the State. There are 6,000 at 15 and the serves in the municipalities, and two national restricts by home Park, 16 miles south of Sydney (33,800 ac.) area : 1 + Hr hand and the Kuringgai Chase (35,300 ac.) 15 miles north to Berling Bay-both with magnificent scenery-less to come and Parramatta and Botany Bay, making a total (14574 6/ 146 hour se reserves besides 440,000 ac. commons within the (greater) states politan area.

The harbour of Sydney, with its coves, creeks and beggs, is a favourite pleasure resort, as are also such besther to Maria for surf-bathing, etc. Sydney has an excellent and as well water supply derived chiefly from the Nepean, Cataract and Company Rivers (347 sq.miles catchment), the reservoirs containing (1941) So,000 million gal. Trams (375 m. of track of which the miles are electric, the remainder steam) and electric and steam research serve the city and suburbs, and ferries ply in the hartway. The great steel-arch Sydney bridge, completed in 1931, spans the her bour from Dawes Point (south) to Milson Point (porth), has a total length of 3,770 ft. (main arch span, 1,652 ft.; cleares; t vessels passing underneath, 170 ft.), and carries a roads av vessels passing underreauti, 170 11.), and carries a roads sy wide, two fontways, and four lines of rulway. It is one largest steel-arch bridges in the world. The city is, is real its social, educational and artistic life a leading city of the ern hemisphero. There are 6,123 factories employing hands in the Sydney Basin area (Cumberland Counts) hands in the Sydney Brain and Committees 5,974 factories and 183,600 hands are in the marea. Clothing, metal, machinery (including railway and committees the committees of th mdustries are the most important, food and drinks coming next. (For industrial areas and suburbs: v. is also the chief commercial, banking, warehousing centre of the State. Upon it are centralized the from its own basin, but from a very large part of the meat, butter, fruit and many other primary pr way to the city, from inland or by coasting s sumption or for export, but most important ar istic is wool. Sydney is by far the largest wo Australia and its sales, which begin in Son months, are world-famous. Port Jackson

rivalled opportunities for harbou The Sydney Harbour Trus has pursued a vigorous policy and largely transformed the e of the water-front. The princi

developp stitufe elop

companies, etc. Woolloomooloo Bay (6.000 ft wharfage) is the principal overseas harbour, Circular Quay (3,600 ft ) is used both for fetry and overseas traffic, Glebe Island (4,800 ft) is the wheat-exporting hatbour with modern appliances including an elevator of 6,500,000 bu, capacity, and there are also wool, timber, and other special cargo whatves, warehouses, etc. All these are on the southern shores and do not include ferry wharves. private jetties, etc. The islands (9) in Port Jackson are either pleasure resorts or used for special (naval, fire-station, etc.) purposes. On Cockatoo Is and at Woolwich are large graving docks. Some 7,500-8,500 vessels (7,500,000-0,130,000 tons) have entered Sydney Harbour in recent years, of which c 2,400 (7,200,oco tons) are engaged in overseas, the remainder in inter-state (coasting), trade. In 1939 the cargoes shipped amounted to 212,oco tons interstate; and 1,000,000 tons overseas. The total discharged was 1,400,000 tons. The total overseas trade is valued at more than £100,000,000, constituting Sydney easily the first port in Australia and one of the foremost in the British empire

in Australia and one of the foremost in the british empire See Griffich Taylor, "The Warped Littoral Around Sydney" in Proc. Royal Soc. N.S.W., vol. lvn, 1923, and also in Commonwealth Year Book, No. 20, 1927, etc.; K. Ussher, The Cities of Australia (1928). Official Year Book of N.S.W. (1938-39).

SYDNEY, the chief city of Cape Breton county, Nova Scotia. on a good harbour, the eastern terminus of the Canadian National railway. Pop. (1951) 31,317. Formerly a quiet country town, it became between 1891 and 1901 the chief shipping port of the Dominion Coal company, which has ten collieries within a radius ot ten miles of the city, and the site of the large works of the Dominion Iron and Steel company.

On the opposite side of the harbour are the flourishing towns of North Sydney and of Sydney Mines. The town is the starting point for the line of steamers to the Bras d'Or lakes and a favourite summer resort. North Sydney is the terminus of the ferry line to Port aux Basques, Nfd. Sydney is a trunk line port of call of

several air lines to St. John's, Nfd.

SYED AHMAD KHAN, SIR (1817-1898): see SAYYID Ahmad Khan, Sir.

SYENITE, in petrology, the group name for a class of plutonic rocks composed essentially of an alkali-felspar and a ferromagnesian mineral A special group of alkali-syenites is characterized by the presence of a felspathoid mineral (nepheline, leucite, analcime or sodalite).

The name was first used by Pliny for the rock occurring at Syene (Assuan) on the Nile in Upper Egypt This rock, so ex-tensively worked in ancient times for monumental structures, is a hornblende-granite with abundant quartz, Werner subsequently adopted the name for the class of tocks defined above, of which the type example is the hornblende-syenite of the Plauen'scher Grund, near Dresden. As essential constituents there occur sodaorthoclase and green hornblende with subordinate amounts of oligoclase felspar The texture of syenites is like that of the granites, hypidiomorphic-granular. Mineralogically these rocks differ from granites only by the absence or scarcity of quartz. The alkali-felspars include orthoclase, perthite or albite, more rarely microcline, while the ferromagnesian mineral may be biotite, hornblende or pyroxene. In the alkali-syenites, the amphiboles or pyroxenes are frequently soda-bearing varieties. The more normal syenites are divisible into augite-, hornblende-, and biotite-syenites according to their prevalent dark-coloured mineral, but syenites are also divisible, as in the case of granites, into potash and soda syenites, according to the type of alkalifelspar. The accessory constituents include sphene, apatite, zircon, magnetite and pyrites. Quartz, except in the special group of alkali-syenites, is rarely absent, but never abundant. A special suite of accessory minerals, cancrinite, eudialyte eucolite, katapleite, melanite, corundum, etc., is found in this latter class. Syenites are by no means common, and are not of equal importance with granites and diorites from a geological standpoint.

Among the potash syenites, are classed the original hornblende-

syenite (Plauen), and the well known hornblende-syenite of Biella, Piedmont, of which analyses are given below.

The rocks known as nordmarkite, akerite, larvikite and pulas-

controls c 63,000 ft. of wharfage which is leased to shipping kite are classed among the soda syenites. Of these the first two are quartz-bearing and were originally described from the Oslo region (Norway) Nordmarkite is built up of pink microperthite and subordinate aegitine and arrvedsonite together with some quartz. Akerite is a quartz bearing augite-syenite with considerable plagnoclase. The larvikites are augite-syenites with large cryptopertintic (anorthoclase) felspars possessing a remarkable schiller structure They are coarse-grained rocks, origmally described from Larvik (Norway), and their great freshness and indescent appearance when polished make them favourite ornamental stone for facades and pillars. The subordinate constituents are titaniferous augite, olivine, and barkevikitic hornblende. The pulaskite svenites, first described from the Fourche mountains, Ark., consist of soda-orthoclase, alkalıhornblende together with some biotite. The occasional presence of nepheline indicates their close relation to the nepheline-syenites (an) Rocks transitional between syenites and diorites are known as monzonites (q v).

The following analyses show the chemical composition of a few of the principal types of syenite. They are characterized by a moderate amount of silica, relatively high alkalis and alumina. while lime and magnesia are more variable, but never in great

	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	FeO	MgO	CaO	Na <sub>2</sub> O	K20
1 2	60·52 59 37	16 65 17 92	2 97 6-77	2 15	2 32 1 83	4·73 4 16	4 43 1 24	4 39 6 68
3	59.88 58.88	17 87	2 67 3 63	1 50 2 58	1 04	2 OI 3 O3	7·96 5 73	5 69 4 50
5	58 97	16 33	2.72	4 14	2 72	4 29	4 10	4 54

- Hornblende-syenite, Plauen'scher Grund, Dresden Hornblende-syenite, Biella, Piedmont Nordmarkite, Oslo, Norway Larvikite, Larvig, Norway Syenite (mean of 12 analyses).

(C. E. T)

SYKES, SIR MARK, 6TH BARONET (1879-1919), English traveller and politician, was born on March 16, 1879, in London, the only son of Sir Tatton Sykes, 5th baronet. He was educated at Beaumont college, Windsor, at Monaco, at Brussels and at Jesus college, Cambridge He served with the Yorkshire Militia in the South African War (1902). On his return he travelled for some time in Syria, Mesopotamia and southern Kurdistan, and, after a short period (1904-05) as secretary to George Wyndham in Ireland, was appointed honorary attaché to the British embassy in Constantinople.

At the outbreak of World War I he raised a battalion of the Yorkshire Regiment, but did not accompany it to France He was sent by the Government on important special missions to Bulgaria, Serbia, Russia, Mesopotamia and Syria. His special knowledge and qualifications led, m 1915, to his participation in the Anglo-French conversations in London on the Syrian question He was an enthusiastic advocate of Arab independence The settlement arrived at is known as the "Sykes-Picot Agreement." Sykes then became attached to the Foreign Office and was on several occasions sent on missions to Egypt He was on friendly terms with the Arabs and designed the flag under which they marched to Damascus. In 1918, hoping to reconcile the aims of the French and the Arabs, he established himself at Aleppo, and his diplomacy in a difficult position rendered valuable service to the Government. His efforts, however, told on his health and he died in Paris of influenza on Feb. 16, 1919.

His publications include: Through Five Turkish Provinces (1900); Derail-Islam (1904), Five Mansions of the House of Olhman (1909); The Caliph's Last Heritage (1915).

See Shane Leile, Mark Sykes, his Life and Letters (1923); for the terms of the Sykes-Peot Agreement, see Temperley, History of the Peac Conference at Paris (vol. vi., 1924).

SYKES, SIR PERCY (MOLESWORTH) (1867-1945), British soldier, was born on Feb. 28, 1867, and educated at Rugby and Sandhurst. In 1888 he obtained a commission in the 16th Lancers, afterwards being transferred to the 2nd Dragoon Guards. In 1893 he began his travels in Baluchistan and Persia, in the

African Wai, he was a member of the Intelligence department. and also commanded with distinction the Montgomery Imperial Yeomanry After holding appointments as consul general for Khurasan (1905-13), and for Chinese Turkistan (1915) he was created KCIE in 1915 In 1916 he was appointed, with the rank of brigadier general and the title of inspector general, to organize a force of Persian troops to restore order in southern Persia This step was taken in consultation with the Persian government He landed at Bandar Abbas in March 1916 For an account of the campaign see Persia, Campaigns in Sykes held the post of GO C in southern Persia until the end of 1918 In 1919 he received the CB He retired in Sept 1920, and died in London on June 11, 1015

He published accounts of his travels in Ten Thousand Miles in Persia (1902), The Glory of the Shia World (1910), Through Deserts and Oases of Central Asia (with Ella Sykes, 1920) He also wrote a History of Persia (1915), a biography of Sir Mortimer Durant (1926), A History of Exploration (1934) and History of Afghanistan, 2 vols (1940).

SYLHET, a town and district of British India, in the Surma valley division of Assam The town is on the right bank of the river Surma, on rising ground, embowered in groves, and has a station on the Assam-Bengal railway With a population (1041) of 28.128. it is, next to Shillong, the largest town in Assam The chief institutions are the Murarichand college, Sanskrit college, Madrasa and leper asylum.

The DISTRICT OF SYLHET has an area of 5,478 sq miles It consists of the lower valley of the Surma or Barak river, and for the most part is a uniform level, broken only by scattered clusters of sandy hillocks called tilas, and intersected by a network of rivers and drainage channels. It is a broad and densely-cultivated plain The rainfall is heavy, reaching an annual average of 159 in , of which over 100 in fall between June and October,

In 1941 the population was 3,116,602. The normal cultivated area is 2,400,000 ac, giving an average of nearly an acre a head. but much of the district is low lying and subject to floods. Ten cultivation is a flourishing industry in the southern hills. The tea gardens had a population in 1921 of 169,000, with 90,000 ac. under tea and an output of 29,000,000 pounds Lime is extensively quarried; under the Mogul Government Sylhet lime was a monopoly of the nawabs of Bengal Other industries are boatbuilding and the manufacture of fine reed mats, buttons from fresh-water shells, ironwork inlaid with brass, and perfume the perfume is exported to Turkey, Arabia and China

SYLLABUS, literally something taken together, a collection (Late Lat syllabus), hence a compendium, table or abstract giving the heads, outline or scheme of a course of lectures, teaching, etc The word in the sense of a list or catalogue is used of a collection of eighty condemned propositions, addressed by order of Pius IX to all the Catholic episcopate, under the date of the 8th of December 1864 The official title is: "A collection (syllabus) containing the principal errors of our times as noted in the Allocutions, Encyclicals and other Apostolic Letters of our Holy Father Pope Plus IX." Discussion of disputed doctrines began in 1840 All aspects were thoroughly debated by clerical and lay theologians gathered in a commission in 1861 The result of it was the Syllabus, in eighty propositions, arranged under the distinct heads; the propositions are not accompanied by any theological censure, but simply by a reference to the Allocution, Encyclical or Letter from which each had been more or less textually extracted. This was addressed to the episcopate together with a letter from Cardinal Antonelli, and dated the 8th of December 1864, the same date as the Encyclical Quanta cura, from which, however, it remains quite distinct. Its publication aroused the most violent polemics; what was then called the Ultramontane party was loud in its praise; while the liberals treated it as a declaration of war made by the Church on modern society and civilization Napoleon III's government forbade its publication, and suspended the newspaper PUnivers for having published it Controversies were equally numerous as to the theological value of the Syllabus Most

course of which he founded the consulates for Kerman and Per- Catholics saw in it as many infallible definitions as condemned sian Baluchistan (1894) and in Serstan (1899) During the South propositions, others observed that the pope had neither personally signed nor promulgated the collection, but had intentionally separated it from the Encyclical by sending it merely under cover of a letter from his secretary of state, they said that it was hastily, and sometimes unfortunately drawn up (cf prop 61); they saw in it an act of the pontifical authority, but without any of the marks required in the case of dogmatic definitions, they concluded, therefore, that each proposition was to be appreciated separately, and in consequence that each was open to theological comment That such is the true view is proved by the fact that Rome never censured the theologians who, like Newman, took up this position (The condemned propositions are given in convenient form in Latin and English in Schaff, Creeds of Christen-dom, vol 11, "Greek and Latin Creeds," pp 213 sqq)

BIBLIOGRAPHY—The documents from which the propositions of the Syllabus were borrowed have been collected together in the Recuerl Syllabus were botrowed have been collected togethei in the Rezeast des allocations constronized, etc., eties dans Pencydque et le syllabus (Paius, 1865). Fou the history of the Syllabus P. Hourat, Le Syllabus (Paius, 1865). Fou the history of the Syllabus P. Hourat, Le Syllabus (Red decarmantare (Paris, 1904), and P. Rindis, Il Valore et al. 1866). Research (Red Control of the Paths of Norfolk (London, 1872). P. Viollet, L'Unigliabitat des pape et le syllabus (Paius, 1904). I. Choupun, Valore des disconsis doctrandes et disciplinares du Sant Salge (Paris, 1907). See sub Mgr. Dupalnoup, La Convention du 3 experimente et proposition de disciplinares du 8 décembre (Paris, 1865), and fou the opposite view, see Tracewa, Le Syllabus et a décâncion des donts de Phomme (Paris, 1865).

SYLLOGISM, in logic, denotes a mediate argument, that is an argument in which an inference is drawn about the relation between two terms from two premises which state the ielation of each of the two terms to the same third term For instance. "The morning star is Venus, the evening star is Venus, therefore the evening star is the morning star" (or vice versa) It is usual to say that syllogism is not only mediate but also deductive reasoning, that is to say that it requires the application of a general premiss to relevant cases For example, "All planets move in elliptical orbits, Venus is a planet, therefore Venus moves in an elliptical orbit" This argument is mediate, like the previous example, but it is also deductive (or involves the application of a general premiss, or a premiss concerning a whole class of objects) whereas the previous example was not deductive Now, it is true that syllogisms are mostly deductive as well as mediate, but there is no sufficient reason for restricting the term to deductive cases only. Moreover, just as an argument may be mediate without being also deductive, so an inference may be deductive without being mediate. For instance, "All watches have a hair-spring, therefore my watch has one" It is also customary to restrict the term syllogism to arguments the propositions of which involve only relations of substance and attribute, as in the above examples But for this also there is no good reason. The arguments (z) "x=y; y=z, therefore x=z," and (z) "M is north of P; S is west of M; therefore S is north-west of P," are also syllogisms. west of M, therefore S is nontrivers of F, are also synogenies. For, after all, "syllogism" means "thinking together" or, as one might say, "putting two and two together." It is true, however, that syllogisms involving other relationships than those of identity or of substance and attribute require special care, much more than the others. See Logic.

SYLT, the largest German island in the North Sea, being about 38 sq m in area and nearly 23 m, long. It is, however, very narrow, being generally about half a mile in width, except in the middle, where it sends out a peninsula to the east 7 m. across. It lies from 7 to 12 m from the Schleswig coast. The chief places are Keitum, Tinnum, Morsum, Rantum and Westerland. The latter is a favourite pleasure resort. During the Danish War of 1864 the island was in the hands of the Danes but was occupied by the Piussians later in that year (See Frisian Islands )

SYLVANITE, a mineral consisting of gold and silver telluride, AuAgTe4, containing gold 24-2 and silver 13-3%; an important ore of gold. Crystals are monoclinic and often very rich in faces; they are frequently twinned, giving rise to branching forms resembling written characters; on this account the mineral was early known as "graphic gold" or "graphic tellurium" (Ger, Schrifterz). It was also known as "white gold," the colour being tin-white with a brilliant metallic lustre. The hardness 15 2, specific masmuch as the bacteria are able, in some way not yet clear, to gravity 8 2 It occurs with native gold in veins traversing porphyry at Offenbánya (= Baia de Aries) and Nagyág (= Săcărâmb) in Transylvania (from which country it takes its name); also at several places in Boulder county, Colorado, and at Kalgoorhe in Western Australia Sylvanite may be readily distinguished from calaverite, AuTe2, by its perfect cleavage in one direction (parallel to the plane of symmetry), but in this character it resembles the very rare orthorhombic mineral krennerite ([Au, Ag]Te2)

SYLVESTER, JOSHUA (1563-1618), English poet, the son of a Kentish clothier, was born in 1563. He was in 1591 in the service of the Merchant Adventurers' Company, and from 1606 had a small pension from Prince Henry He was stationed, in his business capacity, at Middelburg, in the Low Countries, where he died on Sept 28, 1618 He translated into English heroic couplets the scriptural epic of Guillaume du Bartas. His Essay of the Second Week was published in 1598; and in 1604 The Divine Weeks of the World's Birth Sylvester's popularity ceased with the Restoration, and Dryden called his verse "abominable fustian"

His works were reprinted by Dr A B. Grosart (1880) in the "Chertsey Worthies Library" See also C. Dunster's Considerations on Milton's early Reading (1800)

### SYLVIIDAE: see WARBLER.

SYLVITE, a mineral consisting of potassium chloride, KCl, first observed in 1823, as an encrustation on Vesuvian lava Wellformed crystals were subsequently found in the salt deposits of Stassfurt in Prussia and Kałusz in Poland. It crystallizes in the cubic system with the form of cubes and cubo-octahedra and possesses perfect cleavages parallel to the faces of the cube. Although the crystals are very similar in appearance to crystals of common salt, they are proved by etching experiments to possess a different degree of symmetry, namely plagihedial-cubic, there being no planes of symmetry but the full number of axes of symmetry Crystals are colourless (sometimes bright blue) and transparent; the hardness is 2, specific gravity 1-08 Like salt, it is highly diathermanous The name sylvite or sylvine is from the old pharma-(L J.S) ceutical name, sal digestivus sylvii, for this salt.

SYMBIOSIS, a mutually beneficial internal partnership between two organisms of different kinds, such as sea-anemone and unicellular algae. It differs from commensalism, where the partnership is external, as in the case of some hermit-crabs (e.g., Pagurus bernhardus) which have as constant companions certain sea-anemones (e g , Adamsia rondeletii) It also differs from endoparasitism, which is not beneficial to the host; though it is possible that some symbionts or symbions, e.g., the bacteria in the root-tubercles of Leguminosae, began as parasites, and that some parasites began as symbionts. The term mutualism is often used to cover both symbiosis and commensalism; and the term commensalism is sometimes used as equivalent to mutually beneficial symbiosis. This unnecessary confusion is increased when parasitism is called "antagonistic symbiosis"

The idea of symbiosis first became clear in regard to lichens, which were shown to be mutually beneficial combinations of an alga and a fungus This was demonstrated analytically by De Bary (1866) and others, while Rees and Stahl were subsequently successful in building up a lichen synthetically from the appropriate alga and fungus. Symbiosis between two different plants is also illustrated by the numerous cases of mycorhiza (q v), where a fungus has entered into intimate and profitable partnership with the roots of other plants, such as oaks, pines and orchids. Sometimes, as in the case of heather, the partner fungus spreads through the whole plant, from root to stem, from leaf to flower, and even into the seed. It is this partnership with a fungus that enables the heather to flourish on the soil of the moorland where few other plants can survive. This mycorhizarelation is now known to be very common, and it occurs in various forms. Thus the fungus may be ectotrophic, investing the roots externally, as in the beech; or it may be endotrophic, penetrating into the internal tissue, as in orchids. Also symbiotic is the occurrence of tubercle-forming bacteria (e.g., Bacillus radicicola) in the roots of leguminous plants, a linkage of great importance,

capture and fix the tree atmospheric nitrogen

A second form of symbiosis is between an animal and an included unicellular green alga, such as Zoochlorella The plant is sheltered, and it may be borne about by the animal, whose respiratory carbon dioxide it can utilize in its photosynthesis The animal profits by the oxygen given off by its minute partners, and it can also utilize the carbon-compounds which the algae build up. Some green animals-green because of the included algae-can flourish for a long time without any extraneous food, being sufficiently sustained by what their symbionts supply Most animals of a green colour are green because of these partnerplants, many of which are included in the genera Zoochlorella and Zooxanthella This was first made clear by Cienkowsky, Geddes and Brandt in regard to the "yellow cells" found inside radiolarians, whose symbiosis probably contributes to the great wealth of numbers and of species exhibited by these pelagic Protozoa While there seem to be some Protozoa, such as euglenids and Vorticella viridis, which have chlorophyll corpuscles of their own, most of the green or greenish Protozoa, eg. Stentor, owe the colour to their symbionts The same is true for freshwater sponges, Hydra viridis, some sea-anemones, most reef-corals, numerous Alcyonarians, some Turbellarians, and a few higher forms, eg, a polyzoon and a sea-slug Very interesting is the small turbellarian worm, Convoluta roscoffensis, which creeps from the sand and forms green patches on the flat beach at Roscoff, in Brittany, when the tide goes out Its life has become intimately wrapped up with a symbiotic alga, one of the Chlamydomonadineae As Keeble has well shown, there are four chapters in the history of Convoluta The very young worm feeds independently Then green symbionts appear and multiply, and the worm is nourished from within as well as from without Thirdly Convoluta ceases to take any solid food and depends entirely on the photosynthetic activity of the symbions. Finally, the animal digests its partners, and, having done so, dies

A third type of symbiosis, especially studied by Buchner, is seen in many insects where fungoid plants, eg, bacteria and yeasts, live in the lining cells of the food-canal and assist in some obscure way in the process of digestion. These intracellular symbionts are known in at least seven orders of insects, especially in types that feed on dry wood and the like. The fungoid infection usually takes place in the egg-cell. In some cases there is a special organ or "mycetome" for the multiplication of the symbionts. In a few luminescent marine animals, e g, some cuttlefish, (such as Sepiola elegans) there is considerable evidence that the light is produced by symbiotic bacteria

A similar type of symbiosis is illustrated by the wood-eating species of termites, which have remarkable infusorians in their food-canal. These are essential to the health of the termites which die when bereft of them. Their symbiotic function is to digest the wood, which no higher animal is able to do Thus there may be symbiosis between plant and plant, between plant and animal, or between animal and animal

BIBLIOGRAPHY —A. S. Pearse, Animal Ecology (1926); J. M. Coulter, C. R. Barnes and H. C. Cowles, Textbook of Bolany, vol. 2 (Chicago, 1911); Paull Buchner, Tier und Pflanze in intracellularer Symbiose (1921); F. Keeble, Plant-Animals (1910). (J. A. Th.)

SYMBOL, the term given to a visible object representing to the mind the semblance of something which is not shown but realized by association with it. One of the first symbols of the Saviour, the fish, was derived from an acrostic of the Greek word lxθbs, the component letters of which were the initials of the five words Ίησοθε Χριστός, Θεοθ Υίός, Σωτήρ, Jesus Christ, Son of God, Saviour. The ship, another early symbol, represented the Church, in which the faithful are carried over the sea of life Other symbols are those which were represented by animals, real or fabulous, and were derived from Scripture: thus the lamb typified Christ from St. John's Gospel (i 29 and 36), and the lion from the Book of Revelation, where (v 5) Christ is called the "Lion of the tribe of Juda" The peacock stood for immortality: the phoenix for the Resurrection; the dragon or the serpent for Satan; the stag for the soul thirsting for baptism.

sacred monogram Chi Rho, & supposed to have been the celestial sign seen by the emperor Constantine on the eye of the defeat of Maxentius, represents the two first letters of the Greek word Χριστός which Constantine figured on his labarum, or standard. and is tound on early Christian coins bearing also the favourite decoration of the Byzantine sarconhagi

SYMBOLISM: see PAINTING

SYMBOLISTS, THE, the name given to a large but loosely connected group of French poets (many of them of foreign extraction) writing in the 1880's The term decadent was often used as an alternative, especially of the extreme manifestations of the movement. In 1888 the critic Brunctière suggested that the history of French poetry from the 17th century could be plotted in three phases, the architectural, the pictorial and the musical Bearing this programme in mind and taking as examples from his own literature Dryden's Ode to Mistress Anne Killigrew, Keats's Ode on a Grecian Urn and Tennyson's Claribel, the English reader will best understand the scope and extension of the Symbolist movement. In its origin the movement was a revolt against Naturalism as being too concrete, and against Parnassianism as being too clear-cut, to satisfy young minds who had caught from E A Poe and Baudelaire, from Wagner, and to some extent from the Pre-Raphaelites, the "sense of the meffable" and were seeking a medium for its expression. Their object was not to declaim, not to depict, and least of all to transcribe, but to suggest to communicate in their lost subtlety the most intimate and evanescent tones of experience. Baudelaire himself, Banville, Gérard de Nerval and Villiers de l'Isle Adam had already been engaged in the same quest. The common stock of poetic symbolism has been accumulated to serve common uses a private symbolism, unless it is forced into currency by a great poet, is bound to be largely unintelligible and will often be suspected at least to be nonsense It is not surprising therefore that the French public was at first half inclined to regard the new poetry as a hoax, and on the other hand to take seriously a volume of parodies Les Déliquescences d'Adoré Floupette (1885) which first made it popularly familiar. But in the meantime Verlaine had entered the circle, he gave it a watchword "Pas de couleur, rien que la nuance," and in his book Trois Poètes Maudits introduced the young decadents to their true masters, Rumbaud, Corbière, Mallarmé The year 1885 may be taken as the centre of the movement, besides the three already mentioned, Rodenbach, Verhaeren and Jean Moréas had then already appeared Laforgue, H de Régnier and Vielé Griffin published their first volumes in 1885, and they were followed by Rémy de Gourmont in 1886. Maeterlinck in 1889, Claudel in 1890, Robert de Montesquieu in 1803 With Samain's first volume in this last year the movement may be said to rejoin the main stream. Its principal representative, in prose, had been J K Huysmans, as poets, Rimbaud, Verlaine and Mallarmé, still after 40 years dominant influences in French literature. It was Mallarmé who provided the symbolists with their aesthetic theory and the most accomplished models of metric style, and in the whole course of the movement his weekly conversations were probably the most effective influence at work-an influence not unfelt in England, where it coincided with the aesthetic movement and the Celtic renascence.

Constitute with the selected involvent and the centre fractione of Emilionary.—A. Symons, The Symbolist Royement in Literature Emilionary of the Symbolist Royement in Literature A. Barthelot, etc., 31 vols., 1837—1903); Catulle Mendes, Ropport set I movement polique français de 1876 4 1900 (1903); all with blographies; also R. de Gourmont, Livre des Masques (1896); E. Vigid-Locco, La police contemporation (1896).

SYME, JAMES (1799-1870), Scottish surgeon, was born in Edinburgh on Nov. 7, 1799. His chemical experiments at the university led to the discovery that a substance obtainable from coal tar would dissolve india-rubber, and could be used for waterproofing silk and other textile fabrics, an idea patented a few months afterwards by Charles Mackintosh, of Glasgow. From 1818 he held resident appointments in the infirmary and the fever hospital, and in 1823 took charge of the anatomy classes of Robert Liston. In 1824-25 he started the Brown Square school of medicine, and later a surgical hospital of his own, Minto House hospital, which he carried on from 1829 to 1833 with great success

as a surgical charity and one of the first schools of clinical instruction In 1833 he became professor of clinical surgery in the university, a post which he held until his acceptance of the chair of clinical surgery at University college, London, in 1847 Misunderstanding concerning the conditions of this appointment led him to return to his old position in Edinburgh, where he was recognized as the leading consulting surgeon of Scotland In 1849 he broached the subject of medical reform in a letter to the lord advocate and in 1854 and 1857 addressed open letters to Lord Palmerston In 1858 a Medical Act was passed which largely adopted his suggestions, and he became a member of the general medical council called into existence by the act. In April 1869 he

had a paralytic seizure and died near Edinburgh on June 26, 1870 Among Syme's labours may be mentioned his early papers on the nature of inflammation, his demonstrations of the function of the periosteum in the repair of bone, his introduction into Britain of excision of the elbow and of amputation at the ankle-joint, his treatment of ulcers by blistering, his study of diseases of the

rectum and his general improvements in plastic surgery

In 1831 he published On the Excision of Diseased Joints (the celebrated ankle-joint amputation is known by his name); in 1832 Principles of Surgery, Diseases of the Rectum in 1838; Stricture of the Urethra and Fistula in Perineo in 1840 and Exission of the Scapula in 1864, Contributions to the Pathology and Practice of Surgery in 1848 and Observations in Clinical Surgery in 1861 See R. Paterson, Memorials of the Life of James Syme (1874)

**SYMEON,** "the Great," Bulgarian tsar (? -927) succeeded his father Boris  $(q\ v\ )$  in 893, after the short intervening reign of his dissolute elder brother, Vladimir Educated in Constantinople, Symeon was probably destined by his father for the aichbishopric of Bulgaria, and at one time took monastic orders

His dominant ambition, himself to ascend the imperial throne of Byzantium-an aspiration afterwards shared by many Bulgarian tsars-led Symeon to embark on many wars with the empire (894, 896, 913, 917, 923) He never took Constantinople, although it was more than once at his mercy; but he took for himself the title of "Tsar of all the Bulgarians" (918) and raised the archbishop of Bulgaria to the rank of a patriarch. In the Balkans he extended the power of Bulgaria over south Macedonia, south Albania and Serbia, which became his vassal, but Bulgaria's shadowy domimon north of the Danube was probably lost during his reign Symeon was twice married, and left four sons, of whom the second, Peter, succeeded him

SYMEON METAPHRASTES, the most renowned of the Byzantine hagiographers The menology of Metaphrastes, who is thought to have lived in the second half of the roth century, is a collection of lives of saints for the twelve months of the year, consisting of about 150 distinct pieces, some of which are taken bodily from older collections, while others have been subjected to a new recension (μετάφρασιs). Among other works attributed (though with some uncertainty) to Symeon are a Chronicle, a canonical collection, some letters and poems, and other writings of less importance. The Greeks honour him as a saint on Nov. 28, and an office has been composed in his honour See A Ehrhard, Die Legendensammlung des Symeon Metaphrastes (Rome, 1897).

SYMMACHUS, QUINTUS AURELIUS (c. 345-410), was a brilliant representative of 4th-century paganism in Rome He was educated in Gaul, and in 373 was pro-consul of Africa (for his official career see CIL vi. 1699). His public dignities, which included that of pontifex maximus, his great wealth and high character, added to his reputation for cloquence, marked him out as the champion of the pagan senate against the Christian emperors. In 382 he was banished from Rome by Gratian for his protest against the removal of the statue and altar of Victory from the senate-house, and in 384, when he was prefect of the city, he addressed to Valentinian II a letter praying for the restoration of these symbols. After this Symmachus was involved in the rebellion of Maximus, but obtained his pardon from Theodosius, and appears to have continued in public life up to his death In 391 he was Consul ordinarius. His honesty. both in public and in private affairs, and his amiability made him very popular. As his letters do not extend beyond the year 402, he probably died soon after that date

Of his writings we possess (1) Panegyites, written in his youth, two on Valentinian I and one on the youthful Gratian, (2) mine books of Epistles, (3) parts of Complimentary Orations, five trem a palimposes (also containing the Panegyite'), of which part is at Milan painingsest (also containing the Paneryics), of which part is at Milan and part in the Vatiena, discovered by Mai, who published the Milan fiagments in 1815, the Roman in his Scriptorian veterain nova collectro, vol 1 (1825), and the whole in 1846; (4) the Relationes, which contain an interesting account of public life in Rome, composed for the emperor All cather editions are now superseded by that of O Seech in Monumenta Germaniae historica Auctores antiquissimi (1881), 11, 1, with introductions of his line, works and chronology

SYMMACHUS, pope from 498 to 514 had Anastasius II for his piedecessor and was himself followed by Hormisdas He was a native of Sardinia, apparently a convert from paganism, and was in deacon's orders at the time of his election. The choice was not unanimous, another candidate, Laurentius, having the support of a strong Byzantine party, and both competitors were consecrated by their friends, the one in the Lateran church and the other in that of St Mary, on Nov. 22, 498 A decision was obtained in favour of Symmachus from Theodolic, to whom the dispute had been referred; but peace was not established until 505 or 506, when the Gothic king ordered the Laurentian party to surrender the churches of which they had taken possession. An important incident in the protracted controversy was the decision of the "palmary synod" The remainder of the pontificate of Symnachus was uneventful, history speaks of various churches in Rome as having been built or beautified by him

SYMMETRIC FUNCTIONS. A symmetric function is a rational function of  $x_1, x_2, \dots, x_n$ , which is unchanged when any of the  $x_1, x_2, \ldots, x_n$  are interchanged If  $x_1, x_2, \ldots, x_n$ are roots of an equation  $x^n + a_1 x^{n-1} + \dots + a_n = 0$ , then the coefficients as represent certain symmetric functions of the 100ts, for example,  $r_1+x_2+$  .  $+x_n=-a_1$ ,  $(-1)^n$   $r_1$   $x_2$  .  $x_n=a_n$ . This type of function occurs in algebra (see EQUATIONS, THEORY OF), group (R. G SR) theory and statistics

SYMMETRY, due proportion of parts, in geometry the metrical correspondence of parts with reference to a median plane or line or point; and in algebra the correspondence of terms in a function in such a way that the function is unaltered when any two variables on which it depends are interchanged (See Func-TION ) The word is derived from the Greek συμμετρία, symmetria, due proportion, from σύν, syn, with, and μέτρον, metron, measure. In botany it implies agreement in number and distribution of parts among the organs of a flower; and in zoology it implies symmetrical disposition of parts around a line in the body or on opposite sides of a plane through the body. The term is also used with various derived meanings in architecture, aesthetics, crystallography, etc., and it appears even in certain ancient theories (as that of Herodotus, for instance) concerning the distribution of rivers, etc., on the earth

SYMONDS, JOHN ADDINGTON (1840-1893), British essayist and historian of the Italian Renaissance, was born at Bristol on Oct 5, 1840. He was educated at Harrow and at Balliol college, Oxford, and was elected a fellow of Magdalen college. He died in Rome on April 19, 1893.

Of acute sensibility, he developed early symptoms of pulmonary disease and, after many journeys in search of health, finally (1877) settled at Dayos Platz in the Swiss highlands, where most of his work was done, though with frequent journeys to Italy. Symonds found in literary work and in the society of his Swiss friends and neighbours relief from torturing metaphysical doubts, and his output was very large. His chief work, The Renaissance in Italy (7 vol., 1875-86), is rather a series of extended essays than a systematic history but has passages of both insight and eloquence. He also translated the Sonnets of Michelangelo and Campanella (1378), the Autobiography of Benvenuto Cellini (1887), and the Memours of Carlo Gozzi (1890). His Life of Michelangelo Buonarrotts (1892) is a work of great industry and research, but shows signs of failing powers.

Earlier he had published two series of Studies of the Greek Poets (1873-76), several volumes of travel sketches, and monographs on Shelley (1878), Sir Philip Sidney (1878) and Ben Jonson

(1886), and on the day of his death appeared his study of Walt Whitman, with whom he had corresponded and of whom he was Whitman, with whom he had contesponded and of whom he was one of the first European admirers. His verse is of less account Bitallogarativ—HR RF Brown, John Addington Symonds, a Biography, and at Clondon, 1921), Van Werk, Brooks, J. John Clondon, 1921), Van Werk, Brooks, J. John C. Law, and J. S. Clandon, 1921), Van Werk, Brooks, J. John C. Law, and J. 
SYMOND'S VAT, one of the most famous view points on the River Wye. England It stands on the River Wye o mi above Monmouth and 12 mi below Ross, on a deeply incised meander nearly 5 mi long and 600 vd across the neck. The penmsula forms Huntsham bill (Carboniferous limestone), in which there are catterns

The Yat or Gate is situated on the west side of the neck (height 500 ft ), and a road from the east drops to a ferry, which was of early importance The Yat is in Herefordshire, but the railway station opposite is in Gloucestershire. There are cottages and mns on both banks, New Weir is opposite the Yat and a little above it is Whitchurch, both small villages The river banks are densely wooded, except where they become sheer cliffs, as at the Coldwell rocks above the station

The views from the Yat embrace the Forest of Dean to the south and east and are backed by the mountains of the Welsh border in the west

SYMONS, ARTHUR (1865-1945), English poet and critic, was born in Wales of Cornish parents, on Feb 28, 1865. He was educated privately, spending much of his time in France and Italy He was a contributor to the Vellow Book and in 1806 became with Aubrey Beardsley editor of the Savoy Symons was an admirer of Stephane Mallarmé, Charles Baudelaire and Paul Verlaine, and he did much to spread the ideas of the French symbolists in England He was an acute critic and covered a wide field. His poetry belongs mainly to the fin de siècle in feeling. His works include verse-Silhouettes (1892), London Nights (1895), Amous Victima (1807), Images of Good and Evil (1000). The Fool of the World (1906), prose-The Symbolist Movement in Literature (1899), Studies in Prose and Verse (1904), Spiritual Adventures (1905), Studies in Seven Arts (1906), Studies in Elizabethan Drama (1920), Charles Baudelaire (1920), Confessions, an autobiography (1930). He also contributed a number of articles to the Encyclobædia Britannica

Bibliography -Collected Works of Arthur Symons (London, 1924,

SYMPATHETIC SYSTEM, in physiology By the "sympathetic system" is understood a set of neives and ganglia more or less sharply marked off from the cerebrospinal, both functionally and anatomically (For anatomy see Nervous System) Formerly it was thought more independent from the rest of the general nervous system than recent discoveries have found it actually to be The sympathetic system is now known to consist entirely of conducting paths which, like the nerve trunks of the cerebrospinal system, merely conduct nerve impulses either toward the great nervous centres of the spinal cord and brain, or, on the other hand, away from those great centres. In the cerebrospinal nerves, the preponderance of the conduction is toward the centres, in the sympathetic system the preponderance of conduction is away from the centres

More is known of the sympathetic system from its efferent aspect than its afferent, and we shall consider the former first. One great difference between the efferent paths of the sympathetic and those of the ordinary cerebrospinal system is that the former carry nervous impulses not only to muscular tissue but to secreting glands, whereas the latter convey them to muscle only, indeed only to muscle of the striated kind. Another difference is that the efferent path which the sympathetic affords from the great central nervous centres to its muscles and glands consists always of two nerve cells or neurones, whereas the effecent path afforded by the cerebrospinal motor nerves consists of one neurone only. The two neurones forming the sympathetic path are so arranged that one of them whose cell-body lies in the spinal cord has a long axon-process passing out from the cord in the motor spinal

ganglion, quite distant from the spinal cord and somewhere on the way to the distant organ which is to be innervated In this canglion the first sympathetic neurone ends, forming functional connection with ganglion cells there These ganglion cells extend each of them an axon-process which attains the organ (muscular cell or gland cell), which it is the office of the sympathetic path to reach and influence The axon-process of the first neive cell is a myelinated nerve-fibre extending from the spinal cord to the ganglion, it constitutes the pre-ganglionic fibre of the conduction chain The axon-process of the second nerve-cell, that is the neurone whose bell-body hes in the ganglion, is usually non-myelinate and constitutes the post-ganghonic fibre of the chain.

This construction, characteristic as it is of the sympathetic efferent path, has been found also in certain other efferent paths outside the sympathetic proper. And as these other efferent paths convey impulses to the same kind of organs and tissues as do those of the sympathetic itself, it has been proposed to embrace them and the sympathetic under one name, the autonomic system. This term includes all the efferent paths of the entire body excepting only those leading to the voluntary muscles

That the term "autonomic system" is not merely a convensence of nomenclature, but seally represents a physiological entity, seems indicated by the action of nicotine This drug acts selectively on the autonomic ganglia and not on the cerebrospinal. In the former it paralyses the nexus between pre-ganghonic and post-ganglionic fibre It is by taking advantage of this property that many of the recent researches which have done so much to elucidate the sympathetic have been executed.

The term "autonomic system" must not be taken to imply that this system is independent of the central nervous system. As mentioned above in regard to the sympathetic, that is not the case The autonomic system is closely connected with the central nervous system through the ordinary channel of the nerveroots, spinal and cranial. It may, in fact, be regarded as an appendage of certain of the cranial and spinal roots

The sympathetic is that part of the autonomic system which is connected with the spinal roots from the second thoracic to the second lumbar inclusive (man). Its ganglia are divided by anatomists into the vertebral, those which he as a double chain on the ventral face of the vertebral column, and those which lie scattered at various distances among the viscera, the pre-vertebral. Langley has shown that there is no essential difference between these except that the vertebral send some of their post-ganglionic fibres into the spinal nerves, whereas the latter send all their fibres to the viscera. The sympathetic sends its post-ganglionic

- I. To the muscular coats of the whole of the alimentary canal from the mouth to the rectum; to the glands opening into the canal from the salivary glands in front back to the intestinal glands; to the blood vessels of the whole of the canal from mouth to anus inclusive.
- 2 To the generative organs, external and internal, and to the muscular coats of the urinary bladder.
- 3. To the skin; (a) to its blood vessels; (b) to its cutaneous glands; (c) to unstriated muscle in the skin; e.g., the erectors of the hairs
  - 4. To the iris muscles and blood vessels of the eyeball.

The sympathetic nervous system is sometimes called the visceral. It will be seen from what has been said that this term is not well suited in some respects, because the sympathetic supplies many structures which are not visceral. Another objection is that a great deal of important nerve-supply to the viscera is furnished by parts of the autonomic system other than sympathetic. That the sympathetic does, however, of itself constitute a more or less homogeneous entity is indicated by a curious fact. The substance adrenalin has the property when introduced into the circulation of exciting all over the body just those actions which stimulation of the efferent fibres of the sympathetic causes, and no others. It is possible that when a nerve is stimulated some body at the nerve ending is set free, and this by combining with and thus the loss of heat from the body through that channel les-

root, and this extends to a group of nerve-cells, a sympathetic another chemical substance induces activity in the end organ (gland or muscle) It may be that when a sympathetic nerve is excited adrenalm is set free and combines with some substance which induces activity. (See Adrenatin, Supra-renal Ex-

TRACT.) The rest of the autonomic system consists of two portions, a cranial and a sacral, so called from their proceeding from cranial and sacral nerve-roots respectively The cranial portion is subdivided into a part belonging to the mid-brain and a part belonging to the hind-brain The ciliary ganglion belonging to the eyeball is the ganglion of the former part, and its post-ganglionic fibres innervate the iris and the ciliary muscles. The hind-brain portion gives pre-ganghonic fibres to the facial (intermedius), glossopharyngeal and vagus nerves, its post-ganglionic distributton is to the blood vessels of the mucous membrane of the mouth and throat, to the musculature of the digestive tube from the oesophagus to the colon, to the heart, and to the musculature of the windpipe and lungs.

The sacral part of the autonomic system issues from the spinal cord with the three foremost sacral nerves. Its ganglia are scattered in the neighbourhood of the pelvic organs, which they innervate. The distribution of its post-ganglionic fibres is to the arteries of the rectum, anus and external genitalia and to the musculature of the colon, rectum, anus, bladder and external genitalia

The past played by the sympathetic and the rest of the autonomic system in the economy of the body is best considered by

following broad divisions of organic functions.

Movements of the Digestive Tube.-It is those movements of alimentation not usually within range of our consciousness which the autonomic system regulates and controls Nor is its control over them apparently essential or very complete. For instance, the pendular and peristaltic movements of the intestine still go forward when all nerves reaching the viscus have been severed Extirpation of the abdominal sympathetic has not led to obvious disturbance of digestion or nutrition in the dog It is noteworthy that the sympathetic inhibits contraction of the musculature of the stomach and intestine, while the other, the vagus, portion of the autonomic system excites it

Action on the Circulation .- The arterial blood supply of most organs is under the control of vaso-constrictor nerves. All vaso-constrictor nerves are sympathetic Organs to which vasoconstrictor nerves are supplied either poorly or not at all are the lungs heart, lives and probably the skeletal muscles. In some parts the capillary vessels are supplied with sympathetic constrictor nerves. The blood vessels of certain parts of the body have, in addition to vaso-constrictor nerves, nerves which relax their muscular wall, vaso-dilatory nerves. The latter are never furnished by the sympathetic, they are in the mucous membranes and glands at the oral end of the body furnished by the cranial portion of the autonomic system. In regions at the aboral end of the body they are furnished by the sacral portion of the autonomic system. Elsewhere the vaso-dilatators when present are derived from the nerve-cells of the spinal ganglia (Bayliss).

The control of the calibre of the blood vessels by the autonomic system is of importance in several well-ascertained respects By constricting the blood vessels of the viscera the system is able to favour an increase of blood supply to the brain. A noteworthy instance of such an action occurs when the erect attitude is assumed after a recumbent posture. Were it not for vaso-constriction in the abdominal organs the blood would then, under the action of gravity, sink into the more dependent parts of the body and the brain would be relatively emptied of its supply, and fainting and unconsciousness result. Again, it is essential to the normal functioning of the organs of warm-blooded animals that their temperature, except in the surface layer of the skin, should be kept constant. Part of the regulative mechanism for this lies in nervous control of the quantity of blood flowing through the surface sheet of the skin That sheet is a cool zone through which a greater or smaller quantity of blood may, as required, he led and cooled. By the sympathetic vaso-constrictors the capacity of these vessels in the cool zone can be reduced. sened. In cold weather the vaso-constrictors brace up these skin vessels and lessen the loss of heat from the body's surface. In hot weather the tonus of these netwes is relaxed and the skin vessels dilate; a greater proportion of the blood then circulates through the compara-

tively cool skin zone

The heart itself is but a specialized part of the blood-vascular tubing. and its musculature, like that of the arteries, receives motor nerves from the sympathetic. These nerves to the heart from the sympathetic are known as the accelerators, since they mucken and augment the beating of the cardiac muscle The heart receives also nerves from the cramal part of the autonomic system, and the influence of these nerves is an-tagonistic to that of the sympathetic supply The cranial autonomic nerves to the heart pass via the vagus nerves and lessen the beating of the heart both as to rate and force. These inhibitory nerves of the heart are analogous to the dilatator nerves to the blood vessels, which, as mentioned above, come not from the sympathetic but from th cranial and sacral portions of the autonomic system The spleen which functions as a blood reservoir (Barcroft) for the general circulation, discharges its reserves by contraction of its capsule and septa; its scle is innervated by the sympathetic

muscie is inhervated by the sympathetic Skin Glands.—In close connection with the temperature regulat-ing function of the sympathetic stands its influence on the sweat-secreting glands of the skin Secretory nerves to the sweat glands are furnished apparently exclusively by the sympathetic

Pilomotor Nerves.—The skin in many places contains muscle of the unstriped kind Contaction of this cutaneous tissue causes knotting of the skin as in "goose-skin." and erection of the hairs as in the cat, or of the quills as in the hedgehog and porcupine The efferent the cat, or or the quities as in the needgenog and porcupine. The elicient nerve fibres to the unstripped muscles of the skin are furnished by the sympathetic (polomotor nerves, etc.) In this case the sympathetic contributes to emotional reactions and perhaps further to the regulation of temperature, as by fuffling the fur or feathers in animals exnosed to the cold

The Respiratory Tube .- The windpipe and the air passages of the lungs contain in their walls much unstriped muscular tissue, arranged so as to control the calibre of the lumen. The nerve supply to this muscular tissue is furnished by the cranial autonomic system via

the vagus nerves

Eyeball.—An important office of the sympathetic is the controlling of the brightness of the visual image by controlling the size of the pupil The sympathetic sends efferent fibres to the dilatator muscle of the pupil. In this case, as in others noted above, the cranial muscle of the pupil. In this case, as in others hoted above, the crahial part of the automotic system sends never so in altagonistic effect to the effects of the pupil and the property of the sends of the pupil. This same part of the crainal automotic system supplies also motor fibres to the ciliary muscle, thus effecting the accommodation of the lens for focusing clearly objects within the range of what is termed near-vision than the pupil of the pupil and the pupil of the pupil and the pupil of the pupil and the pupil of the pupil and the pupil of the pupi

Of the afferent fibres of the sympathetic little is known save that they are relatively to the efferent, few in number, and that they, like the afferents of the cerebrospinal system, are axons of nerve cells

seated in the spinal gangia (C. S.)
SYMPHONIC POEM (Symphonische Dichtung, Tondichtung, Poème symphonique, etc.) This term was first used by Franz von Liszt in his 12 Symphonische Dichtungen. It implies a large orchestral composition which, whatever its length and changes of tempo, is not broken up into separate movements and which, moreover, gratuitously illustrates a train of thought external to the music and to its conditions of performance The form of the symphonic poem is dictated by its written or unwritten program; and so it is not every piece of "program music" that can be called a symphonic poem. Beethoven's sonata Les Adieux and his Pastoral Symphony are, for instance, works in which the poetic idea does not interfere with the normal development of sonata style.

Great disturbances in musical art have always been accompanied by appeals to external ideas. New art forms are not born mature, and in their infancy their parent arts naturally invite other arts to stand godfather It is certain, first, that no theorizing can long prevent musical ideas from growing where and how they please; secondly, that musical ideas are just as likely to be inspired by literature and other arts as by any other kind of experience; and lastly, that, as musicians gain in mastery, their music outstrips their literary analysis; hence the frequent ability of great composers to set inferior words to music which is not only great, but evidently based upon those words; hence the disgust of great composers at unauthorized literary interpretations of their works; hence, on the other hand, the absence of any strain on the classical composer's conscience as to making his music gratuitously illustrative. Accordingly, the importance of the symphonic poem lies, not in its illustrative capacity, but in its tendency toward a new instrumental art of tomorrow.

The symphonic poem has been described elsewhere (see Music, section 9, and Paosam Music) as the application of the Wagnerian time scale to symphonic music. List is successful only where he is writing on a hardly more than lyric scale, as in Orpheus, or, at the utmost, on a scale less than that of the earliest and best of all symphonic properties. phonic poems, Schubert's Wanderer fantasia (op 15) Schubert had not the slightest idea that he was writing a symphonic poem; but in that piece he achieved everything that Liszt attempted, even to the metamorphosis of whole sections Liszt's efforts on a larger time scale do not even begin to solve the problem, they achieve no sense of movement at all, and the device of deriving all their themes from a single figure is totally irrelevant. Charles Saint-Saens and Césai Franck are incapable of such failure, and their symphonic poems flow very conindepable of such failure, and their symphonic poems flow vely com-venengly, though not on a very large seal. They also illustrate their subjects aniusingly enough. The first achievement of real Wagnesian symphonic at belongs to Richard Strauss The power of composition in his 4800 speach Zarathasira, Ein Heldenkben, the osterationally but deceptively patiety Dor Ojunosie and the Symphonic Domestica with care and the strain of the strain of the strain of the strain SYMPHONY, in music (?) The term outphorie was used

by the Greeks, first, to denote concord, in general, whether m successive or simultaneous sounds, secondly, in the special sense of concordant pairs of successive sounds (i.e., the "perfect") interval of modern music, the 4th, 5th and octave), and thirdly, as dealing with αντιφωνού, the concord of the octave, thus meaning the art of singing in octaves, or magadizing, as opposed to δμοφωνία, or singing and playing in unison. In Roman times the word appears in the general sense, which still survives in poetry, viz, as a harmonious concourse of voices and instruments. It also appears to mean a concert. In St. Luke xv. 25. it is distinguished from vocal and translated as signifying "music and dancing." Polybius and others seem to use it as the name of a musical instrument.

(2) In the 17th century the term is used, like "concerto," for certain vocal compositions accompanied by instruments, e.g. the Symbhoniae sacrae of Henrich Schutz. The modern use of the word symphony for the instrumental ritornello of a song is also found in Schutz's Kleine geistliche Concerte

(3) The principal modern meaning of the word is a sonata for orchestra (see Sonata Forms). The orchestral symphony originated in the operatic overture (qv), which in the middle of the 18th century began to assimilate the essentials of the sonata style. Mozart's overture to his early opera, La Finta Gurdiniera, marks the breaking point between three-movement symphony and operatic overture, since it contains the usual first movement and slow movement, and the curtain rises with what sounds like the beginning of its third movement.

Though the sonata style is dramatic, the stiffness of its early forms did not help C. W. Gluck toward his ideal of an overture that should

and not neight. We direct toward his ideal of an overture that should not not neight to the contrast of loosely kell passages of various textures in vague forms which he learned from San Martini. These as no less wident in the symphonies of Philipp Emmanuel Back niede the dis-wident in the symphonies of Philipp Emmanuel Back niede the dis-mity of the symphony, but the style was more essential than the form, and in Mozarit's and Haydra's matter works we find the sonata form and in Mozart's and Haydn's mature works we find the sonata form a firmly established in the overture as in the symphony, while the styles are quite distinct. Mozart's most chalorate overture, that of lates a symphonis, nor could the finale of his Jupiter symphony be taken for a prelude to an opera See also Muser, SONATA FORMES; INSTRUMENTATION, OTHERURE, SCHENDY, VALISTONE.

SYMPHOSIUS or SYMPOSTUS, the name given to the author

of a collection of 100 riddles of uncertain date, but probably composed in the 4th or 5th century A.D. They have been attributed to Lactantius and identified with his Symposium, but this view is not generally accepted. The style and versification of the riddles, each of which consists of three hexameter lines, are good. They were written to form part of the entertainment at the Saturnalia.

SYMPHYLA. A group of small myriapoda (q.v.), the largest less than a centimetre ( 39 in.) long They are fragile, almost white in colour, often quite active and may readily be mistaken for young centipedes; indeed, when the first symphylid was described by G. A. Scopoli in 1763, he referred it to the well-known centipede genus Scolopendra. Symphyla are known in many countries, about 70 species having been described; but proper search would doubtless greatly increase this number. They live in moist. loose soil, under stones or in damp decaying vegetation Though they occasionally deyour the bodies of small dead insects, they subsist mainly on plant food, in captivity they feed readily on fragments of potato or carrot, and one species (Scutigerella immaculata) has acquired an unenviable reputation in Europe and America as a pest in greenhouses and even in cultivated land, where it damages the roots of asparagus, beets, carrots, lettuce, spinach and many other crops Soil furnigants (carbon bisulphide or paradichlorobenzene) are recommended for control in greenhouses, lengthy flooding may be beneficial on cultivated land

The body of the symphylid (see fig 1) consists of a head and of a trunk of 14 segments, the segmentation being obscured, however, by the presence of two tergites on some of the segments The head bears a pair of long agile moniliform antennae, and at their bases the sense organs of Tomosvary, of unknown function. Eyes are absent The mouth appendages comprise (1) a pan of segmented mandibles, (2) a pair of maxillae, with minute spinclike palp, (3) a pair of second maxillae which, alone among myilapods, are united into a labium as in insects. The first 12 trunk segments bear each a pair The first 12 tunk segments oear each a pail and the first pair being diminutive and rosent indeed sometimes absent. The 13th segment rosent bears the backwardly directed cerd (spin-bears the backwardly directed cerd (spin-bears) and the segment rosent the backwardly directed cerd (spin-bears) and the segment rosent the segment rosent ro nerets), capable of secreting a thread when MANDALATA ADULT the animal is disturbed, the last segment carries a pair of long tactile setae At the bases of most of the legs are



the coxal sacs (presumably moisture-absorbing organs) and, in many forms, the coxal styles (see fig 2) The intestine is a simple straight tube, consisting of fore-, mid- and nid-gut, and from the latter arise two malpighian tubes. The heart ahove the intestine and traverses the length of the body. The hind-gut, and from the latter arise two malpighian tubes. The lies above the intestine and traverses the length of the body respiratory organs are tracheae, of which there is a single pair, with openings on the side of the head, they supply chiefly the brain and

anterior trunk segments. The genital ducts pass forward from the reproductive organs and have a single median opening on the floor of the fourth segment. The only FEMALE GENITAL.
OPENING is the presence of a pair of curved genital plates in the male (fig 2)
The females lay their eggs in

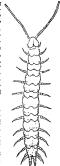
small clumps in the soil or in decaying vegetation, sometimes mounting guard beside them The young emerge with six (in some species seven) leg-bearing segments, the ad-ditional segments being added singly at the hinder end as the larva grows In Scutigerella immaculata

a longevity of as much as four years has been observed.
Three families of Symphyla are recognized (1) Scalependrillidae.
Coal styles weak or absent; 35 tenglios Example Scalependrillidae.
Coal styles weak or absent; 35 tenglios Example Scalependrillidae.
The styles of the Symphyla are styles of the Symphyla shoding to this family, (3) Geophielidae 22 tenglies, rare. Example, Geophielida.
To the scolesight the Symphyla are or much interest, for they are ovidthe Insects arose. Indeed, the name Symphyla was given them by J. H.
Rydur (1885) on Mondest their amendent position between myrispods
and hascit, their remarkable resemblance to such primitive insects as
the state of a longevity of as much as four years has been observed

LATA

Campodae being later stressed by many writers. The one obstacle to this interpretation—the fact that they are Prognosta and not Opisthogoneata (see Myrkarona)—has been removed by the working out of their embryology, for the reproductive ducts are found to arise from pleternal ingrowths in the growing larva and not from recommodates in the reforming the stress of t

(συναγωγή lit. "assembly") or their place of worship or, more gen-



STYLE
FOURTH LEG
COXAL SAG GENERAL PLATES OF MALE

FOURTH SEGMENT SEEN

FROM MICHELBACKER IN "BILGARDIA" (UNI VERSITY OF CALIFORNIA) FIG. 2 -- SCUTIGERELLA IMMACU

FROM BELOW, TO SHOW DIFFER-ENCE BETWEEN MALE (ABOVE) AND

in the porch of Strasbourg cathedral. (Illustrations and explanation of the allegory on pp xii, xxxvi. of Legacy of Israel, 1927 ) The usual Hebrew term for synagogue is not or not the (Kenéseth on Beth hak-Kenésoth), in Ps lxxiv., 8 מיטייאל (assemblies of God) is assumed to refer to synagogues There can be no doubt but that the synagogue, Ezra's main work, grew up with the Temple and developed from it By the time of the fall of the Temple, synagogues were well established, for differences of synagogal and Temple liturgy are known, and when the Temple fell, the synagogue remained unaffected, it had long become an independent institution The synagogue was the place of study, the law was read on Sabbaths (Acts xv , 21), festivals and market days in an annual, and also in a trienmal cycle (on this see articles in Jew Quart Rev by A Buchler [V 420-68 vi, 1-73] and by J Abrahams [vvi, 579-83] and "Trennial Cycle" in Jew Enc) The lessons from the Pentateuch were translated by a Meturgemān or translator (from the same root as Targām and dragoman qqv), lessons from the prophets (see Harrāṣa) concluded the service, in which preaching and exposition were included On Jesus and the synagogue, see I. Abrahams (Studies,

erally, Judaism as contrasted with Christianity; the last sense is

exemplified by the famous pair of statues, Church and Synagogue,

I, 1, 1917)
The synagoue was not limited to Palestine, it has, in fact, been termed the "child of the dispersion," but this does not imply that it was the product of the Helene Tomples, that at Assoum in the stin extension of the still rich contributions to the Temple in 6s s o from the synagogues of Under the term Prosecutive (recomes) place of prayer). Roman authors speak of synagogues, and their allusions show that these places were common. The officials of the synagogue were the degreen/every-to-Luke common the officials of the synagogue were the degreen/every-to-Luke common the officials of the synagogue were the degreen/every-to-Luke common the officials of the synagogue was the degreen that the degree of the deg [Luke XIII, 14.] of Hassan (III. overseer, evenous) a teacher, reader or beadle who inflicted sourping (Madqill, Matt x, x) when decreed by the eldes (peepforgeo, pepseis) through their depower or chef members Major disciplinary punishments were exormunication (Heren) and exclusion (Madqil). The ancient Galienn synagous ran north and south (modern bulkings are orientately) and possegues ran north and south (modern bulkings are orientately) and possegues ran north and south (modern bulkings are orientately) and possegues ran north and south (modern bulkings are orientately) and possegues ran north and south (modern bulkings are orientately) and possegues ran north and south (modern bulkings are orientately) and possegues ran north and south (modern bulkings are orientately) and possegues ran north and south (modern bulkings are orientately) and possegues ran north and south (modern bulkings are orientately) and possegues range (modern bulkings). sessed a nave and turn aisles

sessed a nave and two males. Billionard and session a nave and two males are supposed fluorey, etc., in f etc. f and f at f and f and f at f and f at f and f and f at f and f and f at f and

SYNAPSE, the functional conjunction between two neurons, making conduction of nervous impulses continuous from one to the other. Synapses occur between the axone terminations of one neuron, and the cell body of an adjacent cell This type of synapse is called axosomatic. Synapses also occur between axone terminations of one neuron and the dendrites of the next, and are then termed axodendritic. Adjacent neurons may be connected by both types of synapse. The term synaptic nunction is used to describe this functional and anatomical relation. The term is also used in embryology to denote the pairing and union of the homologous chromosomes of the male and female pronuclei. This process is also named syndesis. (W M M .: X)

SYNCRETISM, the act or system of blending, combining or reconciling inharmonious elements The term is used technically in politics, as by Plutarch, of those who agree to forget dissensions and to unite in the face of common danger, as the Cretans were said to have done; in philosophy, of the efforts of Cardinal Bessarion and others in the 16th century to reconcile the philosophies of Plato and Aristotle; and in theology, of a plan to harmonize the hostile factions of the Church in the 17th century, advocated by Georg Calixtus, a Lutheran professor of theology at Helmstadt. Its most frequent use, however, is in connection with the religious development of antiquity, when it denotes the tendency, especially prominent from the 2nd to the 4th centuries of the Christian era, to simplify and unify the various pagan religions. During this period, as a result of the intimate knowledge of the world's religions made possible by the gathering of every known cult of importance into the religious system of the Roman Empire, belief in the identity of many deities which resembled each other, and indeed in the essential identity of all, received a special impulse. Not only were various forms of the same deity, such as, for example, Jupiter Capitolinus and Jupiter Latiaris, recognized as being really the same under different aspects, but even the gods of different nations were seen to be manifestations of a single great being Roman Jupiter, Greek Zeus, Persian Mithras and Phrygian Attis were one. The Great Mother, Isis, Ceres, Demeter, Ops, Rhea, Tellus, were the same great mother deity under different masks (see Great Mother of the Gods) Venus and Cupid, Aphrodite and Adonis, the Great Mother and Attis, Astarte and Baal, Demeter and Dionysus, Isis and Serapis, were essentially the same pair. Syncretism even went so far as to blend the deities of paganism and Christianity. Christ was compared with Attis and Mithras, Isis with the Virgin Mary, etc. Isis, perhaps more than any other deity, came to be regarded as the great maternal goddess of the universe whose essence was worshipped under many different names

Naturally, the influence of Greek philosophy was very pronounced in the growth of syncretism. Plutarch and Maximus of Tyre affirmed that the gods of the different nations were only different aspects of the same deity, a supreme intelligence and providence which ruled the world. The Neoplatonists, however, were the first school to formulate the underlying philosophy of syncretism: "There is only one real God, the divine, and the subordinate deities are nothing else than abstractions personified. or celestial bodies with spirits; the traditional gods are only demons, that is, beings intermediate between God and man. . . . All, like every other created being, are emanations from the absolute God" (Jean Réville, La Religion à Rome sous les Sévères). Care must be taken, however, not to place too much emphasis represented was not new in the 2nd century A.D. The identification of Latin with Etruscan gods in the earliest days of Rome, and then of Greek with Italian, and finally of Oriental with the Graeco-Roman, were all alike syncretistic movements, though not all conscious and reasoned The ideal of the common people, who were unreflecting, as well as of philosophers who reflected, was "to grasp the religious verity, one and constant, under the multiplex forms with which legend and tradition had enveloped it" (Réville). The advent of Greek philosophy only hastened the movement by conscious and systematic effort.

Syncretism, being a movement toward monotheism, was the converse of the tendency, so prominent in the early history of Rome, to increase the number of deties by worshipping the same god under special aspecta excording to special activities. In the hands of the Neophtonists it was instrumental in retarding somewhat the fall of paganism for the time, but in the end contributed to the success of Christantly by familiarizing men with the belief in one supreme delity.

See Jean Réville, op. ef. especially pages 134-129, 135-134, 284-105, For other catangles of syncretism, of that of Suddhisu Zonostramism in the state religion of the Indo-Scythian kingdom of Kanshka tee Persain History: Amerik, to the Fall of the Sassend Dynasty: The Parthies Empfre); see articles on almost all the religions of the East, of MUTRAS: ZOROMSTER.

SYNDERESIS, a term in scholastic policosophy applied to the inhorn moral consciousness which distinguishes between good and will. The word is really syntherais? (Gr. owerfgorer, from owerspect) to look after, that cears of), but syntheresis is the commoner form. Diageness Lacitius in his account of the Stoics uses the phrase proper heart of to describe the instinct for self-preservation, the inward harmony of Chrysoppus, the recognition of which is owelfgorer. The term syntheresis, however, is not found till Jerome, who in dealing with Rock 1, 4–75, says the fourth of the "living creatures" of the vision is what the Greeks call overlayers, i.e., statistical constantiate the "spars of conscience," Here apparently syndersis and conscience (orweldpuss) are equivalent. By the school intern, however, the terms were differentiated, conscience here

ing the practical envisaging of good and evil actions; synderesis being so to speak, the tendency toward good in thought and action. The exact relation between the two was, however, a matter of convoersy, Argunsa and Duns Scotus holding that both are practical teason, while Bonaventina narrows synderesis to the volutional tendency to good actions.

tendency to good actions
SYNDICALISM is the name given to a form of revolutionary
doctrine first worked out, largely under anarchist influence, by
extain leaders of the French trade-union movement toward the
end of the 19th century. The word syndicalisme means simply
trade unionism; and what is known in English as syndicalisms
called in France syndicalisme révolutionnaire. The movement
flourished in Finance chiefly between 1900 and 1914 and had a
considerable influence on other countries, especially Italy, Spain
and Latin America.

It has also certain close resemblances to the movement of industrial unionism, which developed over the same period first in the United States and then spread to other English-speaking countries; and, in its theoretical aspect, it influenced socialist thought, especially in Great Britain, where guild socialism (q v)can be regarded as an attempt at reconciling syndicalist and socialist ideas After 1914 it lost much of its hold in France, where it was restated in a form closely resembling guild socialism by the French Confédération Générale du Travail, which advanced a plan for nationalisation industrialisée; that is, for a partnership between producers, consumers and state in the control of industry Both in France and elsewhere many of the leading syndicalists went over to communism; but the movement was never entirely submerged, and it tended to reappear in recent years in hostility to Communist party discipline and centralized control.

The anarchist wing remained powerful in Spain and maintained strong hostility to Communist dictatorship; and the lefttrade-union agitations which were often called Trotskyite—especially by Communists—were in fact largely syndicalist in their ideas, if not in name

Syndicalsts have often claimed that theirs is the most "proletanan" of all radical social theories and owes least to "middleclass theorists". This is true of its origination but hardly of its later development at the hands of Georges Sorel and Hubert Lagardelle.

It was Sorel who introduced into syndicalism the notion of social myths by which the workers could be irrationally stirred to revolutionary action. The general strike, advocacy of which the syndicalists had taken over from the anarchists, became in Sorel's hands a myth of this kind.

The syndicalist starts from the assumptions common to most schools of socialist thought He affirms the inherent injustice of the wage system and the fundamental immorality of capitalist society, which is based, in his belief, on the exploitation of labour. He accepts and pushes to its logical conclusion the Marxian dogma of the class war; he therefore affirms that solidarity of interests does not, and cannot, exist as between capitalists and wage earners. From these premises he draws the usual socialist conclusion; namely, that individual ownership of the instruments of production must be abolished and communal ownership and control substituted for it. But at this point syndicalism and socialism part company. Whereas the socialist dicalism and socialism part company. Whereas the socialist demands ownership by the state and its dependent organs such as the municipalities, the syndicalist demand, until recently, was for direct workers' ownership and control, acting through the organizations of their own creation-the trade unions and federations of unions.

State organization and control of industry are, in the syndicalist view, incompatible with true working-class enancepation. The state is, and must be, an instrument of class domination; it is indeed "the executive committee of the capitalist class." It exists to defend the interests of that class and is consequently as much the enemy of labour as capital itself. To extend its powers would be to twine the bonds of wage slavery ever more firmly about the workers' limbs.

The state is, moreover, hopelessly wedded to an uncreative

Its control, even if it were benevolent (which the syndicalist denies it could be), would necessarily be despotic and mefficient, the spirit of routine would combine with inexperience to crush out the possibility of economic progress Here, as will he seen, the syndicalist endorses the ordinary individualistic criticism of state socialism. Workers' control, exercised through the syndicats, would combine freedom with efficiency

The form of social organization in which this ideal could be realized was, until recently, conceived somewhat as follows the unit of organization would be the local syndicat This would be brought into touch with other local groups by means of the Bourse du Travail, the present function of which is to act at once as an employment agency and a general centre for trade-union activities When all the producers were thus linked together by the bourse, the administration of the latter would be able to estimate the economic capacities and necessities of the region, could co-ordinate production and, being in touch through other bourses with the industrial system as a whole, could arrange for the necessary transfer of materials and commodities, inward and outward A species of economic federation would thus replace the structure of capitalist industry, with which would necessarily disappear the political and administrative machinery of the state Two features of this utopia need to be emphasized, consumers as such were excluded from any share in industrial control, and a localized system of industry was envisaged

This latter feature was a direct reflection of French economic circumstances, both industry and trade unionism were much more local in range than in other and more highly developed countries But the movement toward large-scale organization which has so profoundly affected every aspect of modern economic life has produced a corresponding modification in syndicalist ideals

Syndicalist theory starts, as has been said, from the idea of a class war which must be waged relentlessly till a complete social transformation has been accomplished

The essential weapon in this struggle is the power of the organized workers As the cause of the conflict is economic it must necessarily be fought out in the economic sphere. Syndicalist congresses have persistently repudiated political action and pinned their faith to a general strike as the grand instrument of social revolution This reliance upon industrial or direct methods of action flows necessarily from the fundamental notions of syndicalism as to the nature of the state, and also from strictly practical considerations.

Outside the mine or factory, working men hold divergent religious or political opinions which make effective mass action difficult, if not impossible. Inside, the nature of their employment gives them a sense of solidarity which overrides other differences and bands them together in the syndicat for common defense, to persuade them to pass from the defensive to the offensive is the syndicalist's task, and in the accomplishment of this, political labels and controversies would be a hindrance. The strike, therefore, is the characteristic syndicalist weapon. However limited in its scope and object, it is an educative experience, successful, it inspires the workers with a sense of power; unsuccessful, it impresses upon them the servility of their lot and the necessity for better organization and wider aims. Thus, every strike is a preparation for the revolutionary day, when the workers, or a fighting minority of them (for syndicalism repudiates as bourgeois the dogma of the sacredness of majority rule), shall seize the instruments of production by an expropriatory general strike. In the meantime, they are working out from day to day, in the ordinary course of their employment, the ethics and the jurisprudence of the new social order.

The strike, of course, is not the only weapon in the syndicalist armoury. Various other means of waging the class war, known collectively as sabotage, have been both preached and practised. These range from bad work to the grève perlée (extending from ca'canny or go-slow to destruction of goods) and the chasse aux renards (literally, fox hunt); s.e, assaults on "black-legs" or jaunes. Sabotage has a much wider meaning in Franch than in

bureauciacy, incapable of mitiative and ignorant of industrial English, it covers, for example, doing better work than is demanded as well as worse, in order to put up the employer's costs It also covers what is known as the work-to-rule strike. It is fair to say that many syndicalist leaders criticize some of these methods as destructive of the worker's moral and technical com-

Syndicalism reflects French working-class experience and conditions of life, nevertheless, the history of Great Britain shows interesting foreshadowings of it. The idea of industrial self government by the producers attracted for a time the mind of Robert Owen, and the Grand National Consolidated Trades Union of 1833-34 was an attempt to realize it in practice The Operative Builders' union had developed the same notion in the previous year The plan of a general strike-originated by William Benbow some years earlier-for a time, under the strange title of the "Sacred Month," formed part of Chartist propaganda is no evidence, however, that these projects had any echo on the European continent.

The syndicalist idea, as understood in France, may be said to have developed out of the strong anarchist and antiparhamentary traditions of the French working class, and to have been much influenced by the teachings of P J. Proudhon and, on another side, by Auguste Blanqui A French delegate to the Congress of the International Working Men's Association held at Basle in 1869, for instance, prophesied that "the grouping of different trades in the city will form the commune of the future" when "government will be replaced by federated councils of syndicats and by a committee of their respective delegates regulating the relations of labour-this taking the place of politics" These tendencies manifested themselves with increasing strength during the 1800s in the two main labour organizations of the period-the General Confederation of Labour (or CGT under its French initials) and the Federation of Bourses du Travail The secretary of this latter organization, Fernand Pelloutier, did more perhaps than any other individual to work out the characteristic doctrines of syndicalism and to spread them among his fellow workers When these two bodies joined forces in 1902, trade unionism in general and syndicalism in particular received an immense accession of strength, and the doctrine subsequently remained-in spite of the efforts of political socialists to capture the syndicats for their own purposes-the characteristic expression of French revolutionary idealism

Syndicalist doctrine has had considerable influence outside France In the United States the analogous movement known as the Industrial Workers of the World resembled it in advocating direct action and in repudiating parliamentary action but differed from it in favouring strong trade-union centralization as a means of combatting the highly organized power of U S. capitalism

In Spain, the National Confederation of Workers (CNT: 26., Confederación Nacional del Trabajo) has been consistently syndicalist and indeed developed independently out of Spanish

In Italy, though syndicalism never wholly dominated the trade unions, its influence was considerable both before and immediately after World War I and was by no means extinct by the middle of the 20th century.

The influence of these ideas on the trade-union movement in Great Britain and Ireland was for a time pronounced, though they took a different direction, modified by the traditional parliamentarism of the British working class In Great Britain the real cause of the permeation of certain unions by syndicalist ideas between 1906 and 1914 was the absorption of trade-union leaders in administration or in politics which caused them to lose touch with the rank and file Especially was this the case with regard to the miners, the railwaymen and the engineers.

Daniel De Leon was a leader of the Socialist Labour party in the United States from 1880 onward, and his writings influenced British socialist thought, particularly in the Clyde and in South Wales. Though not an opponent of political action, as most syndicalists were, he advocated organization by industry and the general strike.

In England, between 1900 and 1910, there was a growing dis-

satisfaction among the rank and file with political action Despite the fact that the influence of the Labour party in the house of commons secured, to a greater degree than ever before, to the trade unions freedom of industrial and political action by the Trades Disputes Act of 1906 and the Trade Union Act of 1913, real wages were falling, and it was felt by many among the lank and file that a speeding-up was necessary, and state collectivism as a way out toward industrial democracy was discredited James Connolly, the Irish labour leader who was executed after the Easter rising in Ireland in 1916, started on the Clyde, in 1905, an organization similar to that of Daniel De Leon In his pamphlet Socialism Made Easy, he enunciated the syndicalist principles "that they who rule industrially will rule politically," and that "the function of industrial unionism is to build up an industrial republic inside the shell of the political state, in order that when the industrial republic is fully organized it may crack the shell of the political state and step into its place in the scheme of the universe" Tom Mann, while in France and Australia, to which had been imported ideas of the Industrial Workers of the World from the U.S., was powerfully influenced by the same theories; while on the Rand, in South Africa, a small but influential group of leaders was working out the structure, forms and policy of a movement similar in character. In 1910 Tom Mann preached the new faith in all the big British industrial centres and rapidly won many followers. Then followed the railway strike of 1911 and the great coal strike of 1912 The National Union of Railwaymen and the Miners' Federation of Great Britain became organized as two of the most powerful industrial unions in consequence of the new thought. Their leaders disagreed with the syndicalist view of the state, but they recognized the driving power of the theories that asserted that "political power is a reflex of industrial power '

The transport workers soon had a looser federation, and after the strikes of 1911 and 1912 and the Irish transport workers' strike' of 1913, the Triple Alliance (of railwaymen, transport workers and miners) was formed in 1915.

This alliance collapsed in 1021, when an endeavour was made to use it in support of the miners, who were-resisting wage reductions and longer hours during the postwar slump. The other unions withdrew their support when the miners refused to place the power to settle the strike in their hands. A somewhat similar fate brefell the miners in 1926, when the trade unions, after calling a general strike in their support, withdrew on the same grounds.

The general strike was doubtless to some extent influenced by syndicalist ideas; but its leaders, so far from accepting syndicalism, shoutly denied that it had any unconstitutional object and did their utmost to prevent it from developing into an attempt to overthrow the government or to assume power by illegal means.

(See also Direct Action; Sabotage; General Strike and Industrial Workers of the World; also Guild Socialism; Anarchism and Communism)

AMAGHIM and COMMINISM |

Brizzonary—H. Lagradelle, Le Socialisme ouwler (Paris, 1912);

C Sorol, Réflexions ur la suotence (Paris, 1912) (Eng. transl. by T.

Unitre); J. G. Brooks, American Syndication (1913); L. Levine,
Syndication in France, and rev ed of The Labor Movement in France,
(1914); G. D. B. Colo, Self-Government in Industry, 3rd ed. appears

on, 1915), Guild Secondium Resisted (London, 1912); E. Brissenden, I. W.W.,
and ed. (1920); Bertrand Russell, Principles of Social Reconstrucins, 6th ed. (London, 1920); F. Brissenden, I. W.W.,
and ed. (1920); Bertrand Russell, Principles of Social Reconstrucins, 6th ed. (London, 1920); F. Brissenden, I. W.W.,
and ed. (1920); Bertrand Russell, Principles of Social Reconstrucins, 6th ed. (London, 1920); F. Brissenden, I. W.W.,
and ed. (1920); P. Brissenden, I. W. Petgata, C. Revolution from
Marximus (Paris, 1923); G. D. H. Cole and R. Postgata, The Commonle
De Leon, What Messus This Strabet (1888); Reform or Revolution:
Edinburgh, e. 1920, The Barring Question of Trade Unisolum (Edindite); Anonymous, The Misser's Red Step, a suggested scheme for the
date); Anonymous, The Misser's Red Step, a suggested scheme for the
congunation of the (Spotth Wales) Minner Federation (Tonypothe),
1921).

SYNDICATE. PRESS. Press syndicates are organizations

SYNDICATE, PRESS, Press syndicates are organizations which sell the rights to literary and art materials to newspapers; they sell and distribute to considerable numbers of papers (and

even, in some cases, to periodicals). The term in common modern usage is not applied to the general wire news services such as Reuters and the Associated Piess, though it includes services such as the Newspaper Enterprise association which handle news but emphasize features and pictures. Syndicates distribute news, informative articles, descriptive, and entertaining essays and items of many kinds, editorials, signed columns on public affairs, fiction, verse, children's stories, himour, puzzles, comic pictures and strips, cartoris, news and feature photographs, and special material columns of the production of the pro

There were a few examples of syndication in the 18th century, such as the "Journal of Occurrences," distributed from Boston, Mass, in 1768 A few sporadic examples (political and fashion letters) occurred in the first half of the 19th century, but there was no important development of syndication before A N Kellogg of Chicago, Ill, began in 1875 to sell stereotyped plates carrying literary and pictorial matter to weekly papers Kellogg was followed in this technique by Maj. O J Smith in England (1882) and by directors of political parties and factions in Germany But the first modern syndicate was that of Irving Bacheller of Brooklyn, N.Y., who began handling fiction, household departments, and news and gossip letters in 1883 S McClure founded his famous syndicate ten months after Bacheller's Before the end of the century, syndication of features and pictures had become a considerable business in the United States, Britain and the dominions, and western Europe

Leading syndicates in the United States are King Features, owned by the Hearst interests; United Features, affiliated with the United Press; AP Newsfeatures, General Features, Bell Syndicate; and Chiego Tribune-NY News Syndicate Promue English syndicates are Central Press, Exchange Telegraph Co. and Inconported Press of Great Britain. (F L. MT)

and incolporated Press of Great Britain.

SYNEDRIUM, a Rabbien or legal body in Jerusalem, the Sanhedrim the form Sanhedrim is based on false etymology, suggesting a Hebrew mase, plural ending -in added to a non-existent noun Sanhéder The Oxford English Dictionary (cited in H. W. Fowler's Mod Eng. Glasge, 1936, p. 512) makes the following erroneous statement. "the incorrect foim Sanhedrim ... has always been in England (from the 17th ecnt) though form in popular use." As no Hebrew noun ending in M occurs, the only correct equivalent to TYPS must be Sanhedrim The existence of a court at Jerusalem is midcated in II Chron xix, S. An aristocratic Council of Elders and priests is mentioned both before and during the Maccabaean age (e.g., Josephus, Ant., xu, 3, 3). Probably the High Priest pressed from early times

The accounts in the Mishnah do not entirely agree with those of Josephus and with New Testament references but the amount of divergence is a matter of dispute. There are two lines of thought among modern scholars, some supporting the Mishnah, others maintaining that its information is an "academic reconstruction," hence unhistorical. That the Jewish court early lost its power is generally admitted (cf. John xviii, 31). Forty years before the fall of the Temple it could no longer inflict capital punishment (Jer. Sanh, 18a) and the right of deciding financial cases had been abrogated during the reign of Alexander Jannaeus (cf., T. B. Sanh. 41a). Nevertheless legal tradition was well preserved and the evidence of authorities such as Tose b. Halafta cannot easily be brushed aside. Büchler (cit. snfr) reconciles the conflicting evidence by assuming that there were two bodies, one, that of Josephus and the Gospels, possessing civil authority and one, that of the Mishnah, with purely religious functions, e.g., the fixing of the calendar or the purity of priests. The former sat in the town or on the west edge of the Temple hill; the latter, called "the great Sanhedrin," sat in the Xystus or Lishkath hag-Gazsth (chamber of hewn stone) and was composed of 71 members, mostly Pharisees, over whom the Nasi' and Ab Beth Din (rabbis) presided The lesser Sanhedrin of 23 members, mostly Sadducees and priests, was under the leadership of the High Priest,

Bint 1002APITY — "Sanbedila," Jewish Encyclopedia, "Crimes and Punshments" and "Sanbedila," Hastings Encyclopedia of Religion of Edition of Edi rucie on trial of Jesus in Journal of Theol Stud, xxi, pp 51-76 Det 1919) which is criticized by I Abrahams, Studies II, xv (1924) SYNESIUS (c 370 or earlier-c, 414), bishop of Ptolemais

in the Libyan Pentapolis, was born at Cyrene of wealthy parents

who claimed descent from Spartan kings

His extant works, written in Greek, are: (1) a speech before Arcadius, De regno; (2) Dio, sive de suo spsius instituto; (3) Encomsum calvitti, a comic defense of baldness. (4) De providentia; (5) De insomnus (on dreams), (6) 157 Epistolae; (7) 12 Hymni; and several homilies and occasional speeches

Bibliography -For a modein edition of the texts see N Terzaghi BIBLIOGRAFFIX—For a momen ention of the texts see N arxsupu (ed.), Hymst (Rome, 1939) and Opuscula (1944), for an English translation, A. Fitz-Gerald, The Essays and Hymns of Syneisus of Cyrene, 2 vol. (London, 1930), and The Letter of Synesus of Cyrene (1936). See also W S Crawford, Synesus the Hellene (London, 1901); C. Lacombrade, Synesus de Cyrène (Pars, 1931).

SYNGE, JOHN MILLINGTON (1871-1909), Irish dramatıst, was born at Rathfarnham near Dublin April 16, 1871. Educated at Trinity college, Dublin, he travelled for some years on the continent, spending much of his time in Paris He returned in 1898 to the Aran Isles There he wrote a number of sketches dealing with the life of the islanders, which were later collected in The Aran Islands (1907) In these and other sketches of the same period he had not quite shaken off the obsession of stylism, and still had a wish "to do for the west of Ireland what Pierre Loti had done for the Bretons" Gradually, however, Ireland took hold of him, and turning to the dramatization of incidents in the life he now knew intimately, he began to elaborate, partly from his notebooks and partly from the writings of Lady Gregory and Douglas Hyde, that richly imaginative Anglo-Irish dialect which he used with such complete success When, in 1904, he became a director of the newly opened Abbey theatre, Dublin, he had already produced two one-act plays, The Shadow of the Glen (1903) and Riders to the Sea (1904), published in one volume (1905) The Well of the Saints, a beautiful three-act play produced in 1905, was regarded by some as an affront to Irish morals, and when The Playboy of the Western World appeared in Jan. 1907, it was interrupted every night for a week by an organized disturbance. When the real merits of the play became known, it contributed largely to the fame of the Abbey theatre Time has shown how deeply Synge penetrated into the soul of the Irish peasant. The richness of the dialogue and the suggestion which it conveys of a permanent human enigma combine to make it a masterpiece. Synge's latest volumes were a collection of his poetical works entitled Poems and Translations (1909), and another play, Desidre of the Sorrows (1910) which he all but completed before his death. Synge's greatest work is probably The Playboy, though some critics give pride of place to Derrdre. Synge died in Dublin March 24, 1909.

BIBLIOGRAPHY.—W B, Yeals, Synge and the Ireland of His Time (1911); M. Bourgeois, John Milington Synge and the Irish Theatre (1912); P. P. Howe, J. M. Synge; A Chital Study (1912); J. Massifield, John M. Synge; A Few Fersonal Recollections, with Biographical Notes (1915); J. Thorning, J. M. Synge (1915); T. Thorning, J. M. Synge (1916).

SYNOPTIC CHARTS, a term used peculiarly in meteorology for maps of any large or small portion of the globe, on which are plotted weather observations taken at various points over the area represented and at approximately the same time. In addition the data on the map are usually analyzed by means of conventional symbols, isolines and shadings (see Weather FORECASTING). The expression weather map or weather chart is essentially synonymous to synoptic chart. The adjective synoptic implies a brief or condensed means of presenting a combined or general view of something, but in meteorological parlance the word came to have the connotation of synchronous because of the fact that according to most schools of meteorology only synchronous weather observations lend themselves to rational analysis of maps that are to be used for the purpose of preparing forecasts The notable exception is in the USSR where the official weather maps are not based on entirely synchronous observations but on observations made at the same local sun time

Synoptic charts are constituted in various forms according to their purpose and the kind of data plotted on them The basic chart for the use of forecasters is that which shows the synchronous observations at sea level or surface stations over a more or less extended area generally a large part of a continent at least and often a whole hemisphere For each weather station whose observations are taken at internationally standardized synoptic hours-one to four times a day-and received by radio or telegraph at the forecast offices, there are plotted in a model grouping around the circle representing the station on the map the values of or symbolic indications of a number of weather elements For all stations at least the baiometric pressure (usually reduced to sea level), the air temperature, the present weather, the wind direction and speed or force, and the sky cover will be reported. In some countries many stations also give visibility, dew point or relative humidity, forms, amounts and movements of clouds at different levels, net amount of pressure change during the last three hours, the characteristics or the tendency in the pressure during the last three hours and the amount of precipitation after the last observation. In case of ship reports the water temperature, state of sea, position and motion of ship are also reported

An innumerable variety of charts could be constructed from such reports but in practice only a few are made in addition to the standard charts containing the plotting and analysis of the complete surface reports, eg, charts to show the change in pressure and the change in temperature since the previous chart or in the last 12 hr. or 24 hr. are often made. The analysis of the basic surface chart consists usually of isobars (q v.), fronts (q v), and air mass (q v.) designations, and shadings or symbols to show

where precipitation and fog are present.

Such maps are two-dimensional To obtain a three-dimensional synchronous view of the atmosphere, it is customary, in regions where upper-air soundings are regularly made, to construct synoptic charts for several levels in the free atmosphere. Plotted on them, at the appropriate points where soundings are reported, are the values of the elements given by the soundings at that level, usually only pressure, temperature, humidity and wind The levels selected for upper-air charts may be surfaces of constant height, constant pressure or constant entropy. Constant-height surfaces of 5,000 ft, 10,000 ft and 20,000 ft mean sea level have been much used, but during the 1930s and the World War II years, after some experimentation with isentropic charts (q v ), nearly all weather services gradually came to prefer constant-pressure charts; by 1945 they became practically internationally standard

The World Meteorological organization recommended that data for the following surfaces be evaluated from the soundings and broadcast: 1,000, 850, 700, 500, 300 and 200 millibars, and that analysis of the 700- and 500-millibar surfaces be made as a minimum After World War II transmittal of sea-level and upper-air synoptic charts by means of facsimile (both telegraphic and radio)

was developed, in the United States particularly.

With the advent of jet aircraft, analysis of much higher levels in the atmosphere was required. In this connection some forecasters draw lines of equal wind speed (isotachs, isokinetics) on the constant-pressure charts for 500-, 300-, 200-millibar and even higher surfaces; and charts showing the topography of the tropopause are prepared.

For tropical regions isobaric and constant-pressure charts have not proved very helpful for forecasting, and experiments indicated that streamline charts would be more successful, though the technique is difficult and weather reporting stations were still too sparse over most of the tropics in the 1950s.

In addition to the various types of charts already mentioned, which might be called the basic ones, it is customary in the larger forecast centres to prepare many auxiliary charts such as those showing the changes in height of a pressure surface with time, and those for the thickness and temperature of the layers between a lower and a higher constant-puesure surface. Some of the systems of analysis and forecasting under trail in the 1958 movied the preparation of many charts of an intermediate character represting the step-by-step computation of derived rather than observed factors, e, g, in vorticity analysis and in some methods of numerical needs on

Finally, there are the prognostic charts which represent the forecast patterns of pressure, height of pressure surfaces, or other elements (temperature, wind, etc.), for some future time,

Thus the total number of charts constructed in a large forecast central may amount to hundreds per day, and consume the services of a large staff working in shifts around the clock

In connection with forecasting for longer periods of time than one or two days, it is desnable or necessary to construct mean synoptic charts which show averages of the elements over five days, a week, a month or more.

Over much of the northern hemisphere synoptic observations collected munetately by ware and audo permit maps to be made one, two, three or four times a day as desired, in some countries maps can even be made for every hour. The maps can be plotted and analyzed within two to six hours after the observations are made. Upper-air data are available only once or twice a day, however. Large areas of the oceans, and particularly of the polar regions and southern hemisphere, have few observing stations or ships and hence cannot be synoptically charted in the detail required by weather forecautes Methods of extrapolation of southings or map patterns to heights above those reached by many times.

Synoptic charts are published daily by the leading national weather services. A remarkable service of Historical Weather Maps for the northern hemisphere, one a day from Jan. 1, 1899, to June 30, 1393, compiled and analyzed by a uniform technique were published by the US government (weather bureau) during World War II and were resumed in 1946. The earliest weather charts were made well before 1835 by collecting synchronous weather reports by mail. The first telegraphic collection of synoptic reports and mapping thereof for forecasting was accomplished by Urbain J. L. LeVerner following the Crimean War. From about 1870 the leading nations have published charts each day along with the official forecasts: Simplified seal-level weather charts are published daily in many newspapers, posted in public places, and discussed on televisore programs.

For the principles of analysis and use of synoptic charts in forecasting see Air Mass; Fronts, Isallobars; Isentropic Charts; Isobar; Weather Forecasting

Bibliography.—S. Petterssen, Weather Analysis and Forecasting (1940), V. P. Starr, Basic Principles of Weather Forecasting (1942); H. C. Willett, Descriptive Meteorology (1944).

SYMOPTIC GOSPELS AND SYMOPTIC PROBLEM. The first three Gospels, Mathiew, Mark, Luke, are known as the Symoptic Gospels because in matter, language and order they lare much a common, and can, therefore, be viewed together or symoptically. The Symoptic problem is the problem of the relations between these Gospels, whether of influence, interdependence, or common origin, arising from their common features. (See Brus: New Testament: Modern Criticism; Gosper.; and the articles on the several Gospels.)

SYNTHETIC FIRES. The commercial production of synthetic textile fibres has been a development daing from about 1890. The first in the field was rayon, but many other types of synthetic fibres were later developed. All of these man-made fibres are produced either in the form of filament yarn (continuous parallel strands, similar to silk) or as staple fibre (short, uniform-length fibres to be spun into yarn in the same manner as cotton or wool.)

## HISTORY

The first person to visualize the possibility of making an artificial fibre by a process similar to the silk worm's spinning was Robert Hooke, an English scientist, who included a discussion of the subject in his book Micrographia, published in 1664. Again in 1734 the French scientist, René A. F. de Réaumur, predicted

the manufacture of an artificial textile from gums or resins, sinciliar to vamishes then being manufactured, which had the necessary qualities of resistance to heat and solvents. No concrete developments along these lines occurred, however, until the middle of the 19th century. In 1842 an English silk weaver, Louis Schwibe, exhibited a machine for making artificial filaments. This machine used nozeles with fine holes through which the liquid was forced to form filaments, which is the principle of the spinnerest though which rayon is spin today. Schwabe spun his filaments of glass, but he was not satisfied with the product and appealed to British scientists to discover a better material from which to manufacture filaments. A third development preparing the way for rayon was the discovery of introcellulose by C. F. Schonbem, a Swiss chemist, in 1846

The first known patent for the manufacture of rayon was issued to Geogea Audemans in 1855. He prepared three from the inner bark of mulberry and other trees, which he nitrated and dissolved in a mixture of ether and alcohol and combined with a ubber solution to form his spinning mixture. The filaments were spin by dipping the point of a needle into the solution and drawing out a filament which was connected with a winding machine. Two years later a patent was issued to E J Hughes for an elastic substance made of starch, gelatin, resin, tannins, fats, etc., which could be spin into silkight filaments.

A further advance was made by Str Joseph W Swan, who, searching for a better carbon filament for electric light bulbs, patented in 1883 a process for making a falament by squeezing a nitrocellulose solution into a coagulating medium and denitrating the filament. The fact that introcellulose could be denitated by the use of reducing agents such as ammonium sulphide was known as early as 1863. In 1885 Swan exhibited a few articles made from these filaments, but he did not follow up the textile possibilities of his invention.

Nitrocellulose Process.—The development of rayon as a struite really began with the work of Count Hisiar de Chardonaet, who is frequently called the "father of the rayon industry." Chardonnet began experiments on the making of an artificial textile in 1878, and in 1884 produced his first fibre from a nitrocellulose solution of pulp derived from mulberry leaves, coagulating the filaments in heated air. At the Paris Exposition in 1889, be exhibited articles made from these artificial fibres and secured to financial backing to build a factory at Besançon, Fr, where the financial backing to build a factory at Besançon, Fr, where the first commercial production of rayon began in 1891. Chardonnet's process was modified somewhat by Lehner, who used a solution of alcohol instead of warm air to coagulate the filaments.

Cuprammonium Process.—A second process for the production of artificial fibres from cellulose, the cuprammonium process, was patented in 1800 by a French chemist, Louis Henri Despeis-The discovery that cellulose could be dissolved in a cuprammonium solution and then precipitated with sulphuric acid is usually credited to M E Schweitzer (1857), although there is some evidence that John Meicer had already performed this operation. And in 1882 Edward Weston had patented a process for making filaments from a cuprammonium solution of cellulose, but, like Swan's discoveries in the mtrocellulose field, these filaments were developed in connection with the manufacture of electric light bulbs and were not exploited for textules. Despeissis himself did not put his patent into commercial production. Several German chemists (H. Pauly, M. Fremery, E. Bronnert and Urban) developed modifications and improvements on this process and put it into commercial production about 1898. This process of rayon production was comparatively expensive and was falling into disuse when Elsaesser further developed the method of stretch spinning (which had been patented by Edmund Thiele) and put the new process into production in 1919. Stretch spinning permitted the manufacture of very fine filaments and revived the use of the cuprammonium process.

Viscose Process.—A third process for the production of rayon grew out of the researches on cellulose derivatives by C. F. Cross and E. J. Bevan. These men discovered and patented in 1892 a viscous solution resulting from the dissolution of cellulose xanthate in dilute caustic sola. The manufacture of a textile fibre from

this solution was undertaken by C. H. Stearn and C. Topham while they were engaged in the spinning of lamp filaments of this material, but the technical problems of finding a proper solution and a satisfactory method for spinning the varn required years of research In 1808 Topham discovered the aging process in pieparing the spinning solution, and in 1902 he invented his spinning box, a revolving cylinder in which the very tender filaments were coiled by centrifugal force as they were drawn from the spinning bath In the same year (1902) Max Mueller discovered that it was possible to convert the cellulose vanihate into regenerated cellulose at the same time that the spinning solution was being coagulated into filaments, instead of by a separate operation This discovery, permitting the spinning of a yarn strong enough to be wound directly on a spool, greatly stimulated the development of the viscose process The commercial production of rayon yain by the viscose process was started in 1905, the use of this process rapidly increasing and surpassing the other methods of making rayon

In 1910, Samuel Salvage, a young English yarn merchant who had been in business in the United States, persuaded the English textile firm of Samuel Courtaulds & Company that the time was ripe for full-scale production of rayon in the United States The American Viscose company was formed, a tract of land was bought at Marcus Hook, Pa, and a new plant was built and in production by 1911 That year marked the founding of the American rayon industry with a total production of 362,544 lb of

Acetate Process .-- The fourth method for making rayon, the cellulose acetate process, was much later than the others in entering the field of commercial production. Cellulose acetate was produced by Laurent Naudin and Paul Schutzenberger in 1865 Cross and Bevan experimented with it and patented a process for its production in 1894. Bronnert, in Germany, experimentally made a textile thread from it in 1899. The important discovery that cellulose acetate modified by partial saponification (treatment with caustic) was soluble in acetone, instead of the chloroform necessary to dissolve ordinary cellulose acetate, was made by G W Miles in 1003.

In the United States, Arthur D. Little of Boston, Mass., had kept abreast of developments in the English experiments and, in partnership with William H Walker and Harry S Mork, was using the new cellulose acetate compound for electrical wire insulation In 1902 these three were granted a patent for spinning textile varn This first patent on a man-made fibre in the United States led to the first successful manufacture of acetate rayon.

But the full development of this process on a commercial scale was the work of Henri and Camille Drevfus, who made use of the acctone-soluble compound discovered by Miles. During World War I, the Drevfus brothers built a large factory at Spondon, Eng., for the production of cellulose acetate to be used as noninflammable dope for covering aeroplane wings A similar plant was started by them in the United States. When the end of the war destroyed the demand for the cellulose acetate dope, Drevfus turned to the production of rayon as the most promising use for the large plant he had built, and after several years of research a commercially successful spinning process was evolved. By the 1950s total world output of rayon plus acetate had risen to approximately 3,500,000,000 lb. annually, of which about a third was produced in the United States. (S. B. H.: X.) Synthetic fibres are classified in four groups, cellulosic fibres,

true synthetic fibres, protein fibres and inorganic fibres.

### CELLULOSIC FIBRES

Rayons and acetates fall under the classification of cellulosic fibres. The group includes regenerated cellulosic fibres, viscose rayon, cuprammonium rayon and saponified-acetate rayon Acetate, second in commercial importance to viscose, is a cellulose derivative fibre.

Surpassing in poundage all other synthetic fibres, rayon was the first successful man-made fibre, although it was many years after its discovery that the term artificial silk was abandoned and the generic term rayon adopted.

In each of the processes of manufacture of cellulosic textile fibres different solvents and chemical reactions are used in transforming the cellulose to liquid form. The mechanical method of extruding the chemically prepaied solution is fundamentally the same. The operation of extrusion is called spinning, not because of the textile spindle but in reference to the silkworm which discharges its glutinous liquid from external orifices called spinnerets located below its mouth, the threads combining into a single strand and immediately hardening on exposure to air.

The cellulosic solution prepared for synthetic textiles is conveyed from storage tanks through distributing pipes and filters to the spinning frame, consisting of rows of jet holders carrying spinning nozzles at their extremities. These nozzles consist of metal caps made of a hard, noncorrosive and light-weight precious metal or alloy, such as platinum and iridium or platinum and gold They are perforated with circular, concentrically arranged openings of almost microscopic size, about o i mm in diameter. These are called spinnerets, and the size of the aperture governs the size of the filament extruded.

Three systems of spinning viscose rayon came into use-the centrifugal, bobbin and continuous processes; the latter became more important commercially. The product may be continuous filament or cut staple Regular viscose rayon is of low tenacity. and it is this type which is used so extensively in fabrics. High tenacity rayon virtually displaced use of cotton in the cords

A summary of differences in manufacture and uses of cellulosic fibres is as follows.

Viscose Rayon .- Wood pulp or cotton linters are treated with caustic soda and carbon disulphide. The aged cellulose xanthate is dissolved in caustic soda and forced through spinnerets. Desulphurizing, washing and bleaching of the varn follows Stretching the filaments while in a plastic state produces high-tenacity

Typical uses include yarn for crepe, voile and low twists for many woven and knitted fabrics (the only continuous filament synthetic yarn being creped commercially), also hosiery and tire cord The staple is used alone and in blends for dress goods and sports wear, rugs, blankets, upholstery and house furnishings

Cuprammonium Rayon .- Purified cotton linters are dissolved in ammoniacal copper-hydroxide solution and extruded through a spinneret, drawn out in a water bath, and acidified. Uses include knitted and woven material for wearing apparel such as dresses, gloves and hosiery, upholstery and decorative fabrics.

Saponified-Acetate Rayon.-This fibre is manufactured like acetate (below) except that it starts as a cellulose-acetate fibre and after deacetylation under tension becomes regenerated cellulose It is sold only as a monofilament vain under the commercial name of Fortisan and is used for lightweight fabrics for coating, reinforcing, industrial belting and for some military purposes

Acetate.-Cotton linters or wood pulp are acetylated with acetate anhydride to form cellulose acetate which, dissolved in acetone, is extruded into warm air to form filaments. Highelongation acetate is produced by a modification of the piocess Typical uses include diess goods, linings, hosicry, underwear and

fused fabrics Staple (often blended) is used for men's and women's wear, blankets, upholstery, carpets and for fusing,

## TRUE SYNTHETIC FIBRES

True synthetic fibres are made of coal, water, air, petroleum and limestone. The results are the fibres formed by long chain molecules, the polyamides, the polyacrylics and the polyesters. Nylon was the first true synthetic fibre and remained the only important one from a commercial standpoint.

Nylon.-Nylon (a generic term) made revolutionary developments in the textile world. After its introduction to the industry in 1939, it virtually replaced silk in that fibre's most important commercial application-ladies' full-fashioned hosiery It also proved to be an adaptable and versatile yarn for other purposes.

Nylon was due to a laboratory accident. In 1927 the E. I du Pont de Nemours and Company set up a program of fundamental research as an important activity of the chemical department. One of the earlier studies undertaken was that of polymerization-

how and why certain small molecules unite to form giant molecules, such as those found in tubber, cotton and silk. After the work had been under way about two years one of the chemists. in attempting to remove a sample of the molten polymer from the vessel in which it had been prepared, found that it could be drawn out in the form of a long fibre, and that even after the fibre was cold it could be drawn farther to several times its original length Such a phenomenon had never been observed with a compound of that type The strand made was strong, elastic, lustrous and silklike After much more research a variety of polymer was developed which when drawn through a spinneret improvised from a hypodermic needle was actually the first nylon fibre First called "66," it was introduced to the public in 1938 as bristles in toothbrushes In 1030 hosiery knitted of nylon varn was produced in a pilot plant and made available for limited sale, and in May 1040, nylon hosiery was offered to the public on a national scale. Acceptance of pylon full-fashioned hosiery was immediate. and demand steadily increased, keeping ahead of production facolition

Nylon can be made in a number of different ways, such as the reaction between a diamine (for example, hexamethylene diamine) and a dicarboytic acid like adipic acid. In the manufacture of yarn the polyamide is melted, extruded through a spinneret and stretched.

Its great strength, ability to absorb energy dynamically or staticly, made nylon useful for a variety of modartial and military purposes. In addition to hossery it is manufactured into thread, rope, the cord, sail cloth, parachute shrouds and body armour in continuous filament it is popular in satins, taffetas and lingeric fairliers such as triot of (fairbic fairly with fine hornoutal and vertical lines). It can be crimped and blended with other fibres and spun on worsted or cotton systems.

Orlon and Aerilan are puncipally acrylic and are formed from a polymer of acrylonitrile. A solution of the polymer is extruded, the solvent is removed, and the resultant yarn stretched. Orlon is a continuous filament yarn, Aerilan a cut staple yarn. The latter's industrial uses are most important where high temperatures or acid conditions, or both, are found. It is good for awnings, sail cloth, rope, automobile tops, electrical insulation, lammates some chittines, sontwaver and sutures.

Dynel, partly acrilac, is made by a somewhat different process. A copolymer of vnyl chloride and acrylonitrie is dissolved in actone, filtered, and then spun dry by means of extrusion, then cut into desired lengths. Dynel's continuous filament counterpart is Vinyon N (see below)

The principal use of dynel is in pile fabrics, blankets, socks, industrial clothing and filter fabrics. It is used in blends with cotton, rayon or wool for apparel use in items usually considered in the wool category.

Dacron (known as Terylene in England) was the only commercially available polysets fibre in the 1950s. This fibre had been widely advertised for its nonwinkle qualities, its ability to hold a cresse, and the fact that garments made of it may be hold a cresse, and the fact that garments made of it may be affinity for wool and the rather unstable market for that natural fibre turned great attention to Dacron's possibilities. It was in full-scale production by the 1950s.

In the manufacture of Dacron yarn ethylene, glycol and terephthalic acid react to produce the polyester which is melted, extended through a spinneret, and stretched.

Saran, a monofilament yarn, is identified as vinylidene chloride. Petroleum and salt are treated to produce ethylene and chlorine. They are combined to form vinylidene chloride which is copolymerized with vinyl chloride. The resulting resin is melted and extruded to form filaments which are then orientated

Typical uses include screening, cords for racquets and the like, uphobstery, cutrans, filter cloth and shoe and handbag fabrics. Vinyl Resins.—Vinyon—A coplymer of vnyl chloride and vinyl accutte is dispersed in acetone, filtered, decreated, and then do-y-pun by means of oxtrusion After standing, the filaments are wet twisted and stretched. Both continuous filament and staple filter according by the continuous filament and staple filter according by more continuous filament and staple filter according to more continuous filament and staple filter according is unvolved.

Typical uses include filter fabrics, nets and seines, clothing and fabrics for protection against acids and alkalis, and fusible shape-retaining fabrics. Staple is used as a bonding agent in combination with other fibres.

Vinyon N—A copolymer of vinyl chloride and acrylontrile is dissolved in acetone, filtered, and then dry spun by means of extrusion Most types are stretched and twisted, following which they are dimensionally stabilized by additional processes

The unstretched staple (HH) is used in the manufacture of pile fabres, rugs, paper, felts, rope and bonded web, it is also used as a bonding agent. The stabilized, continuous fiament is used in dress goods, house frunishings, hoselw, foundation garments, limngs, multital fabrics (filter), thead, pant-brush bristles, fish lines; rope and multary fabrics.

### PROTEIN FIBRES

One large group of synthetic fibres is made from a natural proterion base (compared with the cellulose base of iayon). Commercial production of fibres in this group has been primarily of the type made from milk casen. Italy led in the development and production of casein-base textiles but they were later also manufactured commercially in Germany, Great Britain, Belgium, Holland and the U.S.

These casem-base fibres have a chemical composition almost identical with wool, with the exception of a lower subplur content. The fibres may be very fine and soft, or a harsh texture similar to coarser wools may be produced by modifications in the manufacturing process. The dyeng reactions of casein-base fibres are the same as those of wool, which is a great advantage in blending these two fibres. Casem-base fibres are usually manufactured in staple fibre form, rather than in continuous filaments, and are used principally in combination with wool. The lack of resiliency in casein fibre and its low wet strength make blending with natural fibres desirable.

It is possible to use many protein materials including peanuts (used to produce ardil), soybeans, sen (a corn protein from which Vicara is made), fish, waste animal skin, leather and muscle tissue to produce synthetic fibres. Other types of synthetic fibres outweigh protein fibres in commercial importance.

### INORGANIC FIBRES

Glass is the principal inorganic fibre Its flameproof qualities made it desirable for fabric purposes such as drapenes and pholstery and for certain purposes in military use. Because of its resistance to acids and solvents it is useful as a filter cloth It is employed also for plastic reinforcement and electrical insulation.

The method of manufacture is as follows special-composition glass marbles are melted in an electric furnace and the molten glass passes through the many munute holes in the base to form continuous fibres. The fibres are attenuated to the desired size; stanle fibres are attenuated and formed by steam jet.

### MILL PRODUCTION

Most synthetic fibres are spun into yams and woven into fabries on the cotton system, using the same, or partly the same machanery. Some synthetic fabrics, however, found greatest consumer acceptance in the hosjery field and knit-fabrics field where high-speed triton imachines can turn out large production. The textile machinery industy invested great amounts of capital in research and development of better processing for the science shrew and the blends of synthetics, cottons, woollens and worsteds. Dyeing and finishing of the synthetic fibres presented special problems to the chemist, as well as to the manufacturer of dyeing and finishing equipment.

The trend to multiblire production brought with it an almost complete reorganization of mill operation. Mills which successfully converted their cotton, woollen or worsted operations to the use of staple synthetics found that considerably more was involved in the conversion than a mere change-over in purchase of raw materials. Synthetics are run on the cotton system, the worsted system and the woollen system. Each has its own con-

version problems Cotton remained the most important fibre (in pounds consumed) but by the 1950s consumption of synthetic fibres equalled 25% of the total US market-still the largest consumer of cotton in the world Much of this increase in synthetic consumption had been due to blends and mixes in varies

Synthetics on the Cotton System.-When synthetics are spun on the cotton system, one of the major steps necessary is a thorough cleaning of the mill Even in the cleanest cotton mill, cotton lint may accumulate on roof beams, window sills and other likely places If the "fly" should by chance become mixed with the synthetic staple it would show up in dyeing and finishing operations because cotton and synthetics do not take the same dyes.

Oil which may have been on machines used for cotton must be removed as completely as possible from all exposed machinery parts Cotton has less affinity for oil than do synthetic fibres, but once oil is dropped on the synthetic varn or fabric it is difficult to remove

The hazard of mixing fibres and the costly results if they are mixed prior to the actual blending process, means that mills must carefully segregate raw material, ie, cotton fibre from synthetic staple This starts in the warehouse if lot blending is done. It is desirable to have separate opening and blending lines for cotton and for the synthetics, otherwise, plant cleaning is essential

The common method of keeping fibres separately identified after leaving the mechanical picker is to have laps of synthetic fibres tinted In a cotton system mill, pink, blue, green or other brightly tinted laps lay side by side with the traditional white of the cotton laps. The costs of tinting the synthetic fibre laps for identification purposes is small compared to the possible costs of accidentally mixing fibres Other problems, such as humidification for different fibres, necessitate adjustments and machine changes

Waste involves a special handling problem. A salable commodity which may mean the difference between profit and loss in a textile plant, waste must be kept as carefully segregated as staple fibre in process This involves cleanliness, care, sorting bins, and a good inventory system in the waste department

Synthetics on the Worsted System .- Most synthetics can be Synthetics on the Worsted System,—Most synthetics can be spun on standard worsted in-dervawing and spinning machinery. The spun on standard worsted in-dervawing and spinning machinery. The count of worsted yarn. Synthetics, usually static, need a small addition of antistatic oil to create better processing conditions. Research showed that in worsted blending synthetics perform best when a minimum of being the standard process. The spinning worst which we have been supported by the spinning worst which is the spinning worst

Synthetics on the Woollen System .- Each synthetic fibre needs special research and treatment when blended with woollens or worsted. One factor is the use of emulsion (usually of olive oil and water). In most cases of blending the synthetic yarn will absorb enough emulsion from the wool When 100% synthetics are being run on the woollen system less emulsion should be used than for wool. on the woolan system nest emittain solute for taket that for wool cardis is begun so that it may agage tensie strength by checking proper drafting (the process of attenuating the threads) on the mule (a type of summing machine). An advantage is guned when spinning 100% of summing machine) and survantage is guned when spinning 100% (unit used in measuring weight or size of silk, rayon and certain other yurns) as relative proportion such as 80% bulk docker: 0%; 5%; 5% in other staple and denier ranges. This gives an advantage similar to interlocking of wool fibres

Machine Developments,-Many mills today must be able to process not a single fibre but ten or more, either separately or in a wide range of blends

The American system of spinning was developed to enable spinners to take full advantage of various fibres available from one inch to seven inches in staple length. The system became sufficiently versatile to handle any required tange of material, and equally satisfactory for natural or synthetic fibres.

natura or synthetic three. The present are comparatively simple. Assuming The mechanics of the six commercial too of staple length up to seven inches (this might be either a too% worsted or a blend of any combination), the operations that follow would be first, pin drafting or its equivalent; second, superdraft rowing; and finally, long-draft synthing. Organizing is the reduction in bulk and weight of stock as it spanning. Officially a the reduction in outs and weight or stock as it passes through the machines involved in yarn manufacture. Pin drafting is a draft operation performed on the stock [fibre] as it passes through, but it is also a series of pins arranged in a rake or comblike fashion over which the stock passes, having the effect of straightening

out the fibres and parallelizing them Superdraft roving is generally understood as being a method of drafting using a 4-roll system and 2-apron pinneple developed by Whitin Machine Works Long drafting is a system of roving or spinning which permits the use of much higher diafts than the conventional system )

drafts than the conventional system)
The pin drafting would be carried out in either two or three stages, depending upon the quality and weight of sliver or thread desired. The roving would be a single-stage operation if number 40s or coarser yarns are to be spun finer yarns can be produced by inor coarser yarns are to be spun Finer yarns can be produced by introducing a scoul towing stage which would not have to be the super-draft type but the simpler three-full long-draft frame. The final process, long-dist spinning, completes the conversion of top to yarn Approximately half the number of machine operations are required compared with former methods of symning on the worsted system A rayon-stabilization process for kint goods to establish rayon in the fixed and circular kint field was developed.

tricot and circuiai kinti field was developed. The need for special lyusties for spinning fibre glass presented some difficult problems. Standard twisters were modified, and cicels, spindles and rolls were altered. Because of the abrasive quality of glass, and because tiny glass filaments were likely to work into and cut the bearings, machines had to be extremely sturdy, and a delicate control of twist had to be maintained at all times

twist had to be maintained at all times. Humshity control was early recognized as of critical importance in milk processing synthetics. One fibre may require a different opinium humshity than another. Systems were improved to obtain uniform humshity and steady evaporative cooling. Refinements were made in yarn conditioning equipments what in a modern mills not fee monsture is permitted within the conditioning room, and the most delicate natural and synthetic yarns are conditioned safely without specific processing the processing of the processing the proc

natural and synthetic yarns are conditioned safely without spotting.

Looms were improved to weave better synthetic fabries more
characteristic or the state of the state of the state of the state
characteristic better the state of the state of the state of the state
meet the need for a modified mechanical construction to weave synthetics and blended yarns with mixed filing was made available in

7.33 Experization was eliminated and production output was 25%

1033 Superstructure was eliminated and production output was 25% higher than average speeds on similar, less modern looms. In the processes of twisting and throwing (the piocess of twisting a number of threads into one flament), new inventions resulted from research into synthetic production. An all-purpose ring twister, which employed rings to twist the yarn, proved excellent for processing rayon, spun rayon, nylon, silk, wool, worsted, cotton and combination yarns (M G B A : X)

SYNTHETIC RUBBER: See RUBBER PRODUCTION AND MANUFACTURE.

SYPHAX, king of the Massaesyli, a tribe of western Numidians, played an important part in the later stages of the Second Punic War. In 213 a quarrel was in progress between him and Carthage; the Scipios leaped at this chance of establishing an ally in Africa, and sent a military mission to Syphax

SYRA or Syros (and Σύρος, perhaps Homeric Συρίη), a Greek island in the middle of the Cyclades (length about 10 mi , breadth 5, area 421 sq mi.). The prehistoric importance of the island is attested by early Aegean antiquities. In ancient times it was remarkably fertile, but the destruction of its forests has led to loss of alluvial soil, and left it a brown and barren rock, with scanty aromatic scrub, pastured by sheep and goats. In the 19th century Syra became the commercial centre of the archipelago, and is also the residence of the nomarch of the Cyclades and the seat of the central law courts. The population rose to about 33,700, but has declined. Hermoupolis had 21,156 inhabitants in 1928 but only 18,925 in 1940. Syra is also a province of the department of the Cyclades Axis troops occupied it in 1941.

Hermopolis (better Hermoupolis), the chief town, is built in a bay of the east coast. Old Syra, on a conical hill behind the port town, was built by the Capuchins, who in the middle ages chose Syra as the headquarters of a mission On the outbreak of the war of Greek independence about 40,000 refugees from Chios (Khios), after being scattered throughout Tenos, Spezia (Spetsai), Hydra (Ydra), etc., and rejected by Ceos (Kea), rallied at Syra under the protection of the French flag till the freedom of Greece was achieved. The harbour, with a breakwater 273 yd. long, has a depth of 25 ft. diminishing to 12 ft.

SYRACUSE, a city of Sicily (Gr. Συράκουσαι; Lat. Syracusae, Ital. Siracusa), the capital of a province of the same name, situated on the east coast of the island, 54 mi. by rail S. E. of Catania, and about 32 mi. direct. Pop. (1881), 21,739; (1921), 45,946 (town), 49,662 (commune); (1931) 23,631 (town), 50,096 (commune); (1936) 43,639 (town), 53,166 (commune); (1951) 70,300 (commune).

Syracuse was the chief Greek city of ancient Sicily, and one

of the earliest Greek settlements in the island. It was founded from Cornih, and Thucydides, who gives the date as the year after the foundation of Naxos (ie, 734 nc), mentions that the leader Archias expelled the Sicel inhabitants from Ortygia (See under Sicriv). Their presence there was definitely proved by the discovery of traces of hits and of a rock-cut tomb of the beginning of the second Sicel penod on Ortyga, while similar tombs may be seen both on the north and south edges of the terrace of Epippolae, and on the pennsula of Plemmyrium. (For this and other prehistoric sites in the neighbourhood of Syracuse see Sicrici, Archaeology)

Till the beginning of the 5th century 1s c our notices of Syracuse hatory are fragmentary, and we do not even know when the mole connecting the saland with the mainland was constructed in its external development Syracuse differed somewhat from other Sicilian cities Atthough it lagged in early times behind both Gels and Aragas (Argientum), it very soon began to aim at a combination of land and sea power In 65g it founded the sestlement of Arraga, 16g (a Samanna, on disp 3g Camarina, of which the first was unusually far inland. The three together secured for Syracuse a continuous dominion to the south-east coast. They were not strictly colonies but outposts, Camarina indeed was destroyed after a revolt agament the ruling city

Gelon and Hieron - Hippocrates, tyrant of Gela (402-485). threatened the independence of Syracuse as well as of other cities, and it was saved only by the joint intervention of Corinth and Corcyra and by the cession of the vacant territory of Camarina. In 485 the Gamoroi, or landowners (i e, the descendants of the original settlers, who formed an aristocratic body), who had been expelled by the Demos and the Sicel serfs and had taken refuge at Casmenae, craved help of Gelon, the successor of Hippocrates, who took possession of Syracuse, without opposition, and made it the seat of his power. He gave citizenship both to mercenaries and to settlers from Greece and added to the population the inhabitants of other cities conquered by him, so that Syracuse became a city of mixed population in which the new citizens had the advantage. He then extended the city by including within the fortifications the low ground (or at any rate the western portion of the low ground) between Upper Achradina and the island and making the agora there, at the same time (probably) he was able to shift the position of the crossing to the island by making a new isthmus in the position of the present one, the old mole being broken through so as to afford an outlct from the Little Harbour on the east. The island thus became the inner city, the stronghold of the ruler. Gelon's general rule was mild, and he won fame as the champion of Hellas by his great victory over the Carthaginians at Himera He is said to have been greeted as king, but he does not seem to have taken the title in any formal way.

Gelon's brother and successor, Hieron (478-467), kept up the power of the city and won himself a name by his encouragement of poets, especially Aeschylus and Simonides, and philosophers, while his Pythian and Olympian victories made him the special subject of the songs of Pindar and Bacchylides. But in his internal government he was suspicious, greedy and cruel After family disputes the power passed to his brother Thrasybulus, who was driven out next year by a general rising. Syracuse thus became a democratic commonwealth. Renewed freedom was celebrated by a colossal statue of Zeus Eleutherius and by a yearly feast in his honour. But when the mercenaries and other new settlers were shut out from office new struggles arose. The mercenaries, as in the last rising, held Ortygia and Achradina The people now walled in the suburb of Tyche to the west of Achradina. The mercenaries were at last got rid of in 461. Although we hear of attempts to seize the tyranny and of an institution called petalism, like the Athenian ostracism, designed to guard against such dangers, popular government was not seriously threatened for more than 50 years. The part of Syracuse in general Sicilian affairs has been traced in the article Sicilia (q.v.). We hear of a naval expedition to the Etruscan coast and Corsica about 453 B C. and of the great military and naval preparations of Syracuse in 439.

The Athenian Siege.-The Athenian siege (415-413) is of the deepest importance for the topography of Syracuse (The chief authorities for the siege are Thucydides [bks, vi, and vii ], Diodorus [bk xiii] and Plutarch, Nicias) Through the whole siege there was a treasonable party within the city, which kept up a correspondence with the besiegers When the Athenian fleet under Nicias, Alcibiades and Lamachus was at Rhegium in Italy, Athens had the prize within her grasp, and she lost it wholly through the persistent dilatoriness and blundering of Nicias It was at his advice that the summer and autumn of AIS were frittered away and the siege not begun till the spring of 414 By that time the Syracusans had built a wall from north to south across Epipolae, taking in Tyche and Temenites, so as to screen them from attack on the side of Epipolae on the northwest They did not, however, occupy Euryelus, at the western extremity of the high ground of Epipolae, and this omission allowed the Athenians to obtain possession of the whole plateau and to begin the investment of the city. The Syracusans then carried a counterwork up the slope of Epipolae, which, if completed, would cut in two the Athenian lines and frustrate the blockade At this point Nicias showed considerable military skill The Syracusans' work was destroyed by a prompt and well-executed attack; and a second counterwork carried across marshy ground some distance to the south of Epipolae and near to the Great Harbour was also demolished after a sharp action, in which Lamachus fell, an irretrievable loss However, the blockade on the land side was now almost complete, and the Athenian fleet had at the same time entered the Great Harbour. The citizens began to think of surrender, and Nicias was so confident that he neglected to push his advantages. He left a gap to the north of the circular fort which formed the centre of the Athenian lines, the point where Epipolae slopes down to the sea, and he omitted to occupy Euryelus. He made a final and irretrievable blunder in letting the Spartan Gylippus first land in Sicily and then march at the head of a small army, across the island, and enter Syracuse by way of Epipolae, past Euryelus Just before his arrival a few ships from Corinth had made their way into the harbour with the news that a great fleet was already on its way to the relief of the city The tables were now completely turned The military skill of Gylippus enabled the Syracusan militia to meet the Athenian troops on equal terms, to wrest from them their fortified position on Plemmyrium, which Nicias had occupied as a naval station shortly after Gylippus's arrival, and thus to drive them to keep their ships on the low beach between their double walls, to take Labdalum, an Athenian fort on the northern edge of Epipolae, and make a third counterwork right along Epipolae in a westerly direction, to the north of the circular fort. The Athenians were thus reduced to such a plight that, as Nicias said in his despatch towards the close of 414, they were themselves berieged rather than besieging. The naval preparations of the Syracusans, under the advice of Hermocrates, had led them, too, to confidence in their powers of giving battle to the Athenian fleet In the first sea-fight, which took place simultaneously with the capture of Plemmyrium, they had been unsuccessful; but in the spring of 413 they actually won a victory over the Athenians in their own element.

On the very next day, however, a second Athenian fleet arrived under Demosthenes and Eurymedon, with 73 ships of war and a large force of heavy infantry and light troops. Demosthenes decided at once to make a grand attack on Epipolae, with a view to recovering the Athenian blockading lines and driving the Syracusans back within the city walls. The assault was made by night by way of Euryelus under the uncertain light of the moon, and this circumstance turned what was very nearly a successful surprise into a ruinous defeat. The aimy was now thoroughly out of heart and Demosthenes was for at once breaking up the camp, embarking the troops, and sailing back to Athens But Nicias could not bring himself to face the Athenian people at home, nor could he be prevailed on to retire promptly to some position on the coast, such as Catania or Thapsus. He dallied till the end of August, many weeks after the defeat, when the coming of Syracusan reinforcements decided him to depart; but

on Aug 27 was an eclipse of the moon, on the stiength of which he insisted on a delay of almost another month The Syracusans

Dionysius' Successors.—Under his son, the you now blocked the mouth of the Great Harbour, and the Athenian fleet, after a frantic effort to break out and a desperate conflict, was utterly defeated and half destroyed. The broken and demoralized army, its ranks thinned by fever and sickness, at last began its hopeless retreat, attempting to reach Catania by a circuitous route, but, harassed by the numerous Syracusan cavelry and darters, after a few days of dreadful suffering it was forced to lay down its arms The Syracusans sullied the glory of their triumph by putting Nicias and Demosthenes to death

Dionysius I .-- Her great deliverance and victory naturally stirred up the energies of Syracuse at home and abroad Syracusan and Schnuntine ships under Hermocrates now play a distinguished part in the warfare between Sparta and Athens on the coast of Asia Under the influence of Diocles the constitution became a still more confirmed democracy, some at least of the magistracies being filled by lot. Diocles appears also as the author of a code of laws of great strictness. Under these influences Hermocrates was banished in 409 In 407 he was slain in an attempt to enter the city, and with him was wounded Dioaysius, son of another Hermocrates and an adherent of the aristocratic party, but soon afterwards a demagogue, though supported by some men of rank, among them the historian Philistus By accusing the generals engaged at Acragas in the war against Carthage, by obtaining the restoration of exiles, by high-handed proceedings at Gela, he secured his own election as sole general with special powers. He next procured from a military assembly at Leontini a vote of a bodyguard, he hired mercenaries and in 406-405 came back to Syracuse as tyrant of the city Dionysius kept his power till his death 38 years later (367). But it was well-nigh overthrown before he had fully grasped it. After his defeat before Gela (see Sicily) his enemies in the army reached Syracuse before him, plundered his house, and horribly maltreated his wife. He came and took his vengeance, slaving and driving out his enemies, who established themselves at Aetna In 397 Syracuse had to stand a siege from the Carthaginians under Himilco, who took up his quarters at the Olympieum, but his troops in the marshes below suffered from pestilence, and a masterly combined attack by land and sea by Dionysius ended in his utter defeat Dionysius, however, allowed him to depart without further pressing his advantage. This revolution and the peace with the Carthaginians confirmed Dionysius in the possession of Syracuse, and left it the one great Hellenic city of Sicily, which, however enslaved at home, was at least independent of the barbarian Dionysius was able, like Gelon, though with less success and less honour, to take up the rôle of the champion of Hellas

During the long tyranny of Dionyslus the city grew greatly in size, population and grandeur Syracuse absorbed the population of Gela, Camatina and Acragas, and received large accessions from some of the Greek cities of southern Italy, from Hipponium on its west and Caulonia on its east coast, both of which Dionysus captured in 389 B.C. There had also been an influx of free citizens from Rhegium. Dionysus largely extended the fortifications of Syracuse. The island (Ortygia) had been provided with its own defences, converted, in fact, into a separate stronghold. Dionysius, to make himself perfectly safe, drove out a number of the old inhabitants and turned the place into a barracks, he himself living in the citadel. Profiting by the experience gained during the Athenian siege, he included in his new lines the whole plateau of Epipolae, with a strong fortress at Euryelus, its apex on the west; the length of the outer lines (excluding the fortifications of the island) is about 12m. Syracuse was now the most splendid and the best fortified of all Greek cities. Its naval power, too, was vastly increased; the docks were en-larged, and 200 new warships were built. The fleet of Dionysius was the most powerful in the Mediterranean It was doubtless fear and hatred of Carthage, from which city the Greeks of Sicily had suffered so much, that urged the Syracusans to acquiesce in the enormous expenditure which they must have incurred under the rule of Dionysius. Much, too, was done for the beauty of the city as well as for its strength and defence. Several new temples

Dionysius' Successors .- Under his son, the younger Dionys ius-an easy, good-natured, unpractical man-a reaction set in amongst the restless citizens of Syracuse His uncle, Dion, was for a time the trusted political adviser of his nephew Dionysius II Dion's idea seems to have been to make Dionysius something like a constitutional sovereign, and with this view he brought him into contact with Plato But Dionysius had Philistus and others about him, who were opposed to any kind of liberal reform, and the result was the banishment of Dion from Syracuse as a dangerous innovator Ten years afterwards, in 357, the exile entered Achradina a victor A siege and blockade followed, till Dion made himself finally master of the mainland city Ortygia, provisions failing, was also soon surrendered. Dion's rule lasted only three years, for he perished in 354 by the hand of an assassin

Of what took place in Syracuse during the next ten years we know but little The younger Dionysius came back and from his island fortress again oppressed the citizens Sicily, too, was again menaced by Carthage Syracuse, in its extremity, asked help from the mother-city, Corunth, and Timoleon (qv) delivered Syracuse from the younger Dionysius and from Hicetas, who held the rest of Syracuse, and won a decisive triumph over Carthage and the safe possession of Sicily west of the river Halycus, the largest portion of the island From 343 to 337 he was supreme at Syracuse, with the hearty good will of the citizens Syracuse, with an influx of a multitude of new colonists from Greece and from towns of Sicily and Italy, once more became a prosperous city Timoleon, having accomplished his work, accepted the position of a private citizen After his death (337) a splendid monument, with porticoes and gymnasia surrounding it, known as the Timoleonteum, was raised to his honour

In the interval of 20 years between the death of Timoleon and the rise of Agathocles  $(q \ v)$  to power another revolution at Syracuse transferred the government to an oligarchy of 600 leading citizens It was shortly after this revolution, in 317, that Agathocles, with a body of mercenaries from Campania and a host of exiles from the Greek cities, backed up by the Carthagiman Hamiltar, became tyrant of the city, and the senate and the heads of the oligarchical party were massacred wholesale, while a unanimous vote of the people gave him absolute control over the fortunes of Syracuse His wars in Sicily and Africa left him time to do something for the relief of the poorer citizens at the expense of the rich, as well as to erect new fortifications and public buildings, and under his strong government Syracuse seems to have been at least quiet and orderly. After his death in 289 comes another period of revolution and despotism; and but for the brief intervention of Pyrrhus in 278 Syracuse, and indeed all Sicily, would have fallen a prey to the Carthaginians

A better time began under Hieron II, who had fought under Pyrrhus and who rose from the rank of general of the Syracusan army to be tyrant-king, as he came to be soon styled-about 270. During his reign of more than 50 years Syracuse enjoyed tranquillity and seems to have grown greatly in wealth and population. Hieron's rule was kindly and enlightened, combining good order with a fair share of liberty and selfgovernment. His financial legislation was careful and considerate; his laws as to the customs and the corn tithes were accepted and maintained under the Roman government, and one of the many bad acts of Verres was to set them aside. It was a time, too, for great public works-works for defence at the entrance of the Lesser Harbour between the island and Achradina, and temples and gymnasia. Hieron through his long reign was the stanch friend and ally of Rome in her struggles with Carthage.

Capture by the Romans.-Hieronymus, the grandson of Hieron, thought fit to ally himself with Carthage, but he soon fell in a conspiracy. There was a fierce popular outbreak and more bloodshed; the conspirators were put to death and Hieron's family was murdered; whilst the Carthaginian faction, under the pretence of delivering the city from its tyrants, got the upper hand and drew the citizens into open defiance of Rome, Claudius Marcellus was then in command of the Roman acmy in Sicily, and he threatened the Syracusans with attack unless they would get rid of Epicydes and Hippocrates, the heads of the in origin it was in Sicily that it reached its highest www.opment anti-Roman faction Marcellus struck his first blow at Leontini, which was quickly stormed, and its sack roused the feeling of the Syracusans against any negotiations with the Roman general, and, putting themselves under Epicydes and Hippocrates, they closed their gates on him Marcellus, after an unsuccessful attempt to negotiate, began the siege in regular form (214 B C.) by both land and sea, establishing a camp on Polichne, where stood the old temple of Olympian Zeus; but he made his chief assault on the northern side and on the defences of Tyche. The city was defended by a numerous soldiery and by the ingenious contrivances of Archimedes, whose engines dealt havoc among the Roman ships and frustrated the attack on the fortifications on the northern slopes of Epipolae Marcellus had recourse to a blockade, and at last, in 212, information was given him that the Syracusans were celebrating a great festival to Artemis. Making use of this opportunity, he forced the Hexapylon entrance by night and established himself in Tyche and on the heights of Epipolae The strong fortress of Euryelus held out for a time, but, being now isolated, it soon had to surrender The "outer" and the "inner" city of Thucydides still held out, whilst a Carthaginian fleet was moored off Achradina and Carthaginian troops were encamped on the spot. But a pestilence broke out in the autumn of 212, which swept them clean away and thinned the Roman ranks. The ships sailed away to Carthage; on their way back to Syracuse with supplies they could not get beyond Cape Pachynus owing to adverse winds, and they were confronted by a Roman fleet. All hope for the city being now at an end, the Syracusans threw themselves on the mercy of Marcellus; but Achradma and the island still held out for a brief space under the Syracusan mercenaries, till one of their officers, a Spaniard, betrayed the latter position to the enemy, and at the same time Achradina was carried and taken. Marcellus gave the city up to plunder, and the art treasures in which it was so rich-many of the choicest of them, no doubt-were conveyed to Rome Archimedes perished in the confusion of the sack while he pursued his studies.

Syracuse was now simply one of the provincial cities of Rome's empire. It retained much of its Greek character and many of its finest public buildings. Its importance and historic associations naturally marked it out as the residence of the Roman practor or governor of Sicily. Cicero often speaks of it as a particularly splendid and beautiful city, as still in his own day the seat of art and culture Caligula restored its decayed walls and some of its famous temples It was plundered by Frankish pirates about AD. 286. In the 4th century it is named by the poet Ausonius, chiefly, perhaps, on the strength of its historic memories; and there was a purple factory here under an imperial procurator. In 665 Heraclius Constans fixed his capital here, but owing to his oppressive government was assassinated in 668. Syracuse has been a place of comparatively little importance since the year 878, when it was destroyed by the Saracens.

Archaeology.-The mediaeval and modern town of Syracuse (with the exception of a new quarter which has sprung up since the construction of the railway between the station and the island) is confined to the island. This contains the remains of two Doric temples. The older, belonging probably to the beginning of the 6th century B.C., appears, from an inscription on the uppermost step, to have been dedicated to Apollo It was a peripteral hexastyle of 42 columns; the portion excavated shows that its total width is 741ft., the width of the cella 381ft, the lower diameter of the columns 61ft. The other temple, into which the cathedral was built in AD. 640, is to be dated 474-460 BC. It was a peripteral hexastyle of 36 columns, with a total length of 180ft, and a total breadth of 72ft.; the columns have a lower diameter of 52ft., and the intercolumniation is 134ft. It is almost certainly the temple of Athena. The site was previously occupied by buildings of the 7th and 6th centuries B.C., including an archaic temple and a great sacrificial altar; which were destroyed to make room for it. Their terra-cotta decorations were, however, carefully buried under the pavement of the space which surrounded it; and they are of the highest importance in the history of design, showing that even if the method was Corinthian

Near the west coast of the island is the famous fountain of Arethusa According to the legend, the nymph Arethusa was changed into the fountain by Artemis to deliver her from the pursuit of the river-god Alpheus (q.v); and the spring, which was fresh until an earthquake broke the barrier and let in the salt water, was supposed to be actually connected with the river. There are interesting remains of mediaeval architecture in the closely built town with its narrow streets, the beautiful 14thcentury windows of the Palazzo Montalto may be especially noticed, and also the 13th-century Castello Maniace at the southern extremity of the island The town also contains the large and well arranged archaeological museum which is the creation of Prof. Orsi, and is of the highest importance for both pre-Hellenic and Hellenic archaeology The discoveries of recent years in the south-eastern portion of Sicily, including especially the objects found in Sicel and Greek cemeteries, may be studied there. The isthmus connecting the island with the mainland, which was defended by strong fortifications erected by Charles V and Philip II. (now demolished), does not occupy the site of the mole erected in the 6th or 7th century B C, running due north from the north point of the island. On the landward side of the new isthmus was the agora, in which remains of a colonnade of the Roman period have been found. To the west are the remams of an extensive building of the Roman period, probably a palaestia with a small Odeum attached. To the west-north-west is an extensive necropolis, mostly of the 7th and 6th centuries BC (For the cemeteries see The Year's Work in Classical Studies, p. 123 [1924-25]) This necropolis was included within the defensive wall of Dionysius, a portion of which, no less than 181ft. thick, was found 1unning diagonally across the new cemetery, and later an outwork in front of it was discovered. East of this point it probably followed the edge of the low terrace above the marsh (the ancient Lysimeleia), while in the other direction it ran north-north-west. making straight for the western edge of the gorge known as the Portella del Fusco, which was thus included within the fortifications, as it would otherwise have afforded a means of access to the enemy Here the wall gained the top of the cliffs which mark the southern edge of the plateau of Epipolae, which from this point onwards it followed as far as Euryelus. The south wall of Epipolae, considerable remains of which exist, shows traces of different periods in its construction, and was probably often restored It is built of rectangular blocks of limestone generally quarried on the spot. Euryelus, the point where the terrace of Epipolae narrows down to a ridge about 60yds, wide, which is its only link with the hills to the west, had thrice proved during the Athenian siege to be the key to Syracuse. It now bears the ruins of a mighty fortress, finer than that which defends the entrance to the acropolis of Selinus-the most imposing, indeed, that has come down to us from the Greek period-which there is no doubt is the work of Dionysius. The total length of the works is about 440yds. In front of the castle proper are three ditches, the innermost of which can be reached from the interior of the castle by a complicated system of underground passages The front of the castle is formed by five massive towers; behind it are two walled courtyards, to the north of the easternmost of which is the well-guarded main entrance to the plateau of Epipolae (narrower minor entrances are to be seen on both the north and the south sides) communicating by a long underground passage with the inner ditch in front of the castle proper. On the north side of Epipolae the cliffs are somewhat more abrupt; here the wall, of a similar construction to that on the south, is also traceable, but here it is apparently all of one period. It is, indeed, recorded by Diodorus that Dionysius built the north wall from Euryelus to the Hexapylon in 20 days for a length of 22m., employing 60,000 peasants and 6,000 yoke of oxen for the transport of the blocks.

The most important buildings of which we have any remains are to be found in the lower part of Achradina and in Neapolis. a quarter of which we hear first in the time of Dionysius, and which at first was confined to the lower ground below Temenites: but in Roman times included it and the theatre also, though it

did not extend beyond the theatre to the uppermost part of the plateau In lower Achiadina remains of Roman private houses have been found, and it is in this district that the early Christians constructed their catacombs (St Paul tarried at Syracuse three days on his way to Rome [Acts xxviii 12] ) Those which are entered from near the 12th-century church of S Giovanni, situated near an ancient temple, are extensive and important, and include the ancient crypt of S Marcianus, and the type is different from that of the Roman catacombs, the galleries being far larger (partly owing to the hardness of the himestone in which they are excavated), and having circular chambers at the points of junction In Neapolis, on the other hand, public buildings pre-dominate The temple of Apollo Temenites has entirely disappeared, but the theatre, entirely hewn in the rock, is still to be seen. It is the largest in Sicily, being 1385yds in diameter, and having 59 rows of seats, the 11 lower tiers were originally covered with marble Each of the nine cunes or divisions bore a name, the inscriptions of five of them, still preserved on the rock, are in honour of Zeus, Heracles, King Hieron II, his wife Philistis, and his daughter-in-law Nereis It was restored after 238, after her marriage to Gelon Of the stage nothing but cuttings in the rock and foundations are visible (See G E Rizzo, Il Teatro Greco di Siracusa [1923] foi a most careful study) The situation is well chosen, commanding a splendid view over the Great Harbour, and it is often used for classical performances Not far off to the southeast is the amphitheatre. probably erected by Augustus when he founded a colony at Syracuse, it is partly cut in the rock and partly built. It is inferior in size only to the Colosseum and the amphitheatres of Capua and Verona, measuring about 153 by 130 yd over all the arena is 76 by 43 yd To the west of the amphitheatre is the foundation of the great altar erected by Hieron II, 217 yd long by 24 wide, and about 6 yd in height. To the northwest of the theatre a winding road ascends through the rock, with comparatively late tomb chambers on each side of it. In this district are seen hundreds of small niches cut in the rock, as a rule about 2 ft square and a few inches deep, which served for containing inscriptions or reliefs, sometimes of a sepulchral character, but sometimes relating to the cult of a divinity. Both the districts just described also contain huge quarries, the famous Lautumiae (from Gr. λâas, stone, and τεμεῖν, to cut; hence λα-ομία, quarry) of Syracuse, over 100 ft deep and of great extent (though through the collapse of the pillars supporting the undermined rock they have become still larger than they were in ancient times)

We have already seen that immediately outside Lower Neapolis on the south the marshes of Lysimeleia begin, which proved fatal to more than one besieging force They are traversed by the Anapus, with its tributary the Cyane, the latter famous for the papyrus planted by the Arabs, which here alone in Europe grows wild in the stream. To the south of the Anapus is the hill of Polichne, on which stood the Olympieum, attributed on stylistic grounds to 581 B.C. Its monolithic columns, of which two are still standing, are about 21 ft. in height and 6 ft, in lower diameter: its length is estimated at 197 ft , its breadth at 662 ft This and the temple of Apollo are the earliest known examples of peripteral temples in stone. The hill was frequently occupied in attacks on Syracuse by the besieging force. The hill of Dascon is a trifle to the southeast. From this point southward the shore of the Great Harbour begins to rise, until the rocky promontory of Plemmyrium is reached

As an important sesport, Syraciase was bombed by the Allies a number of times during World War II. With the rest of Sicily it was occupied by Angle-American forces in the summer of 1943. See A. Hölm and F. S. and C. Cavallari, Topograpia archeologica di Siracusa (Palermo, 1883), or the more handy German translation by B. Lugus, Topographie von Syracus (Strassuburg, 1897); P. Ord, in Atti del congration of sciences storicke, v. 151 (1994), in Monument Mauceri, Siracus (Palermo, 1940); J. Falhert and V. Schultze, "Die altchristlichen Grabstatten Stalliese," Jarbuach das h. d. arch, Instagnangsheit vii zi zigg. (1997), fort the archeology of Syracus; and alsg E. A. Freemap, History of Siddy, (1947–94), Sozian.

SYRACUSE, a city of New York, U SA, the county seat of Onondaga county, mudway between Albany and Buffalo, at the south end of Lake Onondaga, on federal highway 11 and the state barge canal I It has a municipal airport and is served by the Lackawanna, the New York Central, the West Shore and by motor-truck lines Pop (1950) 220,067, in 1940 it was 205,097 by federal census.

Syracuse has a beautiful location on high ground, in an amphatine of hills around the south end of Lake Onondaga (5 mt long), surrounded by a nch agricultural region, within a short drive of the Finger lake region and less than 100 mt from the Adinondacks and the Thousand Islands. Two creeks wind through the city to the lake. Wide boulevards have been constructed over the abandoned beds of the Erre canal (which crossed it from east to west) and the Oswego canal (which came from the northwest and ioned the Erre in the heart of the city).

There are seven large parks and many small parks and playgrounds, large modern hotels and beautiful residential streets,

many of them arched with interlacing elms.

Salma street is the main business thoroughfare Around St Mary's circle are grouped the county courthouse, the public hibrary, the Cathedral of the Immaculate Conception, and the unique and beautiful building of the First Baptist church which houses a hotel, built around and above the church.

Syracuse university occupies 100 ac in the southeastern part of the city, and on the western border are the state fair grounds (with extensive exhibition halls and a coliseum seating 7,500)

where the annual state fair was first held in 1890
Six miles south is the Onondaga Indian reservation

The city operates under a mayor-and-council form of government The water supply, brought from Skaneateles lake (20 ml. SW) by a gravity system, is ample for a much larger population Hydroelectnic current is available from Niagara falls and the Salmon river.

The Syracuse region, when first visited by Europeans, was the home of the Onendaga Nation and the capital of the Five (later Six) Nations of the Iroquois. It was visited by Champlain in 1615, by Radisson (while a captive of the Mohawks) in 1651, and in 1654 by Simon le Moyne, a Jesut missionary, who found that the spring of which the Indians would not drink (because they believed a demon lived in it and gave the water an evil smell) was a fountain of salt brine. A mission was founded in 1651 by Chaumonot and Dablon near the present village of Liverpool (5 mi. N.W of Syracuse) and the next year the mission and a military post were formally established with pomp and ceremony Both were abandoned because of the hostility of the Mohawks in 1658, but the mission was resumed in 1668 and continued through the century.

The Onondaga village (south of the lake) was visited by many important representatives of the Fiench and the English between 1570 and 1766 in their ravally for the friendship of the Five Nations; and the raid from Ft. Schuyler (April 21, 1779) which determined the Chondagas to side with the British in the Revolution, took place within the present limits of Syracuse. The first white settler on the site of the city was Ephraim Webster, who established a trading post near the mouth of Onondaga creek in 1786.

In 1788 Asa Danforth came from Mayfield (New York) with his wife and son. He built a sawmill and a gristmill, organized the militia, and is called "the father of Onondaga; county" In 1788 the state undertook, by treaty with the Onondagas, to manage the salt springs, and in 1795 it acquired title to them and rosqum. of surrounding land, in return for \$1,000 in cash and promise of an annual rental of \$700 and 150 bushels of salt. In 1797 the state begain leasing the salt lands, on a royalty basis. Three villages soon sprang up around the southern end of the late. Webster's Landing and Salma in 1797 and Geddes (founded Late. Webster's Landing and Salma in 1797 and Geddes (founded scale) in 1603 ("see the state of the salt lands, and Geddes (founded scale) in 1603 ("see the salt lands, so soon of thown by several names in succession until 1840, when 500 one of flown by several names in succession until 1840, when 500 one of flown by several names in Strick.

Syracuse was incorporated as a village in 1825, became the county seat in 1827, and in 1847 Syracuse and Salina were consolidated and chartered as a city. The population in 1850 was 22,271. From time to time various annexations of contiguous territory were made, including the village of Geddes in 1884.

The salt industry was the foundation of the city's development Until about 18,70 it was the dominating industry and Syracuse was the principal source of supply for the United States Not only was this andustry the base of most of the eatly individual fortunes in Syracuse, but pressure from the men interested in salt-making increased the demand for the Eric canal, the first section of which, passing through Syracuse from Rome to the Seneca river, was opened in 1820. In the 1850s Syracuse made many bicycles, and by 1900 at was one of the centres for the manufacture of type-writers. Later, the industries of the city became highly diversified, including steel, electrical products, hardware, roller bearings, automobile parts, in cans, agricultural implements, chinaware, soda sh, home appliances, foundry and machine shop products, radio and television sets, furniture, shoss, food products and numerous

other items SYR-DARYA (Gr and Lat Javartes, Alab Shash or Sihun), (1) a river of Asiatic Russia, flowing into the Sea of Aral, and having a length of 1,500 m. and a dramage area of about 320,000 sq miles Its headstream is the Naryn, rising in the Tianshan south of Lake Issyk-kul, on the south slope (12,000 ft.) of the Terskei Ala-tau. After union with the Barskaun, it flows W.S.W. at 11,000 to 10,000 ft, above the sea, in a barren longitudinal valley between the Terskei Ala-tau and the foothills of the Kokshal-tau. As the Naryn it flows through a wild gorge in the south-west continuation of the Terskei Ala-tau, falling 4,000 feet. Fort Narynsk, 20 m. below the confluence of the Great and the Little Naryn, is only 6,800 ft above the sea. Here the river enters a broad valley-formerly the bottom of an alpine lake-and flows past the ruins of Fort Kurtka, for 90 m. westward, as a stream some 50 yd wide and from 3 to 11 ft deep, used by the Kirghiz for irrigating their cornfields. The At-bash a large mountain stream, joins the Naryn at the head of this valley and the Alabuga or Arpa at its lower end, both from the left. Before reaching the lowlands the Naryn cuts its way through three ridges which separate the valley of Kurtka from that of Ferghana, and does so by a series of wild gorges and open valleys (170 m), representing the bottoms of old lakes; the valleys of the Toguztorau, 2,000 ft. lower than Kurtka, and the Ketmen-tube are both cultivated by the Kirghiz. Sweeping north, the river enters Ferghana-also the bottom of an immense lake-where, after receiving the Kara-darya (Black River) near Namangan, it assumes the name of Syr-darya The Kara-darya is a large stream rising on the northern spurs of the Alai mountains. As it deflects the Naryn towards the west, the natives look upon it as the chief branch of the Syr-darya, but its volume is less. At the confluence the Syr is 1,440 ft, above sea-level

On issuing from this gorge the Syr citers the Ard depression, and flows for 85 cm. in a north-westerly and northerly direction before reaching the Sea of Aral. On this section it is navigated by steamers Between the Fight rapids and Ballyd-rutagal (where it bends north) the river flows along the base of the subsidiary ranges which flash the Chotkal montains on the north-west, and receives from the longitudinal valleys of these alpine tracts a series of tributaries (the Angren, the Chrichig, the Keles).

Some 50 m. below Chinas (770 ft. above sea-level) the Syr bends northwards, but resumes its north-westerly course 150 m. farther down, following with remarkable persistency the edge of the beas. Its low banks, overgrown with reeds and rendered unliabilitable in summer by clouds of mosquitoes, are inundated for 20 m. on both sides when the snows begin to melt. These inundations prevent the moving sands of the Kyryl-kum desert from approaching the Syr; blow Perovsk (Kyryl-Cota, or akrom approaching the Syr; blow Perovsk (Kyryl-Cota, or akmudry sellow waters, at the rate of 3 to 5 m, an hour, in a channel 300 to 600 yd wide and 3 to 5; athorns deep; at Perovsk its vertical section is \$200 soft; and 312,500 cut. of water are discharged per sectiond. The Ary and the Bugun are the only

tributaries worthy of notice along this part of its course; the other streams which descend from the Kara-tau fail to reach the river. The Kirghiz rear numerous heads of cattle and sheep in the valley of the Arys, while lower down, as far as Julek, the Iginchis carry on agriculture. All this applies of course only to the right bank, on the left the moisture is absorbed by the hot winds which cross the Kyzyl-kum sands towards the river The dryness of the atmosphere has a marked effect upon the Syr when it gets below Julek, the Kara-kum sands being then on its right Ten miles below Perovsk the river traverses a marshy depression (the bottom of a lake not yet fully dried up), where it divides into two branches-the Jaman-darya and the Kara-uzyak The latter spreads out into marshes and ponds, from which it again issues to join the former at Karamakchi, after a course of 80 miles The main arm, owing to its shallowness and sinuosity, is very difficult to navigate, and the difficulty is increased by the rapidity of the current and the want of fuel Between Kazalinsk and the Sea of Aral (158 ft ) navigation becomes somewhat easier, except for the last 10 m., where the river divides into three shallow branches before entering the "Blue sea" All three have at their mouths sandy bars with only 3 ft of water.

Two former right-hand tributaries of the Syr-the Chu and the Sary-su-now disappear in the sands some 60 m before reaching it. The Chu, which is 600 m in length, rises in the Tian-shan south-west of Lake Issyk-kul, and as the Kashkar flows towards Lake Issyk-kul, but a few miles before reaching that lake turns suddenly to the north-west, enters under the name of Chu the narrow gorge of Buam, and, piercing the snow-clad Kunghei Alatau, emerges on its northern slope, having descended from 5,500 ft. to less than 2,000 in a distance of not more than 50 miles In this part of its course it receives from the right the Kebin, whose high valley equals in size that of the upper Rhone It then flows north-westwards through the valley of Pishpek, and, avoiding the Muyun-kum sands, describes a wide curve to the north before finally taking a western direction. Numberless streams flow towards it from the snow-clad Alexander mountains, but they are for the most part lost in the sands before reaching it The Talas, 170 m. long, formerly an affluent of the Chu, which rises in the highest parts of that range, pierces the Cha-archa mountains, and, flowing past Aulie-ata on the south border of the Muyun-kum. enters the salt lake of Kara-kul 60 m from the Chu The Chu terminates in the Saumal-kul group of lakes, 60 m from the Syr. Another elongated group of lakes-the Uzun-kul-near the above, receives the Sary-su, which has a length of nearly 570 m and flows rapidly in a narrow channel along the western edge of the northern Famine Steppe (Bekpak-dala).

The delta of the Syr begins at Perovsk, whence it sends a branch to the south-west, the Jany-darya (New River), which formerly reached the south-eastern corner of the Sea of Aral, very near to the mouth of the Amu-darya. The Kirghiz affirm that a canal dug for irrigation by the Kara-kalpaks gave origin to this river. It had, however, but a temporary existence A dam erected by the people of Khokand at Ak-mechet (Perovsk) caused its disappearance, and the Russians found nothing but a dry bed in 1820 When the dam was removed the Jany-darya again reappeared, but it failed to reach the Sea of Aral; in 1853 it terminated in Lake Kuchka-denghiz, after a course of 250 m; all traces of its bed were then lost in the sand. Five centuries ago, in the time of Timur, the Mongol prince of Samarkand, the Jany-darya brought the waters of the Syr to the Daukara lakes, close by the present mouth of the Amu. The series of old river-beds in the Kyzyl-kum, which are still seen above Perovsk, indicate that the Syr had a constant tendency to seek a channel to the southwest, and that its present delta is but a vestige of what it was once. At a still more remote period this delta probably comprised all the space between the Kara-tau and the Nura-tau in Samarkand; and the series of elongated lakes at the base of the Nuratau-the Tuz-kaneh and Bogdan-ata lakes-represent an old branch of the delta of the Syr which probably joined the Zarafshan before reaching the Amu The cause of this immense change is simply the rapid desiccation of all northern and central Asia. The extension of the Caspian sea as far as the Sary-kamysh lakes

during the post-Pliocene period and the extension of the Sca of Aral at least roo mi to the east of its present position are both proved by the existence of post-Phocene marine deposits

(P A K , J T BE )

See W. R. Rickmers, The Duab of Turbestan (1913) A Boutquin,
L'Asie Centrale, la Question du dessechement du globe (1910).

(2) A former province of Asiatic Russia, now included in the Kazakstan ASSR and Uzbek ASSR (ag v)

SVRIA, a country of western Asia, covering an area of 66,065, sq mi, bordered on the north by Turkey, on the east and on the southeast by Iraq, on the south by Jordan and Israel and on the west by the Mediterranean sea and by Lebanon. The modern state was created after World War I from portions of the Turkish vilayets of Aleppo, Damascus, Zou and Jazrah and, with Lebanon, came under French mandate in 1939 the snajk of Alexandretta was ceded to Turkey and then named the Hatay. Though the mandate over Syran was federated to be at an end by the Free French in 1941 the country did not effectively gain independence until 1046 (see History, below).

The population was 2,930,107 by the census of 1038 and was estimated at 5,043,310 in 1047 and at 3,517,000 in 1951. It is divided among numerous religious communities roughly as follows: Molems, 8.7%, mainly Sunni Arabs, Christians, 14%, comprising Roman and Uniate Catholics, members of the Orthodox Bastern Church. Iacobites and Gresorian Armenians, Druses, 4%: 1ews:

and some Vezidis.

Damascus, the capital had 3,3,100 inhabitants in 1950, Aleppo 362,500, Home 244,100, Hama 146,600. The country is divided into nine provinces (muhafisat). Damascus, Aleppo, Homs, Hama, Lutakus, Euphrates, Jazurah (Jeare), Haura and Jabal Druse (Jelel Druze). The chief port is Latakia (100,500 in-

habitants), the ancient Laodicea Physiography.-The whole area of the states of Syria and Lebanon (q.v) may be regarded as a single geographical unit extending from the eastern shore of the Mediterranean to the Syrian desert (which is crossed diagonally from northwest to southeast by the Euphrates) and the Jazirah east of that river. It is bounded on the north by the footbills of the Taurus ranges and terminates south of the Anti-Lebanon and Mount Hermon with the volcanic region of the Hauran and the Jabal Druse The coastal strip is a narrow, discontinuous plain measuring about 200 mi. in a direct line from Kara Duran on the northern frontier to Ras an-Nakurah (Ras en Nagura) in the south There are many varieties of shore line, from the cliffs and headlands north of Latakia and the rugged coast between Tripoli and Beijut, to the sandy shore near Tyre. Behind, from north to south, lie the Ansariyah and Lebanon ranges divided by the valley of the southern Nahr al-Kabir (the ancient Elcutherus) The Ansarıyah averages 18 to 20 mi. in width and is of fairly uniform, rounded outline intersected by deep valleys. The highest peak, Nebi Yunis (5,194 ft.), is toward the northern end of the lange. The Lebanon rises steeply from the Bika (Bekaa) plain to a tableland more than 8,000 ft, high from which rise several peaks, the highest being Kurnat as-Sauda (Qurnet es Sauda) (10,131 ft ) The main pass, which carries the Beirut-Damascus road, is the Dahr al-Baidar (5,057 ft.). South of this pass the main ridge is narrower and falls away southeast to the plain of Mery Ayun, south to the Litani gorge and southwest to the coast near Sidon. The upper slopes of the Lebanon are bleak, stony and desolate; the middle slopes, below 5,500 ft., are the most densely populated region and cultivation extends up to 5,200 ft. East of the coast ranges is a long depression. At the northern end are the Orontes valley and the Ghab marshes which extend for 38 mi. from north to south with a maximum width of about 9 mi. South of the Ghah the Orontes follows a tortuous course to Lake Homs, south of which is the Bika valley. The northern end of this valley, through which the Orontes flows is, for the most part, poor soil strewn with basalt houlders mixed with limestone and flint. South of the Baalbek ridge, the watershed between the Orontes and the Litani, the soil is rich and well-cultivated. The Litani river falls very gradually through it from northeast to southwest until it reaches the barrier of Jabal Gharbi, a low ridge between the Lebanon and Mount Hermon. The Bika valley is dominated on

the east by the Anti-Lebanon range which runs from northeast to The main ridge southwest nearly parallel with the Lebanon (8,300 ft ) rises steeply about 17 mi south of Homs and extends for 65 mi to the Zebdani depression through which pass the railway and road between Beirut and Damascus Mount Hermon (9,232 ft ) rises south of this gap Northeast of Damascus are the three Kalamun 11dges, the easternmost of which stretches for more than 130 mi to Palmyra Northwest of Palmyra hes a semiarid steppe sloping eastward to the Euphrates The Syrian desert, the Hamad, to the east of the Anti-Lebanon, comes up in places almost to the foot of the range Where water is available (as in the Ghuta around Damascus which owes its fertility to the Barada [the Abana of the Old Testament]), or rainfall is abundant (as in the Hauran farther south), cultivation pushes out toward the desert East of the Hauran lies the Jabal Druse (5.900 ft ), much of which is fertile though large areas of the district are lava-covered. To the northeast of the Euphrates is the Jazirah, roughly triangular in its Syrian portion, with a projection in the northeast (the "Duck's Bill") to the Tigris between Jazirat-ibn-Omar (in Turkish Cizre) and Faish Khabur. Except in the neighbourhood of the Euphrates and its tributaries, the Balikh and the Khabur, which cross the Jazirah from north to south, it is a district of stony hills and low ridges.

Climate.-Syria has a climate varying from the Mediterranean type in the west through the steppe type to the continental or extreme type, with a wide range of temperature and absolute aridity for six months, in the inland region, which is open to the Arabian desert on the south The two gaps in the mountain ranges screening the interior from the sea cause an extension of the maritime influence inland to the region south of Homs and to the Hauran and Jabal Druse south of Damascus The rainy season is from November to March, though abundant rainfall may occur in April or May. The average of rainfall varies from 20-40 in in the coastal belt (rising to 50 in or more in the mountains), through 10-20 in between Aleppo and Damascus, to 5-10 in in the crescent from Damascus to the northern frontier and to Dair az-Zor (Deir) and to as little as o s in, in the desert from Palmyra to the southeast. Snow falls on the mountains and may lie even on Mount Hermon until late in the summer. Normally Syria has a hot summer and a mild winter Temperatures increase from west to east and also. though to a lesser extent, from north to south. Summer temperatures, taking an average over a number of years, vary from mean monthly maxima and minima (August) of 106° F. and 68° F at Aleppo to 110° and 65° at Palmyra, with absolute maxima at Aleppo (115° F), Damascus (113°), Palmyra (120°) and Dair az-Zor (115°) Mean monthly maxima and minima for January, which is usually the coldest month, are: Aleppo 58° F. and 22° F., Damascus 62° F and 28° F, Palmyra 62° F, and 25° F.

(K. C. B.) Vegetation.—The coastal strip of Syria is intensely cultivated and planted with groves of mulberries, olives, etc., and there is httle space for natural flora Rocky patches bear brushwood with Calycotome villosa, buckthoin, tamarisk, etc : in swampy places reed-grasses grow; and among the crops brilliant flowers of the Mediterranean element such as Anemone coronaria, Ranunculus asiatious, Papaver syriacum, etc., spring up wherever possible. There is high forest of Aleppo pine in the north of the Ansariyah range with sessile and Syrian oaks (Quei cus syriaca); in the centre are stunted oak woods; in the south mulberry, valonia oak (O. aegilops), etc. The shrub constituent includes rock roses, tamarisk, terebinth, oleander, etc. On the Lebanon mountains there are forests of oaks, Aleppo pine, cypress, juniper, cedar and fir. Near Beirut there has been considerable re-afforestation with stone pine, and large areas of the lower slopes, up to 5,000 ft., are planted with olive, fig and mulberry (for silkworms). Wild plants in this zone include valerian and danewort, and above, where wheat and barley are cultivated (up to 6,000 ft.) is the montane region of sea holly and rhododendrons. The alpine zone supports peculiar plants such as Acantholimon libanoticum, a spmy milk vetch which grows in clumps, and sainfoin The Bika plain is almost treeless while composites, labiates and milk vetches are characteristic. On the foothills of the steppes terebinth predominates; on the plains 716

oak. The Hamad supports only halophytes and xerophytes except along the Euphrates and other water courses where poplars, tamarisk and a few others flourish.

Fauna .- In the upper regions of the Lebanon bear is still occasionally found-the largest remaining wild animal in Syria Antelope and gazelle are common in the Hamad. Other mammals include deer, polecat, wild cat, ichneumon, porcupine, hedgehog, squirrel, marten, ermine, otter, dormouse, rats, hares and the hyrax, Many migrating buds call at Syria on their way north and south Flamingoes, pelicans, cormorants, ducks, herons, snipe, etc., frequent the fresh waters and marshes; bustards and ostriches the desert; kingfishers, cuckoos, woodpeckers, etc , the valley , eagles, huzzards, kites and falcons the mountains. Horned and other vipers occur in the desert, and lizards and chameleons are common. Of innumerable insects, the mosquito is the most harmful but locusts and grasshoppers also do damage. In the lakes and rivers mullet, eels and bass are among the fish.

#### HISTORY

Fint implements of palaeolithic types have been found in caves in Syria and in Palestine, associated with bones of the rhinoceros and of the hippopotamus and, in the district of Mount Carmel, with skeletal remains of a manlike creature (these dating to the Mousterian period). The remains and industries of man, who already made use of fire, continue through the late Palacolithic into the Mesolithic age, which is well represented in the so-called Natufian culture found chiefly near Jerusalem. This was the work of men who appear to have been smaller than their predecessors and might be racially similar to the Hamites and Semites At first purely hunters, they began, before the end of the Mesolithic penod, to cultivate the wheat and bailey which, in their wild state, were indigenous to the country; and thus they made the decisive step from a nomadic to a sedentary life in which the arts of civilization could be born Rough pottery is found in a very early age (perhaps c. 4000 BC.) at Jericho, and not long afterward there was centred in northern Syria and in northern Mesopotamia a prehistoric manufacture of the finely made and beautifully painted ware named after Tell Halaf, the place of its first discovery. At about the same time began the use of copper for tools and ornaments. Oxen, sheep, goats and pigs were domesticated, and even irrigation was practised Population was mixed, the heavier Armenoids being mingled with a slighter race, which may already have spoken a Semitic language.

### EARLY HISTORY

History begins with the invention of writing, which took place in southern Babylonia perhaps c. 3500 B.C., the script being an original picture-character which developed later into cuneiform. An early Sumerian ruler of the city of Erech, named Lugal-zaggisi, recorded his triumphal progress from the lower sea to the upper (sc. the Mediterranean), and this may be taken as the first mention of the land of Syria, though not of the name, in history. Immediately after this mention, Syria appeared as the provenance of a great migration of Semitic invaders into Babylonia by way of the Euphrates, the first of several such movements which may all have begun from northern Arabia, but are never traceable farther back than Syria. These first intruders have been given the name of Accadians, from their leader, Sargon of Agade or Akkad, with whom is connected a legend that he was born obscurely on the upper Euphrates, launched on the river in a reed basket and adopted in Babylonia, where he found favour with a king, supplanted him and became the greatest conqueror and the most famous name in Babylonian history. From his new city of Agade he marched back up the Euphrates to the "cedar mountain" (the Amanus) and far beyond, if the various sources may be trusted. It is probable that he and his equally famous grandson Naram-Sin (c. 2300 BC.) ruled effectively over the whole of Syria, to which they doubtless introduced the Sumerian writing that they had learned and adapted to their Semitic language in Babylonia. But their successors were feebler men, and the dynasty of Agade was soon overthrown at its centre and superseded by the dynasty of Ur. Nothing certain is

١

wormwood; and in the Jabal Druse maquis with forests of kermes known about the authority (if any) that the kings of Ur exercised in Syria, so far away from their capital The end of their dynasty, however, was brought about chiefly by the pressure of a new Semitic migration from Syria, this time of the Amorites (se, the westerners), as they were called in Babylonia Their invasion began before 2000 BC and by the 18th century BC. they had covered both Syria and Mesopotamia with a multitude of small principalities and cities, mostly governed by rulers bearing some name characteristic of the Semitic dialect that the Amorites spoke The period of Amorite ascendancy is vividly mirrored in the Mari letters, a great archive of royal correspondence found at the site of Mari, near the modern frontier with Iraq. They treat of the wars and general affairs of a multitude of states extending from northern Palestine to the upper Tigris Among the principal figures in them are the celebrated lawgiver Hammurabi of Babylon (himself an Amorite) and a king of Aleppo, reckoned the most powerful of all, but of whom little is yet known Part of his kingdom was the city of Alalakh, on the Orontes near what was later Antioch This has yielded to excavation records both of the Amorite period and of a later age

At about the same time (later in the 18th century B.C.) there began from Syria a movement of people in the opposite direction This resulted in the Hyksos invasion of Egypt, which was subject to this foreign domination for about 150 years. The mixed multitude of the Hyksos certainly included Khurrians (Hurrians, Horites), who, not being Arvans themselves, were under the rule and influence of Aryans and learned from them the use of light chariots and horses in warfare, which they introduced both into Egypt and into Syria and Mesopotamia These Khurrians established the kingdom of Mitanni, with its centre east of the Euphrates, and this was for long the dominant power in Syna, reaching its height in the 15th century B C. But other nations were growing at the same time, and in the 14th century Syria was the arena in which at least four great competitors contended. The Khurrians were first in possession, and these maintained friendly relations with Egypt, which, after expelling the Hyksos, had established a vast sphere of influence (it was scarcely an "empire") in Palestine and Syria, under the kings of the 18th Dynasty. Third of the powers disputing Syria in the 14th century were the Hittites, who finally, under their greatest warrior Shuppilulumash (c 1350 B.C.) not only defeated the kingdom of Mitanni but established a firm dominion of their own in northern Syria with its principal centres at Aleppo and Carchemish. Fourth was the rising kingdom of Assyria which became a serious contender in the reign of Ashuruballit I. Indeed a fifth actor also appeared on the scene, the king of Babylon, but he was too distant and impotent to affect the issue This was the period of the Amarna letters which vividly illustrate the decline of Egyptian influence in Syria, especially under Amenhotep IV (Ikhnaton), the distress or duplicity of local governors and the rivalry of the aforesaid powers, contending with Egypt and with one another in a strife that was not to leave any of them with a final victory. Egyptians and Hittites continued their struggle into the 13th century, but even the famous battle of Kadesh, which Rameses II so boastfully claimed to have won (c. 1285 B.C.) led to no more than a treaty maintaining the equal balance. Assyria had already swept away the remains of Mitanni but soon fell into decline, and the Hittites were not long afterward driven from their centre in Asia Minor into a chain of minor states on the northwestern fringes of Syria by the migration of "peoples of the sea," west-ern invaders from the sles of the Aegean and from Europe. These immigrants then marched down the coast of the Levant and threatened Egypt, but were repulsed by Rameses III c. 1190 BC

While all the neighbouring states had failed to establish a lasting ascendancy in Syria, the actual possession was assumed gradually by a people without sufficient cohesion to appear as a power at all. Various documents of the 14th century mention the Akhlamu, who were forerunners of another vast movement of Semitic tribes called generically Aramaeans. By the end of the 13th century these had covered with their small and loose principalities the whole of central and northern Syria and a great part of Mesopotamia. The Assyrians, however, were able to guard their homeland from this penetration: henceforth much of the warfare of Assyrian kings

was to be a mixture of aggression and defense aimed at the A1amaean states of Syria and at the borderland "Hittite" principalities At about the same time as the Aramaean invasion there was proceeding the exodus of Israelite tribes from Egypt, and as these, toward the end of the 11th century established a kingdom centred upon Jerusalem, so did the Aramaeans set up their principal kingdom at Damascus, and the wars between kings of Judah or of Israel and kings of Aram make up much of Old-Testament history But the most formidable enemies of the Aramaeans and often of the Hebrews as their allies, were the great military kings of the Assyrians After a premature Assyrian incursion under Tiglathpileser I early in the 11th century BC, the real contest was reserved for the 9th and the 8th, during which the Assyrian empire was established over the west, though destined to be short-lived At the battle of Karkar in 853 B C Shalmaneser III of Assyria was opposed by Ben-Hadad of Damascus, Ahab of Israel and by 12 vassal monarchs. In 732 Damascus, the Syrian capital, was at length captured by Tiglath-pileser III But campaigns against the Aramaeans and Anatolians of northern Syria (called "Hatti-land") had to be undertaken by the Assyrians until almost the end of the Assyrian empire Culturally, the most important achievement of the Aramaeans was the bringing of the alphabet into general use for public and private business. It had been invented along the Syrian coast before the middle of the 2nd millennium B C. This was perhaps the greatest single contribution ever made to human civilization

Before the close of the 8th century BC began a massive southward movement of people, partly of Aryan stock, from the north and west Pressure of these upon the Assyrian dominions and homeland became ever more severe, and they deeply affected Syria also; and in the 7th century came the invasion of the Cimmerians, followed by the Scythians. To these and to the Medes, another Arvan people, Assyria finally succumbed with the fall of Nineveh in 612 BC A remnant supported itself in Harran for a year, but that city was evacuated before the advance of the Medes, now reinforced by Nebuchadrezzar, king of Babylon. Nebuchadrezzar finally defeated the attempted rescue of Assyria by Necho, king of Egypt, and annihilated his army at Carchemish in 605 BC. In 586 BC he captured Jerusalem and carried its people into exile Thereafter Syria was, for half a century, under the rule of Nebuchadrezzar's successors on the throne of Babylon. But another and greater Aryan power, the Persians, then came to the Under the leadership of Cyrus they subverted the rule of the Medes and assumed their empire, extending their conquests into Asia Minoi, where Cyrus defeated and captured Croesus of Lydia. No longer able to brook a rival, he thus came to a final collision with Babylon, which he occupied in 539 B C. He returned all the gods of Babylonia to their own places, and among the measures of restoration commanded by him and continued by his successors was a project of sending back the exiled Jewish community to Jerusalem and encouraging them to rebuild the temple. In Darius I's great organization of the Persian dominions more than 20 satrapies were constituted; Syna, with Palestine and Cyprus, was the fifth, bearing the name of "Across the River" (26., the Euphrates), and its tribute was fixed at 350 talents of silver. Damascus and the Phoenician cities were still the chief centres of Syna under the Persians, and in Sidon was the core of the Phoenician revolt against Artaxerxes III, which ended with the destruction of that city in 351 B.C But by this time the end of the Persian domination was at hand, and the Macedonians under Alexander the Great were about to bring the whole near east under Greek rule and influence. Alexander invaded Asia Minor in 334 B C., and his first decisive victory over the Persians was won on the fringe of Syria at Issus in 333; it was followed by the capture and enslavement of Tyre and Gaza With the battle of Gaugamela and the destruction of Persepolis the downfall of Persia was completed. See further Amorites; Hittites; Phoenicia; Damascus; Sidon; TYRE; and works cited in the bibliographies to these articles.

## (C. J. G.) HELLENISTIC AND ROMAN SYRIA

After Alexander's death in 323 BC his marshals contended for

gained the northern part and Ptolemy I Lagus gained the southern (Coele Syria) This partition between the Seleucids and Ptolemies was maintained for 100 yr despite intermittent Syrian wars during the 3rd century (see Seleucid Dynasty) Their administrative methods varied In the south the Ptolemies respected the existing autonomous cities, imposed a bureaucratic system on the rest of the country and established no colonies, while the Seleucids divided their part into four satraples which embraced the cities, and founded many cities and military colonies (including Antioch, Seleucia Pieria, Apamea and Laodicea [qq v]), drawing on settlers of European blood Republics replaced kings in the Phoenician coastal cities of Tyre (274 BC), Sidon, Byblus and Aradus. Further political and cultural changes followed - Antiochus III the Great defeated Ptolemy at Panium (200 B C or perhaps as late as 198) and thus secured control of southern Syria, where he introduced the satrapal system. His subsequent defeat by the Romans at Magnesia (Dec or Jan, 190-189), however, diminished both his territory in Asia Minoi and his prestige, thereby fundamentally weakening the Seleucid empire, which ceased to be a Mediterianean power Antiochus Epiphanes (175-163) stimulated the spread of Greek culture in Syria, with which went Greek political ideas, by a policy of urbanization increased city organization and municipal autonomy involved greater decentralization of his kingdom, his attempted hellenization of the Jews is wellknown Under the later Seleucid kings, with rival claimants to the throne and constant civil war, Syria disintegrated In the north the Seleucids controlled little more than the areas of Antioch and Damascus (Coele Syria) Commagene asserted its free-dom, many of the cities claimed independence and numerous petty chiefs established little principalities Southern Syria was partitioned by three tribal dynasties, the Ituraeans, the Jews and the Nabataeans The country was seized later by Tigranes of Armenia (83) until his defeat by Pompey who ended years of anarchy by making Syria a Roman province (64-63)

Pompey in the main accepted the status quo, but he reestablished a number of cities and reduced the kingdom of Judaea, 10 cities of the interior formed a league, the Decapolis Roman province of Syria therefore included the native kingdoms of Commagene, Ituraea, Judaea and Nabataea A Parthian invasion was thrown back in 39 BC, while Antony's extensive territorial gifts to Cleopatra (Ituraea, Damascus, Coele Syria, etc.) involved only temporary adjustments Under the principate Syria, which stretched northeast to the upper Euphrates and, until A D 73, included eastern Cilicia, became one of the most important provinces Its governor, a consular legate, generally commanded four legions until A D. 70. Administrative changes followed, Rome gradually annexed the client kingdoms Ituraea was incorporated (s.e., its territories were assigned to neighbouring cities) partly in 34 BC, partly c AD 93 Judaea became a separate province in AD 6, governed by procurators (apart from Herod I Agrippa's shortlived control; A.D. 37-44), until the destruction of Jerusalem in 70 Then the governor was a praetonan legate in command of a legion, next, under Hadrian he was a consular with two legions, and the province was named Syria Palaestina Commagene was annexed temporarily from AD. 17 to 38 and permanently by Vespasian in 72. The caravan city of Palmyra came under Roman control, possibly during Tiberius' reign. Finally, Nabataea was made the province of Arabia in 105, governed by a practorian legate with one legion. Syria itself was later divided by Septimius Severus into two provinces-Syria Coele in the north with two legions, and Syria Phoenice with one. By the beginning of the 5th century it was subdivided into at least five provinces. The frontiers of Syria were guarded by a fortified limes system, which was thoroughly reorganized by Diocletian and his successors (particularly against cavalry attacks) and endured until the Arab conquest, much knowledge of this system of "defense in depth" has been obtained with the aid of air-photography

Syria's economic prosperity depended on its natural products (e g, wine, olives, vegetables, fruits and nuts), on its industries (e.g., purple-dyeing, glassmaking at Sidon, linen and wool weaving and metalwork) and on its control and organization of trade passcontrol of the country, until after Ipsus (301) Seleucus I Nicator ang by caravan from the east to the Mediterranean through such

centres as Palmyra, Damascus Bostra and Petra Further, Synan merchants spread westward throughout the Latin provinces of the Roman empire The population of the country must have been larger than that of today. Some cities were founded under the empire, but these were not numerous and Syria remained essentially tural The urban upper and middle classes might be hellenized, but the lower classes still spoke Aramaic and other Semitic dialects in town as well as country Roman influences were naturally weaker than Greek though the army at first beloed the spread of romanization, while Latin, not Greek, was the language of instruction in the famous law school at Berytus until c AD 400 The splendour of Syrian culture is seen in the magnificence of the cities (Antioch, ranking among the greatest cities of the empire, was the residence of the governor and later of the comes Orientis), and in the luxury, gaiety and versatility of the Syrians splendour is also evident in their schools of rhetoric, law and medicine, in their art (the pre-eminence of Italian or Syrian elements in Syrian art is debated), in their literature and philosophy and in the variety of their religions, both pagan and Christian

During the three centuries Syria was administered from Constantinople, its cultural and economic life remained active, as names like Libanius, Ammianus Marcellinus, Procopius and John Majalas bear witness Government became more bureauciatic but it was efficient. From the middle of the 5th century, by which time paganism had died out and monasticism was spreading, religious controversy took a political turn with the growth of the Monophysites, in whom anti-imperial, nationalist and secessionist sentiment found a rallying point. The reperculsions of this heresy seriously weakened Syria and the Eastern Roman empire. Nor were external dangers lacking In the 4th century, during the campaigns of Constantius and Julian against Persia, Syria had again become a base of operations and at times endured Persian invasion, and the Huns had appeared before the end of that century The Persian menace died down during the 5th century, but it blazed up again in the 6th, when Arabs also added to the danger. The Persian Chosroes I captured Antioch itself (540); and though he was outwitted by Belisarius and though Justinian's Persian wars ended in a "50 years' peace" (562), yet ten years later the Persians were back again. The invasion of Chosroes II, which began in 666. was later rolled back by the victories of Heraclius, but the peace of 628 brought no tranquillity to Syria The Arabs advanced, Damascus and Antioch fell, and Herachus was forced to evacuate Syria Islam was master of the land which seven centuries earlier Pompey had formally added to the Roman empire

(See also Palestine; Maccabees, Nabataeans; Jacobite CHURCH; also ANTIOCH; BAALBER, PALMYRA, SELEUCIA.)

CRURCH; also ANTIOUT; BAALBEK, PALMYBA, SELEULIA, BELLIORANY—C. A. Harry, Studies in the History of the Roman Prosince of Syna (1914); E. S. Bold and the History of the Roman Prosince of Syna (1914); E. S. Bold and Econ. Harry of the Colord, 1914; D. M. Rockottedt, Social and Econ. Hist. of the Hellentitic World (Oxford, 1914) and Soc. and Econ. Hist. of the Renate Empire (1926); A. H. M. Jones, Cillies of the Rastern Roman Provinces (Oxford, 1927); P. Orobburd, La Trace de Rome dans devert de Syne (Paris, 1934); F. M. Buchechelmem, Roman Syria Charles (2014); P. M. Beichelheim, Roman Syria (1828); P. M. Beichelheim, Roman Roman Roman

### MEDIAEVAL SYRIA

In 633 the Mohammedan Arabs invaded Syria from the south. After their decisive victory on the Yamnuk river in 636 they occupied the whole country piecemeal and made it a base for further conquests north and west. When civil war broke out in 656, the Arabs of Syria stood firm behind their governor, Mu'awiya, of the Meccan house of the Omayyads, who, after warding off at Siffin an attack by the Iraqi Arabs, extended his authority over the neighbouring provinces and was recognized as caliph in 661 (see CALIPHATE).

During the Omayyad caliphate (661-750) Damascus was the capital of an Arab empire which, despite internal outbreaks, extended by 715 from Spain and Morocco to Turkistan and Sind and held the mastery of the Mediterranean With the wealth drawn from the dependent provinces the caliphs 'Abd ul-Malik and Walid I endowed Jerusalem and Damascus with magnificent religious monuments, the Dome of the Rock and the Omayyad

mosque The first senous setback was the failure of the third and final Arab assault on Constantinople in 719 During the following decades unrest and weakness in the outer provinces involved the wide dispersion of Syrian troops on expeditions and garrison duty this, combined with factional feuds among the Arabs, undermined the military power of the Omayyads, who were finally overthrown by the Khurasaman army of the new Abbasid caliphate in Iraq

Under the Abbasids Syria reverted to the status of a dependent province It had little share in the economic and cultural development of the Abbasid empire and was increasingly abandoned to its sedentary Arab population and to the nomads on the desert frontiers As the empire disintegrated, Syria was anneved, in whole or in part, by the Egyptian dynasties (Tulunids, Ikhshidis, Fatimites), except for the brief principality of the Arab Hamdanids of Aleppo founded by Saif ud-Daula (044-067), whose early successes against the Byzantine empire were followed by the Greek recovery of Antioch (969)

During the 11th century the fragmentation of Syria was momentarry arrested by its unification under the Seliuk Tutush (1078-95) and attachment to the empire of his brother, the sultan Malikshah (see Seljuks) On his death the Seljuk kingdom fell to pieces, and Antioch, Jerusalem, the coastal regions and Kerak (Trans-Jordan) were occupied by the crusaders against feeble local opposition between 1098 and 1124 (see CRUSADES) hammedan counterattack began with the annexation of Aleppo by the Turkish atabegs of Mosul (1125), with the recovery of Edessa (1144), and with the union of inner Syria under Nureddin (1146-74), who also annexed Egypt in 1169 After Nureddin's death his principality was rebuilt and enlarged by his Kurdish viceroy in Egypt, Saladin (q v) (1174-93), who recovered all of Palestine and most of the inland crusader strongholds after his victory at Hattin (1187) but lost the Palestinian coast again as a result of the third crusade Concurrent developments of the 12th century were the rise to power of the sect of the Assassins (q v) and the rapid proselytism conducted by the Druses (q v)

The crusades, paradoxically, did much to rehabilitate inner Syria, both by the economic development resulting from the establishment of Itahan trading centres on the coast and by the impetus given to its cultural life by Nureddin and Saladin Although it was again split up after Saladin's death between the members of his family, the Ayyubites, who established separate principalities in Aleppo, Hama, Homs, Damascus, Baalbek and Trans-Jordan and disturbed by intermittent hostilities between their princes or against the crusaders, Syrıa as a whole regained during the Ayyubite period (1193-1260) a level of prosperity such as it had not enjoyed since the 3rd and 4th centuries. A severe blow was dealt by the first Mongol invasion and sack of Aleppo in 1260, but the Mongols were thrown back by the Mameluke sultans of Egypt, who re-organized the Ayyubite principalities as Mameluke governorships and completed the expulsion of the crusaders by 1291. After the defeat of a fourth Mongol invasion in 1304 Syria remained relatively peaceful and prosperous as a centre of culture, learning and industry under Mameluke rule until the invasion of Timur (q.v.) in 1400. From this fresh blow its economy never really recovered, and it continued to decay slowly under the later Mamelukes until its annexation in 1516 by the Ottoman sultan Selim I, who divided it into three Turkish pashaliks Its incorporation in the vast Ottoman empire brought some revival of economic prosperity to Aleppo and Damascus through trade and the pilgrimage to Mecca but did little to arrest the decline of agriculture and general security under the increasing pressure of the nomad tribesmen. (H A. R. G.)

## THE 19TH AND 20TH CENTURIES

For nearly three hundred years, then, the history of Syria was that of a province of the Ottoman empire (see Turkey); its internecine troubles of the 17th and 18th centuries are outlined in the article DRUSES. It was the French invasion of Palestine in Feb 1799 that brought the country once more under the full light of international concern Napoleon Bonaparte sought to secure Syria as a bulwark in defense of his newly conquered Egypt and

also as a base from which to threaten both Constantinople and the British power in India The campaign (see French Revorti-TIONARY WARS), though abortive, was one that Napoleonic piopaganda could represent as glorious the memory of it made a lasting and fatal impression on the mind of the French public

The revolt of Mohammed Alı, pasha of Egypt, and the conquest of Syria for him by Ibrahim Pasha (q v.) in 1832 had repercussions which are discussed at length in the article Eastern Oues-French sentiment saw Mohammed Ah as the continuator of the Napoleonic tradition in the Levant and was deeply incensed at the convention of London (1840), when the other interested European powers agreed to Turkey's recovering the lost territories. The Syrians themselves, however, though they had welcomed the advent of the Egyptian armies, had been in sporadic rebellion since 1834 and rose in revolt against Ibrahim as soon as the joint Turkish, British and Austrian fleet appeared off Beirut (See M Sinasi, Studien zur Geschichte der syrischen Politik Mehmed Alis [Gottingen, 1036] )

The 1840s and '50s were marked by recurring dissension between the Druses and the Uniate community of the Maronites, the latter being sustained by the informal but enthusiastic protection of France-whose interest in these particular Turkish subjects might indeed be traced back at least to Louis XIV's time (see CAPITULATIONS) The massacres of 1860 led to positive French intervention and to the constitution of Lebanon as an autonomous province in 1864 Further trouble for the Turkish authorities arose with Joseph Karam's insurrections in Lebanon (1866-67) and again when a costly and indecisive campaign had to be undertaken against the Druses (1895-96).

The Turkish revolution of 1908 gave impetus to the nationalist movement in the Arabic-speaking provinces of the empire, especially in Syria The political demands of the Arabs, whose representatives met in June 1913 in Paris, involved a decentralization of the Turkish empire with administrative and cultural autonomy for the Arab provinces The Syrian nationalists co-operated with similar movements in Mesopotamia and Egypt During World War I the nationalist leaders entered into close contact with Faisal (see Faisal ibn Husain). The Turkish administration persecuted them several of them were executed and were regarded by their followers as martyrs of the movement of national liberation.

The French Mandate, - Fassal had meanwhile formed an Arab army, which fought together with the British under Lord Allenby While the British conquered Palestine, the Arabs moved through Trans-Jordan northward and by the end of 1918 had reached Damascus, where, according to the promises given to the Arabs during the war, an independent Arab government was set up under Faisal But France, already holding Beirut and the coastal zone, desired a mandate over the whole of Syria, in spite of the fact that on Nov. 7, 1918, the British and French governments had jointly declared their intention of establishing in Syria and Mesopotamia "national governments drawing their authority from national congress, however, elected Faisal king of Syria on March 11, 1920, and adopted on July 3 a democratic constitution for the whole of Syria, including Palestine and Trans-Jordan; and in the summer of roro a United States commission found that the population rejected the idea of a French mandate. Nevertheless the French mandate was decided upon at San Remo on April 25, 1020, and the French high commissioner Gen. Henri Gouraud sent an ultimatum to Faisal demanding recognition of it in July. The Syrians rejected the demand, but their army under Yusuf al-Azmi was defeated at Khan Maisalun, the French entered Damascus, and Faisal left the country. The terms of the mandate were approved by the League of Nations on July 24, 1022.

To strengthen their position against the predominantly Moslem. nationalists, the French established on Sept. 1, 1920, an independent state of the Lebanon. Its nucleus was the formerly autonomous mountain district with its predominantly Christian population; but the French incorporated into it coastal and inland districts with a predominantly Moslem population who protested violently against separation from the rest of Syria. Syria itself was further divided into four "states": the state of Damascus,

2Ĭ--ĈC

the state of Aleppo, the state of the Jabal Druse and the state of the Alawis with the capital at Latakia The Sanjak of Alexandretta was made autonomous Damascus and Aleppo, however, had soon to be united again in a state of Syria. Beirut was chosen as the seat of the French high commissioner, and most high commissioners were accused of favouring the Christian minority at the expense of the Moslems Paper constitutions were given to the different states, representative councils were set up, some of them even elected presidents and ministers, but real power remained in French hands Discontent found expression in violent

demonstitations
The struggle for independence assumed a new form with the success
of a local revolt in the Jabail Druse under the leadership of Sultan
Pasha al-Attan which broke out in July 1925 On Aug 2 the
Druses approached Danascus itself, where the nationalists quickly
the Druses approached Danascus itself, where the nationalists quickly
the property of the pr

make greater concession

In 1928 the French high commissioner Hemi Ponsot abolished mar-tial law, reintroduced certain civil liberties, asked Sheikh Taj ud-Din that hav, reintroduced certain over inferties, asked Sneish risk up-al-Hasant to form a cabinet and, on March 10, announced electrons for overwhelming victory to the nationalists, and on June 9 the assembly was opened in Damascus Hashim al-Atas, who had been Syran prime minuter under Fassal in 1920, was elected president of the assembly and by August the draft of the constitution was ready. As a result of and by August the draft of the constitution was ready. As a result of conflict with the high commissioner, the assembly was finally disabled for the dustion of the mandate, was preclaimed on May 14, 1390. If provided for a legislature elected for four years and for the election of provided for a legislature elected property and the cute of the provided for a legislature elected property and the cute over 20 years of 1800 pind at work; there was only a property and the over 20 years of 1800 pind at work; there was only was responsible to the chamber, compulsory primary education for both sexes was provided. The Syrian lepublic adopted the Arab national flag. France promised to negotiate a treaty with Syria that would terminate the mandate and proclaim Syna's sovereignty In the next six years the constitutional life of Syria went through several periods of storm and stress, caused by disagreements with the high commissioner, which led to a temporary suspension of parliamentary life The former states of Latakia and of the contraction of the state of Latakia and of the contraction of the state of Latakia and of the state of roclaim Syria's sovereignty In the next six years the constitutional the Jabal Druse continued their autonomous existence under French administration

A first treaty draft submitted by France was rejected by the Syrians A finst treaty draft submitted by France was rejected by the Syrams in Nov 1938, whereupon the Syram parliament was suspended But in 1936 the growing tension in the Mediterranean and the example set in 1936 the growing tension in the Mediterranean and the example set attitude. In January the Syriams had a general stitute for independence Finally a calegation under Hashma si-Atas was invited to Pars, where Sach, a text was signed providing for a perpetual framedship besolves of the state of the state of the state of the sach set of the state of t

tories of Latakan and the Jabal Drüse; and either nation was to enjoy most-favoured-nation treatment from the other. This treaty failfuled imany Syman demands, except for that of union with the contract of of the Arabs in Palestine: many Syrians went to help the Palestunians in the uprising which started in 1936, until the British government in Palestine built a strong wall of barbed wire all along the frontier.

Under the shadow of the impending war and faced with strong op-

Under the shadow or, one impending war and tacca with strong op-position in partiament the French government announced on Det. 14, 1938, that they did not intend for the present to ask parliament to ratify the Syrian treaty. After several months of manouviring the Syrian government and president resigned, and on 10 yr 10, 1939, the new French high commissioner, Gabriel Puaux, suspended the constitution of 1930 and set up a directorate under his own control. Public

opinion in Syria was highly agitated, and serious disorders threatened

With the outbreak of World War II Gen Maxime Weygand, who as high commissioner had gained an intimate knowledge of Syria, became commander in chief not only of the French forces in Syria but also of the Albed troops in the near east and in the eastern Mediterranean the Allied toops in the near cast and in the eastern Mediterranean. In May 1940, however, he was called to assume command of the French army in Europe and Itel Cen. Eugène Mittelhauser as commander in April Mittelhauser and Fraux Getern Syram. Mittelhauser and Fraux Getern Syram Mittelhauser and Fraux Getern Syram Commander in Mittelhauser and Central Cent Syna into a basis of operations against the British. The Arab leaders first believed that Great Britain had been decisively defeated and that its empire would be inherited in the middle east by the Italians and They sounded the intentions of the German armistice the Germans commission, but the successful resistance of the British and the defeat of the Italians in Africa deterred them from committing themselves prematurely Abd un-Rahman Shahbandar had been assassinated, yet prematusely Abd us-Rahman Shahbandar had been assassmater, yet the idea of a unified Auban with Syma as its nucleus gained in atrength common state of the common state of the common state of the common state of the common state of the common state of the common state of the common state of the common state of the Chappe's death in an neroplane excident in December of that year, Gen Henii Deniz took his place The unsettled condizions, the szardiy and hoarding of food and the

The unsettled conditions, the scarcity and hoarding of food and the fast-rusang prices for all commodities hought the Arab unrest into the open in a wave of widespread and often violent strikes which paralysed communications. On March 70, 174, the Syrian national pair yield communications on March 70, 174, the Syrian national pair independence of the country. The tevolt grew so violent that, after French troops had been used several times to quell tools, the French were forced again to try to meet the native demands halfway. In April 154, they appointed Khalid Al-zam head of the Syrian government and Allied Nakkash prime minister of the Lebanon In May the Verlay government allowed Genma narcarlt to land and

between the British and a revolutionary pro-German government) and also supplied arms and ammunition to Iraq. At the end of the month asso supplied arms and ammunition to 1740. At the end of the month of the British foreign secretary, Anthony Eden, annunced Green Britains. British imperial forces and Free French troops started military operations for the iberation of the Eventh I took them about a month to overcome the teststance of the French troops under Vichy command Damasseu was occupied on June 21, and hostitutes ceased on The food situation remained difficult until the 1942 harvest,

mand Damaguis was occupied on June 21, and hostilities cased on but absequently Syria became once more an exposit of grain, at highly inflated prices. The British built railway lines from Bernat to Trapoli and Haift and so established a direct link between Egypt on British to Trapoli and Haift and so established a direct link between Egypt on British to the state of linguabed most of the departments of state to the Syrian and Lehanese governments; but they retained the locally securitied tempes sphenics, whom the two governments coveted to form the nucleus of their satisfact arms at Reb. 1949 Winson Charchill met at LeQuwalt in Carlo and times at Reb. 1949 Winson Charchill met at LeQuwalt in treaty comparable with the Anglo-Inqu treaty of 1940. But in May the French haple commissioner's return with his government's proposale concluded with the dissubstantant of two small contingents of French ments, not ramofroments, the Syrau and Lebanese governments fell that they would be negotiating under dures; and in any case the French proposals (losed on the abovitor treaty of 1949) were no longer compatible with their insistence on total independence. Discreters in Compatible with their insistence on total independence. the principal Syrian towns culminated in the French bombardment or Damascus by aircraft and heavy guns on May 19-30, causing about 500 Syrian deaths. The British government ordered their commander in chief in the middle east to intervene, the French troops were compelled to return to barracks, and French influence in the country came to an

Independence.-Meanwhile in March the Syrian and Lebanese overnments were invited to the United Nations conference at San Francisco, signifying their recognition as sovereign states. They appealed to the Security council to order the immediate withdrawal of French and British troops from their territories in Feb. 1946, and the

evacuation of Syria was completed by April 15 The National Bloc government was confirmed in power by elections in 1947, but discontent at its inefficient and allegedly corrupt administration was aggravated by the poot performance of the Syrian army in the Palestinian wai of 1948, which gave use to further political scandals. In Dec 1948 student demonstrations forced the replacement of the National Bloc government by a nonparty administration led by Khalid al-Acam On March 30, 1949, this was overthrown and President al-Quwali de-posed by a bloodless coun d'état led by the chef of staff, Husin az-Zaum. posed by a bloodless coup d'état led by the chief of stait, Husin az-caim, a Kiud who for a few weeks seemed as if he might prove the long-hoped-foi "saviour with a swoid". As the political leaders were reluctant to commit themselves by seving under him, however, he sought support from the still-hated French and from Egypt and, rapidly quarreling with all the neighbouring Atab governments, degenerated into an arbitrary despot On Aug 14 he was arrested and summarily shot by another military junts under CO Sami Hinnawi A general election m November returned a government of the Popular party, opposed to the National bloc and favouring a closer union with Iraq, but this project was forestalled by a third military coup on Dec 19, which removed Sami Hinnawn from power Meanwhile, Sylia had latified agreements for the construction of two oil pipelines from the Pessan gulf to the Mediterianean, which would eventually bring Syria 10yal-ties in dollars and so alleviate its acute shortage of foreign currences. but new difficulties arose after Syna's denuncation of the customs-agreement with Lebanon in Maich 1950 Internal disorders were pro-longed by the assassination of the commander in chief of the air force, longed by the assassination of the commander in their of the art torce, Mohammed Nasser, in July 1950. A new constitution was adopted on Sept 6, 1950 this strengthened the legislature by stipulating that the president should sign legislation within three days or else refer it to a state council constitutionally established. Hashim al-Atasi became president

Hostilities between Syma and Israel broke out in March 1951 be-Hostilites between Syna and Israel broke out in Masici 1951 incases of a fospute about the demilitarized frontier zone and went on until the Security council of the United Nations intervened in May A new criss a rose when Great Britain, France, Turkey and the United States submitted their scheme for the defense of the middle east to the countries of the Arab league in October Hassan Hakim, who had States submitted their scheme for the defense of the middle east to the countries of the Atab league in Octobe. Hassan Hakum, who had become prime minister in August, wanted to accept the plan and resigned in November because of cabinet opposition to it. After three weeks of crisis, Maruf ad-Dawalibi formed a cabinet, but was overweeks of crass, Maruí ad-Dawaibh formed a cabinet, but was over-thrown nine house later by a coup d'état. (Nov 29) engeneerd by the thief of the general staff, Adb sah-Shubakly President Hashım al-Kası resugned on Dec 1, and the lipher mitatury council under ash-rial march 1952 a new trade agreement was reached with Lebanon In March 1952 a new trade agreement was reached with Lebanon An important piogram of land cform, muvolum the distribution of some 4,000,000 ac among groups of agricultural co-operatives, was announced. (X., G. E. K.)

### GOVERNMENT AND ECONOMY

GOVERNMENT AND ECONOMY

Constitution.—In the earler yeas of the French mandate the state of Syna excluded the districts of the Alawas (Latakas) and the state of Syna excluded the districts of the Latay to 1496, they were to provide the state of the state of 1496, they were to the state of 1496, they were to the state of 1496, and the state of 1496, and the state of 1496, and the state of 1496, and a result of which an appeal was made to the Security council, the state of 1496, and the state of 1496, and a result of which an appeal was made to the Security council, the 1496, and 1

solutions, and in the estimation of the constituent assembly in 1969 whomes one deputy for every 3,0000 electron; the electracts being limited to men of 18 years of age and women of the same age holding, at least, an elementary school extrincts. Of the 11d deputs elected 1, swere Christians. The president nommates the pume minister, usually from the members of the contract of the 11d deputs elected 1, swere Christians. The president nommates the pume minister, usually from the numbers of the colinet. The party system is not highly developed, political groups tend to form round prominent individuals rather than follow as ten policy, and there are many "independents" —

Education.—There has been a steady increase in the provision of the colinet of the provision of the colinet of the provision of the colinet of the provision of the colinet of the colin primary and 2,954 secondary grade pupils. By 1948 there were 1,376 primary schools with 188,200 pupils and 93 secondary schools with

primary sensons with 188,000 pupus and 50 securiary sensons was also pupils. As 800 pupils and 800 pupils in leneases in gifts deducation took place after 1909 gitta attending schools numbered 5,500 at primary and about 100 at secondary schools numbered 5,500 at primary and special secondary schools numbered 5,500 at primary and 3,600 at secondary in 1948, when there were also 400 pirls at the university. The Syran University of Damacus, founded in 1923 (1,028 students in 1935-40; a 100 in 1936), has schools of medicine and law and later established schools of artis, some can en engineering. There are two

agricultural colleges, a teachers' training college at Damascus, and a college of engineering at Aleppo The Arab academy at Damascus, financed by the government, is a recognized cente for the study of A1-ab history and literature

Agriculture, Industry and Commerce,- Agriculture is the main industry and supports more than 55% of the population. The proportion of cultivable land is low (about 33%) and less than half of this is actually under cultivation, partly because of the system of of this is actually under cultivation, parity operaties of the system of Indi-denute The principal crops are wheat (c. 56,000 tons), barley (350,000 tons) and other cereals, vegetables and futt include olives, paritots, grapes, tigs and apples. Rice is grown in the Jazula and Aleppo districts (22,000 tons in 1948). Industrial plants are colotin, hem, liax sugart beek, liquicine, tobacco, seame and sugar cane. Only nemp, nax, sugan been inquorize, tobacco, sessing and sugar cane. Only about 15% of the land under cultivation is irrigated, on the remainder extensive dry faming is practised. Stock raising is characterized to a large extent by seasonal migrations. flocks and herds follow the pasture from region to region or move from the hills to the warmer plains in tiom region to region of move non the mins to the warmer plants in winter. The animal population in 1947 was sheep 3,176,000, goats 1,185,000, cattle 354,000, hotses 141,000, donkevs 330,000, mules 47,000, chickens 937,000. The development of industry has been assisted by the admission of industrial machinery duty-free. Modern variety of foodstuffs The government has instituted standards to be applied to certain industries

A concession to prospect for oil in all Syria north of Damascus is held A concesson to prospect for oil in all Syra north of Damacus is held by the Syinan Fertoleum company, one of the Iraq Petroleum company groups. The Iraq Petroleum company's notifier pipeline from Another pupeline crossing Syras is that of the TranchAnian company, a subsidiary of Aramoo, whose line from the Persain guilt terminates at Sanda (Lebanon). The agreement with Middle East Pipe-Lines, Ltd (Anglo-Ianuan Oil company), agued in 1949 piovides for a tenimal on the Syram coast site of a Bangon, and the Syram coast site of a Bangon, as most nutril below conservation.

Before March 1040 when the customs union with Lebanon was termi-Before March 1950 when the customs unon with Lebanon was termi-nated by Synia, separate statistics for foreign trade were unobtamable Figures published by the Syrian government to: the period from and imports at LS 112,600,000 though it was expected that an export balance would be shown by the end of 1950. The total customs re-cepts for the year ending March 1951 were 18, 41,124,000, as com-pared with LS 27,000,000-30,000,000 which Syria formerly received as its share under the customs unifor

as its share under the customs union

Communications—The ralways of Syrna, with the exception of
the portion of the Hegs railway from Damaseus to Der's (on the
of the Syro-Lebanes system belongang to a French company, the
Société du Chemm de Fer Damas-Hama et Prolongements (DHP).

The Hegar railway (5 ft §1, agaque) extendés fom from Damaseus to
Derr' to Bosra cela Sham (a<sub>d</sub> m<sub>d</sub>). The DHP lines are from Riyan

Chemno to Darjon (65 m<sub>d</sub>), and from Damaseus to Bearut, via Riyan

Josa Shama (15 m<sub>d</sub>), and from Damaseus to Bearut, via Riyan

Josa Shroud Syrua the loop from Madana Exbes on the Turkish

nouter to Aleppo van Muslimitye, and from Muslimiye to Choban Bey

Cotal 173 m<sub>d</sub>) and the section between Tell Züman (cara Nishin

nother to Aleppo van Muslimitye, and from Damaseus to Raran. the tisck between Chohan Bey and Tell Zumán being in Tulkish tentritory on the northern frontier of Synia. Passenger traffic on the internal lines, except that from Rayak to Aleppo, is very light. The total length of roads in Syran in 1948 was about 4,00c min. The total length of roads in Syran in 1949 was about 4,00c min. Latakin, Bunnas (Banyas) and Tutus to Berutt and onward to the frontier of Israel at Ras an-Nakarah, Aleppo to Homs with alternative routes on either side of the Anti-Lebanon to Damassus; from Damassus to Kunnetra Quentra, El and thence via Jist Banat Yakub on the Israels frontier (5 mil ) to Tiberias and Jerusalem, from Damassus to Shahh Mackin and thence to Suyakida or Der'a (66 mil.) Damsettu to Shalth Mackin and there to Stundard Prosessett, 1991. Transverse roads andiate from Damsetus: to Befort via Bhatana (77 mi) and to Tripoli via Baalbek (130 mi); from Aleppo to Alexandretta (77 mi), not not to Tripoli via Baalbek (130 mi); from Aleppo to Alexandretta and to Trattes (65 mi), and from Hama to Banisa (52 mi) and to Latikai (122 mi). There are also roads from Homes to Tripoli (65 mi). and from Hama to Banisa (52 mi) and to Latikai (120 mi). The Control Hama to Banisa (52 mi) and to Latikai (120 mi). The Control Hama to Banisa (52 mi) and Abu Kemal (140 mi) and Abu Kemal (140 mi) and Abu Kemal (140 mi) and Abu Kemal (140 mi). A road Eollows the west bank of the Euphrates from Damsetus Abu Kemal (140 mi). The mum desert voute from Damsetus Abu Kemal (140 mi). The mum desert voute from Damsetus Mackin (140 mi) and Abu Kemal (140 mi). The mum desert voute from Damsetus Mackin (140 mi) and Mackin (140 mi). The mam desert voute from Damsetus Mackin (140 mi) and Mackin (140 mi). The mam desert voute from Damsetus Mackin (140 mi) and Mackin (140 mi) and Mackin (140 mi). The mam desert voute from Damsetus Mackin (140 mi) and Mackin (140 mi) and Mackin (140 mi). The mam desert voute from Damsetus Mackin (140 mi) and Mackin (140 mi) and Mackin (140 mi) and Mackin (140 mi) and Mackin (140 mi). The mam desert voute from Damsetus Mackin (140 mi) and Mack

man strong the choice caret, proved inadequate for the handling of heavy traffic. It was arranged that the government-sponsored Laistin Harbour corporation should carry out it is the Syrian pound which, by a Finance.—The monetary unit is the Syrian pound which, by a Finance.—The monetary unit is the Syrian pound which, by a rency with a value fixed at 405 fiz mg, of pure gold. From the date of this decree the Syrian currency was no longer linked to the France.

franc "Free market" selling-lates for the dollar and for the pound stelling in Jan 1951 were LS 3 63 and LS 94 respectively. The total currency in circulation on Dec 31, 1950 was LS 215,000,000

Revenue and expenditure for the years 1947-50 are indicated in the accompanying table

TABLE - Revenue and Expenditure

	(11 000,000 5)	rian pounds)		
Revenue E-penditure	1947 101 29 75 53	1948 197 00 76 37	1949 103 53 77 62	1050 105 30 8/ 54

Bibliography —Royal Institute of International Affairs, The Middle East (London, 1950). A H. Houran, Syria and Lebanon, a Political Evay (London, 1960). E Bobuchad, That'y Fears of Lebanon & Syria (1977—1947) (Berut, 1948). George Rink, a Short History of the Middle East (London, 1948), Allord Carleton, "The Syrian Cope affact of 1936), "Middle East Fournal, vol. (1950), 1948); also the rev. Lond and Power's ni the Middle East (1930). (1960), 1948; also the official Syrian monthly economic bulletins (Damascus)

SYRIAC LANGUAGE. Syriac is the name given to the language used by Christian writers in the region east of Antioch, including the Christian subjects of the Peisian empire. It seems to have been originally the local Aramaic dialect of Edessa (q v ). which became a centre of Christianity as early as the last third of the 2nd century Edessa was till 216 the seat of a native monarchy, consequently the new religion took a vernacular form there whereas inside the Roman empire no languages except the imperial Greek and Latin were used by Christians for literature or public worship until the 4th century But the Bible and the forms of Christian liturgy having been translated into the Edessene dialect and publicly used, this dialect was accepted all over the east by native Christians as a classical literary language

Since the 5th century AD owing to theological differences Syriac-using Christians have been divided into Nestorians or East Syrians and Jacobites (Monophysites) or West Syrians, and these groups are now linguistically distinguished by certain differences of pronunciation, chiefly in the vowels The East Syrians in most cases have kept the more primitive pronunciation; eg, the old Semitic ā with them remained ā, but with the Jacobites passed into  $\delta$ . The name Jesus is by the East Syrians pronounced Isho, by the Jacobites Yeshu. The language of the Maronites, a religious body now in communion with Rome and chiefly living in the Lebanon region, is in all respects the same as that of the Jacobites or West Syrians Classical Syriac is now nowhere a spoken language A variety of the Western Syriac survived till about 1880 in some villages near Damascus, and the Nestonans of the Tigris valley speak a modern dialect akin to the old East Syriac though differing considerably from it

Writing .- Syriac has the same 22 letters as Hebrew. Their forms are ultimately derived from the Old Hebrew and Phoenician alphabets. The oldest mss., of the 4th and 5th centuries are written in a very beautiful current hand known as Estrangela, the lapidary form of which is still preserved in some old inscriptions at Edessa. This gave place to other scripts from about the 9th century, the Jacobite form being less graceful and further removed from the Estrangela than the Nestorian. Speaking generally, this writing only indicates the consonants, the vowel # (short or long without distinction), long s and final a. The other vowels, so long as Syriac remained a living language, were not indicated at all, or only partially indicated by a dot above or below the whole word. But about the time when Syriac began to be supplanted by Arabic, two systems of vowel-signs were invented, one by West Syrians, who borrowed the forms of Greek vowels, and the other more elaborate by East Syrians, who used combinations of dots. These signs are written above and below the consonantal letters. Neither system completely distinguishes long from short vowels; the Nestorian system is more satisfac-

tory, though more cumbrous Consonantal Permutations.—Syriac is a dialect of Aramaic (see Semitic Languages), and uses the same alphabet as Hebrew. as remarked above. As in Hebrew the six letters b g d k p t are aspirated ( $\beta \gamma \delta \chi \phi \theta$ ) when immediately preceded by any vowel sound. Thus "he wrote" is in Arabic kataba, in Hebrew kaθaβ in Syriac  $k\theta a\beta$ . We may note that the unwritten light vowel after k (light as e in "belong") aspirates the following consonant, but the second member of a diphthong is reckoned as a consonant.

so that we get bayta ("house"), not bayta

The peculiar dentals and sibilants of early Semitic, preserved
almost in their original diversity in classical Arabic came to be
pronounced differently in Hebrew and Syriac So we get

Arab thdidthā Heb. shlāshā Syr thoda ("three")

" dhahab " zākāg " dahpā ("godd")

" "ar¢ " "ere; " "arā ("earth")

" puhr " shōhrash. " lahrā ("midday")

In the Arabic s and sh sounds Syriac generally agrees with Hebrew against Arabic, but the details are too complicated to be

given here

Parts of Speech. (1) Pronouns—As in Hebrew the personal pronouns entis in two forms the longer is used as a nominative and is a separate word, the shorter is attached to verbs as an accusative and (in a slightly different from to nomes as a pessessive. These suffixes give use to less change in the vowels of the words to which they are attached than in Hebrew. The relative pronoun is d (i.e., d followed by the shortest kind of

vowel), which is prefixed to words

(a) Nourss—There are two numbers, sing and pl, and two genders, mass and fem Syriac, like all Aramaic dialects, has no definite article, but the noun has three "states"—absolute, construct, emphatic, e.g., risk, 'head," on headi'? irêk (mdkh), "the-head of (the-king)", rēskā, "the-head" But in Syriac the emphatic state (rēskā) has almost superseded the simple "absolute," which is hardly used except for adjectival or participial predicates and in certain stock phrases. The construct, which, as in Hebrew, must be immediately followed by a gentive, is less used than in Hebrew, except as the form on which to hang the possessive suffices In its place the relative participle d is used, in place of rēsk malkā ("the-head of the-king") we find rēskā dmalkā, i.e., "the-head which-the-king (has)," or rēškhē dwalkā, i.e., "this head which (\*d.)-the king." Here the d s s practicully equivalent to our "of" This genitive (with prefixed d), does not require the governing noun to precede it immediately, as must be the case with the construct: in this and many respects Syrac has gained greater fleability in synatus thum Hebreus.

The fem sing ending is -ā (absolute), -ab (construct), -la of (emph.): thus the fem sing abs is always identical in form with the mase sing, emph. The plural endings are: mase. abs -an, const. -ab, emph. -ā; fem. abs. -an, const. -ab emph. -abla.

(3) Verba—The most notable pecubarity of Syriac as

(3) Verbs.—The most notable pecularity of Syriac as compared with other Aramaci dallects, and indeed other Semilic languages generally, is that the prefix to the imperfect is n, not y, e.g., "how all vinite" is nextyle, not veytigh: this is hely to have been originally a mere local peculiarity of the speech of Edessa The Syriac verb has lost the original passive forms still surviving in Arabic, and in their place uses reflexive forms, with prefixed e<sup>0</sup>- and a change in the last towed. The simple active holig makes its passive e<sup>0</sup>bblog; the intensive hatte? makes e<sup>0</sup>bhattep; and the causative oxyle? makes utill passive makes in the b g d b p letters caused by the presence or absence of a preceding vowel.)

In Syriac the verbs have become real tenses, partly with the help of the autiliary (h)ws. a truncated form of hew ("was"). Thus we get Pres. k8669, "in writes," "he is writing"; Impt. k8669 ad, "he was writing"; Fut. nex/t6, "he will write"; Subj. dws/t6, "that he may write", Aor. or Petr. 1869, "he wrote; "he has written", Plupt. 1862 ws., "he had written"—sometimes also used for simple Aorist

slao used for simple Aorist. (4) Particles and Syntax—Syriac uses a great many conjunctions, many of them adapted from Greek. Thus we have give from γio, dos from θi for at least used like Greek δi), even man, from μio. The order of words which is permissible is also very free, more so than in, any other Semticle language, a fact which gives to Syriac great flexibility and also renders word-for-wood translation into it easier.

In some Syriac translations from the Greek, notably the later

Jacobte translations of the Bible and other Greek theological works, Greek idom is very slavishly followed This, however, is to be regarded rather as learned pedantry than as linguistic evolution. In other works,  $\varepsilon_g$ , the Syrac version of Fseudo-Callisthenes Lafe of Alexander, which was translated not from the original Greek but from a Pahlavi text, the influence of the Persian idom is quite perceptible in the syntax.

Christian Patertinian Syriae is the name given to a literative written not in "dasacal Syrae." but in the vernacular dialect of Palestine. It is exclusively theological (Bible Homiles, Cyris' Garchesses, etc.) and appears to date from the 5th or 6th centuries when certain emperors, notably Justiman, made belate efforts to evangelize the non-Greek-speaking populations of Palestine. The documents are written in a peculiar script. The language is very similar to the Jewish Targums and to some Aramaic parts of the Talmud unfortunately the linguistic value of this literature is greatly diminisable by the fact that it wholly consists of translations from the Greek and follows the Greek vidions with panful literaliess.

Idloms with paintill incrainess
Bibliography—Th Noldeke, Compendious Syriac Grammar, Eng
trans by J. A. Crichton (1904) For "Palestinain Syriac," see F. C.
Burkitt, J. Theol Studies, vol. 11, pp. 174–185; vol. xiv., pp. 415–424.
(F. C. B.)

SYRIAC LITERATURE. The use of Syriac by Christians as a literary medium had its original centre in Edessa (Syr Ürhäi, modern Urfa), where, in all probability, the chief Syriac versions of the Bible were made. The use of the same dialect appears in the earliest Christian literature connected with such Mesopotamian cities as Nisībis, Amid, Mardin, Taghrīth and Seleucia-Ctesiphon, as well as west of the Euphrates at such centres as Mabbogh (Hierapolis) and Aleppo, northwards at Malatiah and Maiperkat and in the districts of Lake Van and Lake Urma, and to the east and south-east of the Tigris in many places which from the 5th century onwards were centres of Nestorian Christianity within the Sassanian empire. In Palestine and western Syria, the home of pre-Chustian Aramaic dialects, the vernacular Semitic speech had under Roman dominion been replaced by Greek for official and literary purposes Apparently this state of things lasted till after the Mohammedan conquest, for Barhebraeus tells us that it was the caliph Walid I. (AD 705-715) who, out of hatred to Christianity, replaced Greek by Arabic as the language of official documents at Damascus.

Syriac literature continued in life from the 3rd to the 14th century AD, but after the Arab conquest it became an increasingly artificial product, for Arabic gradually killed its vernacular use.

Religious Literature.-In the literature as it survives many different branches of writing are represented-homilies in prose and verse, hymns, exposition and commentary, liturgy, apocryphal legends, historical romance, hagiography and martyrology, monastic history and biography, general history, dogmatics, philosophy and science, ecclesiastial law, etc. But the whole is dominated by the theological and ecclesiastical interest. When we put aside one or two exceptionally fine pieces, like the hymn of the soul in the apocryphal Acts of Thomas, the highest degree of excellence in style is perhaps attained in straightforward historical narrativesuch as the account of the Perso-Roman War at the beginning of the 6th century by the author who passes under the name of Joshua the Stylite, or by romancers like him who wrote the romance of Julian; by biographers like some of those who have written lives of saints, martyrs and eminent divines; and by some early writers of homilies such as Philoxenus (in prose) and Isaac of Antioch (in verse).

For the general history of culture the work of Syrfac writers as translators is, perhaps, as important as any of their original contributions to literature. Beginning with the earliest versions of the Bible, which seem to date from the and century AD, the series comprises a great mass of tanslations from Greek originals—theological, philosophical, legendary, historical and scientific. In a fair number of cases the Syrfac version has preserved to us the substance of a lost original text. Often, moreover, the Syriac translation became in turn the parent of a later Arabic version. This was notably the case with some of the Artistotelian writings,

on the touch of Greek thought to the Arabs, by whom it was in turn transmitted to mediaeval Europe. The early Syriac translations are in many cases so literal as to do violence to the idiom of their own language, but this makes them all the more valuable when we have to depend on them for reconstructing the original texts. The later translators use greater freedom. It was not from Greek only that translations were made into Syriac Of translations from Pahlavi we have such examples as the version of oseudo-Callisthenes' History of Alexander, made in the 7th century from a Pahlavi version of the Greek original-that of Kalilah and Diminah executed in the 6th century by the periodeutes Bodh-and that of Sindbad, which dates from the 8th century, and in the late period of Syriac literature, books were translated from Arabic into Syriac as well as vice versa

The Cradle of Syriac Literature.-All our historical sources support the view taken above that Edessa, the capital of the kingdom which the Greeks and Romans called Osrhoene, was the earliest seat of Christianity in Mesopotamia and the cradle of Syriac literature But as to the date and circumstances of its evangelization we have little reliable information. The well-known legend of the correspondence of Abgar Ukkāmā, king of Edessa, with Christ and the mission of Adda to Edessa immediately after the Ascension was accepted as true by the historian Eusebius (d 340) on the faith of a Syriac document preserved in the official archives of the city An amplified form of the same story is furnished by the Doctrine of Addas, an original Syriac work which survives complete in a St Petersburg (Leningiad) ms of the 6th century, and is also represented by fragments in other mss of the 5th and 6th centuries. This work was probably written at Edessa about the end of the 4th century. But whether in its longer or its shorter form, the whole narrative must be pronounced unhistorical In all probability the first king of Osrhoene to adopt Christianity was Abgar IX, son of Ma'nū, who reigned from AD 170 to 214 or 216, and the legend has confounded him with an earlier Abgar, also son of Ma'nu, who reigned first from B C 4 to AD 7 and again from AD 13 to 50 (See Lipsius, Die edessenische Abear-Saga, 1880 ) A contemporary of Abgar IX at Edessa was the famous Bardaisan, himself a convert from heathenism, who was of noble birth and a habitué of the Edessene court. It was no doubt partly under his influence-also possibly in part through impressions received by Abgar during his visit to Rome about AD 202-that the king's conversion took place But Christianity must have reached Edessa some 30 to 50 years earlier Our oldest native historical document in Syriac-the account of a severe flood which visited Edessa in Nov AD 201-mentions "the temple of the church of the Christians" as overthrown by the flood The form of this notice shows, as von Gutschmid and others have remarked, that Christianity was not yet the religion of the State; but it must for some time have had a home in Edessa. By a skilful piecing together of the data furnished by the oldest Syriac versions of the Bible-such as the derivation of the Old Testament version from the Jews, and the almost exclusive use of Tatian's Diatessaron as the gospel of the Syriac Church down to the be-ginning of the 5th century—F C Burkitt has shown it to be probable that the preaching of Christianity at Edessa reaches back to the middle of the 2nd century or even to about the year 135 (Early Eastern Christianity, Lecture II ).

The Syriac versions of the Bible are treated elsewhere (see BIBLE) and may here be dismissed with a brief summary of facts and opinions The received Syriac Bible or Vulgate (called the Peshitta or "simple" version from the 9th century onwards) contains all the canonical books of the Old Testament. In the New Testament, 2 Peter, 2 and 3 John, Jude and the Apocalypse were originally left out, but Syriac versions were made at a later time. The Peshitta version of the Old Testament must have been originally made mainly by Jews, of whom we know there were colonies in Mesopotamia in the 2nd century. The translation was executed entirely from the Hebrew, but underwent later revision which brought it more into conformity with the LXX .- this to a greater degree in some books than in others. The Peshitta New Testament-according to the convincing theory which at present

so that in this field, as in some others, the Syriac writers handed holds the field-is not the oldest form of the Syriac version, at least as regards the Gospels From the beginning of the 31d to the beginning of the 5th century Tatian's Harmony or Diatessaron whether originally compiled in Syriac, or compiled in Greek and translated into Syriac-was the current form of gospel in the Syriac Church The text of the Gospels underlying it "represents the Greek text as read in Rome about AD 170" Slightly later was made the Old Syriac version of the separate Gospels, which survives in two mss -the Curetoman and the Sinaitic-in two differing forms but this never obtained much currency Its text "represents, where it differs from the Diatessaron, the Greek text as lead in Antioch about A D 200" Then at the beginning of the 5th century, by the efforts of the masterful Rabbūlā, who was bishop of Edessa from 411-412 to 435, a new version or recension of the Gospels was made and incorporated in the Peshitta or Vulgate, the use of the Diatessaron being henceforth proscubed Rabbūlā's text of the Gospels "represents the Greek text as read in Antioch about AD 400" The history of the Peshitta rendering of the Acts and Epistles is less clear

Apocryphal Books.-Of the large number of Apocryphal books existing in Syriac the majority have been translated from Greek, one or two (such as Bar Sira or Ecclesiasticus) from Hebrew, while some (like the Doctrine of Addai above referred to) are original Syriac documents Special mention may be made here of the tale of Ahikar-the wise and virtuous secretary of Sennacherib, king of Assyria-and of his wicked nephew Nadhan. This is the Syriac version of a narrative which has had an extraordinary vogue in the world's literature. It is now known to have existed in Aramaic as far back as the 5th century B C, appearing in Jewish papyri which were lately discovered by the German mission to Elephantine. It appears to be traceable in its Greek dress in writings of the philosopher Democratus and the dramatist Menander; it was certainly known to the author of Tobit and perhaps to the author of Daniel, some would trace its influence in the New Testament, in the parable of the wicked servant and elsewhere; it was known to Mohammed and is referred to in the Koran: it has been included among the tales in the Arabian Nights: and it survives in a good many versions ancient and modern The old Syriac version, which is to be found in a number of mss., was probably made from an early Aramaic version, if not from the original itself (which must surely have been Semitic) The Syriac has in turn become the parent of the Arabic, Armenian and Ethiopic-possibly also of the Greek and Slavonic-versions (See F Nau, Histoire et sagesse d'Akikar l'Assyrien, 1909.)

Another deeply interesting Syriac Apocryphon is the Acts of Judas Thomas (i.e., Judas the Twin), which is included in the collection of Apocryphal Acts of the Apostles The Acts of Thomas is now generally recognized to be an original Syriac work (or "novel," as Burkitt calls it), although a Greek version also exists It seems to have arisen in Gnostic circles, and its tendency is wholly in favour of asceticism and celibacy Among its peculiarities is the fact that Judas Thomas is regarded as the twin brother of Christ. The author has incorporated in it the finest poem to

be found in all Syriac literature, the famous Hymn of the Soul Lives of the Saints.—Lives of saints and martyrs form a large group among Syriac books. Among such documents connected with the early history of Edessa we have, besides the Doctrine of Addai, certain martyrdoms, those of Sharbēl and Barsamya assigned to the reign of Trajan, and those of Gurva and Shāmona and of the Deacon Habbībh under Diocletian and Lincinius. All these documents, like Addai, belong probably to the 2nd half of the 4th century, and are unreliable in detail for the historian though they may throw some light on the conditions of life at Edessa under Roman government. There are also accounts of martyrdoms at Samosāta (Assemani, Acta Mart. ii. 123-147), including that of St Azazail published by Macler (Paris, 1902). But the great bulk of the Syriac martyrdoms have their scene farther east, within the Persian dominions.

The life and writings of Bardaişan, "the last of the gnostics," and in some sense the father of Syriac literature and especially of Syriac poetry, have been treated in a separate article. The Book of the Laws of the Countries, which embodies his teaching was re-edited in 1907 by F. Nau (this also in the 2nd volume of logical position of Nestorius is to be obtained from the long lost Graffin's Patrologia). Mention may here be made of the valuable edition and translation by the late C. W Mitchell of S Ephrasm's prose refutations of Mani, Marcion and Bardaisan Transcribed from the palimpsest B M Add 14628 (1912-21)

An early Syriac document, probably of the 2nd or 3rd century, is the Letter of Mara son of Serapion, which was edited by Cureton in his Spicilegium Syriacum. It is almost the only exception to the rule that all surviving Syriac literature is Christian

By the beginning of the 4th century much progress had been made with the organization of the Christian church not only within the Roman district of Mesopotamia, but also to the east and south-east within the Sassanian enipire, round such centres as Seleucia-Ctesiphon on the Tigiis (near Baghdad), Karkā de-Beth Sělokh (modern Kerkuk) and Běth Lapat or Gunděshabhor (m the modern province of Luristan) The adoption of Christianity by Constantine as the official religion of the Roman empire had an unfortunate effect on the position of the Christians in Persia They were naturally suspected of sympathizing with the Roman enemies rather than with then own Persian rulers. Accordingly when Sapor Il (310-379) declared war on Rome about 337, there ensued almost immediately a somewhat violent persecution of the Persian Christians, which continued in varying degrees for about 40 years. One result of this and later persecutions of the same kind has been to enrich Syriac literature with a long series of Acts of Persian Martyrs, which, although in their existing form intermixed with much legendary matter, nevertheless throw valuable light on the history and geography of western Persia under Sassanian rule,

4th and 5th Centuries .- The two most important 4th-century writers-Aphraates and Ephraim-are dealt with in separate articles The importance of the former lies in the simple cast of his religious thought, his independence of theological formulas, his constant adherence to the letter of Scripture, his quaint exegesis, and the light he throws on the circumstances of his time, especially (1) the feeling between Jews and Christians, and (2) the position and sympathies of the Christian subjects of Sapor II. The position and character of Ephraim are very different He is the typical exponent in Syriac of unbending Catholic orthodoxy

Before leaving the 4th century we may mention two other writers who probably both lived on into the 5th-Balai and Cyrillona The former was the author of a good many poems, the longest-which is however by some attributed to Ephraim-is the work in 12 books on the history of Joseph, of which a complete edition was published by Bedjan in 1901 Other poems of his were edited by Overbeck in S. Ephraemi Syri, etc., opera selecta, pp. 251-336; and these have since been supplemented by Zetterstéen's edition of a large number of his religious poems or metrical prayers (Beitrage zur Kenntniss der religiösen Dichtung Balais, Leipzig, 1902). His favourite metre was the pentasyllabic. Cyrillona composed a poem on the invasion of the Huns in 395.

The 5th century was a time of storm and conflict in the churches of Mesopotamia and Persia, as in other parts of the Christian world. The teaching of Apollmarius that in Christ the Divine Word took the place of the human rational soul, thus seeming to do away with his possession of a true humanity, had led to a reaction by Paul of Samosāta, Diodore of Tarsus. Theodore of Mopsuestia, and Nestorius of Constantinople. Though with some points of difference, they agreed in emphasizing the permanence of the two separate natures in Christ, united but not mingled or confused, and laid stress on the reality of our Lord's human experience. One question on which great contention arose was as to the propriety of applying to the Divine nature attributes which belonged to the human nature-e.g., birth from a human mother-and vice versa. Hence the great dispute about the application to the Virgin Mary of the epithet θεοτόκος It seems to have been the objection of Nestorius to the use of this expression which mainly led to his condemnation and deposition at the Council of Ephesus (431) under the influence of Cyril, although as patriarch of Constantinople (428-431) he had distinguished himself by his zeal for Nicene orthodoxy. New light on the theo-

Book of Heraclides, a work of his own which has turned up in a Syrac version and was published by Bedjan in 1910

At Edessa the result of the conflict between the Nestorians and their opponents was long doubtful. When Rabbūla, the fierce anti-Nestonan and friend of Cyril, died in 435, he was succeeded in the bishopiic by Ibas, who as head of the famous "Persian school" in the city had done much to inculcate on his pupils the doctrines of Theodore of Monsuestia. But the feeling against the Nestorian party grew in strength, till on the death of Ibas in 457 the leading Nestorian teachers were driven out of Edessa. The Persian school continued to exist for another 32 years, but was finally closed and destroyed by order of the emperor Zeno in 489 The Nestorian teachers then started a great school at Nisibis (which had been under Persian rule since Joyian's humiliating treaty of 363) By the energetic efforts of Barsauma, bishop of that city, practically the whole church of Persia was won over to the Nestorian creed.

Great Churchmen .-- At the beginning of the 5th century one of the most able and influential men in the Syriac-speaking Church was Mārūthā, bishop of Maiperkat or Martyropolis Without entering on the details of his ecclesiastical activity, we may note that he was twice associated with embassies from the Roman emperor to Yazdegerd I (399-420), that along with lsaac, patriarch of Seleucia (390-410), he obtained from the Persian monarch a concordat which secured a period of religious toleration; and that he arranged for and presided at the Council of Scieucia in 410, which adopted the full Nicene creed and organized the hierarchy of the Persian Church As a writer he is chiefly known as the reputed author of a collection of martyrologies which cover the reigns of Sapor II, Yazdegerd I and Bahram V. By his history of the Council of Nicaea he made a great contribution to the education of the Persian Church in the development of Christian doctrine

The next bishop of Edessa, Ibas, who succeeded in 435 at the death of Rabbūlā, proved himself a follower of the Nestonan doctrine (See above ) As a teacher in the Persian school of Edessa he had translated, probably with the help of his pupils, certain works of "the Interpreter," ie, Theodore of Mopsuestia. Among these may have been the commentary on St. John of which the complete Syriac version was published by Chabot in 1897 He may possibly have translated a work of Aristotle. To the Nestorian movement in Persia he rendered useful service by his letter to Märi of Beth Hardasher, in which he maintained the tenets of Diodore and Theodore, while allowing that Nestorius had erred On the ground of his writings he was condemned and deposed by the "robber synod" of Ephesus (449), but was restored by the Council of Chalcedon (451), after he had anathematized Nestorius. His death in 457 was followed by a strong anti-Nestorian reaction at Edessa, which led to the expulsion of many of the leading teachers,

On Isaac of Antioch, "one of the stars of Syriac literature," see the special article. In spite of his over-diffuseness, he is one of the most readable of Syriac authors,

A Nestorian contemporary of Isaac, Dadhishos, who was catholicus of Seleucia from 421 to 456, composed commentaries on Daniel, Kings and Ecclesiasticus His chief importance in the history of the Persian Church lies in his having induced a synod of bishops to declare that church independent of the see of Antioch and of the "Western Fathers." (See J. Labourt, Le Christianisme dans l'empire perse, 1904, p 122 seq )

The most powerful missionary of Nestorianism during the and half of the 5th century was Barsauma of Nisibis, whom his opponents called "the swimmer among the reeds," i.e., the wild boar. Born probably between 415 and 420 he imbibed Nestorian doctrine from Ibas at the Persian school of Edessa, but was driven out in 457 on the death of his master, and went to be bishop of Nisībis. In a succession of missionary journeys he succeeded, partly by persuasion and partly (if his enemies are to be believed) by violence, in attaching to Nestorianism nearly all the Christian communities of Persia, with the exception of Taghrith, which was always strongly Monophysite. He had many quarrels with made peace with Acacius soon after the accession of the latter in 484. Among other severities towards the Monophysites, he persuaded the Persuan king Pērōz (457-484) to banish many of them into the Roman dominions. One of his great aims was to secure for the Nestorian clergy freedom to marry, and this was finally sanctioned by a council at Seleucia in 486 (Labourt, op cst. chap vi ), Barsāumā must have been bishop of Nisībis for nearly 40 years, but was dead by 496 His writings seem to have been chiefly liturgical, he gave the first set of statutes to the school of Nisibis, which was founded during his bishopric

His fellow-worker Narsai, whom the Jacobites called "the " but the Nestorians "the harp of the Holy Spirit," apparently accompanied Barsauma from Edessa to Nisibis, where according to Barhebraeus he lived for 50 years Barsauma appointed him head of the new school, where he taught rigidly Nestonan doctrine He was a copious writer, especially in verse Many of his poems have now been published (See Mingana, Narsai, homiliae et carmina, 2 vols Mosul, 1905) His theological position is clearly defined in a homily on the three doctors -Diodore, Theodore and Nestorius-published by the Abbé Martin in the Journal asiatique for July 1900

To about the same period belongs The book of Hierotheus by the "pantheist" Stephen bar Südh-arte, which has recently been edited and translated by F. C Marsh (1927)

Early Monophysites .- Among the early Monophysites were two of the best of Syriac writers-Iacob of Serugh and Philozenus of Mabbogh, who have been treated in special articles. The one

wrote mainly in verse, the other in prose. See also Ioshua the STYLITE

Another early Monophysite was Simeon of Beth Arsham, who by a series of journeys and disputations within the Persian empire did all he could to prevent the triumph of Nestorianism among the Persian Christians He had considerable success at the time, but the ground he had won was soon reconquered by his opponents, except at Taghrith and the surrounding district. It was after a successful disputation in presence of the Nestorian catholicus Bābhai (497-502/3) that Simeon was made bishop of Bēth Arsham, a town near Seleucia He made several journeys to Constantinople, where he enjoyed the favour of the empress Theodora It was there he died, probably about 532-533. His biography was written by John of Asia in the collection of lives of eastern saints which has been edited by Land (Anecd syr vol 11 ). His literary productions consist only of a liturgy and two exceedingly interesting letters. The one has for its subject Barsauma and the other Nestorian leaders in Persia, and gives a highly malicious account of their proceedings. The other, which has been often edited, is an account of a severe persecution which the Himyarite Christians of Najran in south-west Aiabia underwent in 523, at the hands of the king of Yemen. (See The book of the Himvarites, a Syriac work edited and translated by A. Moberg, Lund, 1924) As Simeon had repeatedly visited al-Hirah and was in touch with the Arab kingdom which centred there, his letter is a document of first-rate historical importance

Mention should be made of two other early Monophysite Justin I. (518-527) The one, John of Tellä, author of 538 canons, answers to questions by the priest Sergius, a creed and an exposition of the Trisagion. His life was written by his disciple Elias, and also by John of Asia. The other, John bar Aphtonya, was the founder of the famous monastery of Kenneshrë, opposite Jerābīs on the Euphrates, and wrote a com-mentary of the Song of Songs, a number of hymns and a biography of Severus, the Monophysite patriarch of Antioch (512-

The life of the great missionary bishop Jacob Burdě'ānā or Baradaeus, from whom the Monophysite Church took its name of Jacobite, belongs rather to ecclesiastical than to literary history (See H. G. Kleyn, Jacobus Baradaeus, de Stichter der Syrische monophysietische Kerk, Leyden 1882.)

his ecclesiastical superior the catholicus of Seleucia, but finally Sylla has produced. Of his life little is known, and that little not wholly creditable He wavered curiously in his ecclesiastical views, and ended by helping the persecutors of the Monophysite Church, to which he himself had belonged. He seems to have lived as a priest and physician at Ras'ain in Mesopotamia most of his life About 535 he travelled on various ecclesiastical missions, and finally made a journey to Rome and thence to Constantinople (in this latter accompanied by the pope Agapetus). The result was to bring about the deposition and banishment of the Monophysites from the latter city. Sergius died almost immediately atterwards, in 536 Among the works which he translated into Syriac and of which his versions survive are treatises of Aristotle, Porphyry and Galen, the Ars grammatica of Dionysius Thrax, the works of Dionysius the Areopagite, and possibly two or three treatises of Plutarch His own original works are less important, but include a "treatise on logic, addressed to Theodore (of Mery), which is unfortunately imperfect, a tract on negation and affirmation, a treatise, likewise addressed to Theodore, On the Causes of the Universe, according to the Views of Aristotle, showing how it is a Circle; a tract On Genus, Species and Individuality; and a third tract addressed to Theodore, On the Action and Influence of the Moon, explanatory and illustrative of Galen's Hepl κρισίμων ήμερων, bk in, with a short appendix 'On the Motion of the Sun'" (Wright) According to the historical compilation which passes under the name of Zacharias Rhetor, he also wrote a treatise on the faith. Some of his translations were revised at a later time by Honain ibn Ishāk (d 873).

Another translator from Greek was Paul, Monophysite bishop of Callinicus or ar-Rakkah, who, being expelled from his diocese in 510, retired to Edessa and there occupied himself in translating into Syriac the works of Severus, the Monophysite champion who was patriarch of Antioch from 512 to 519 This version appears to be quite distinct from that used by the compiler of the chronicle of Zacharias, and also from the version of "the 6th book of the select letters of Severus" which was made by Athanasius "presbyter of Nisibis" in 669, edited by E W Brooks (1902-04).

That important legal work, The Laws of the Emperors Constantine, Theodosius and Leo, which was composed in Greek about 475, and "which hes at the root of all subsequent Christian oriental legislation in ecclesiastical, judicial and private matters" (Wright), must have been repeatedly translated into Syriac. The oldest form is contained in a British Museum ms, which dates from the earlier part of the 6th century, and this was edited by Land (Anecd, syr i. 30-64). A later (probably Nestorian) recension is contained in a Paris ms., which was used along with the other by Bruns and Sachau in their exhaustive edition (Syrischromisches Rechtsbuch, Leipzig, 1880) In Notulae syriacae (privately printed 1887) Wright edited the surviving fragment of a 3rd recension which is preserved in a 13th-century ms at Cambridge. Finally Sachau has published three new reductions of the treatise from a ms found at Rome in 1894 (Syrische Rechts-

bucher, vol i, Lepzig, 1907).

Anonymous Works.—We may here take note of three important anonymous works, of which the first probably and the other two certainly belong to the 6th century.

The Më'arrath gazzë or Cave of Treasures, translated and edited by C. Bezold (Leipzig, 1883-88), is akin (as Duval remarks) to the Book of Jubilees. It is an imaginary history of the patriarchs and their descendants.

The tripartite narrative which is known as the Romance of Julian (the Apostate) has no claim to be regarded as an historical document. Its hero is Jovian, one of the feeblest of Roman emperors, and Julian is everywhere exhibited in flaming colours as the villam of the story.

A valuable historical source, though of small dimensions, is the Chronicle of Edessa, which gives a record of events from 132-131 BC. to AD. 540-at first exceedingly brief, but becoming somewhat fuller for the later years It appears to be thoroughly reliable wherever it can be tested It has been three times editedfirst by Assemani in the Bibliotheca orientalis (i. 388-417), sec-Translators from the Greek.—In Sergius of Rās'ain we ondly by L Hallier (Leipzig, 1892) with a translation, introduction one of the best Greek scholars and ablest translators whom tion and abundant notes, and thirdly by Guidi with a Latin version (in Chronica minora, Paris, 1903)

On John of Asia or Ephesus, the enginent Monophysite bishop and earliest Syriac church historian, see the separate article

An historical work of somewhat similar character to John's is the compilation in 12 books which is generally known by the name of Zacharias Rhetor, because the anonymous Syriac compiler has incorporated the Syriac version or epitome of a lost Greek history written by that author The Syriac work exists (not quite complete) in a British Museum ms of about the beginning of the 7th century this can be in part supplemented by an 8th-century ms at the Vatican From the latter Guidi published the interesting chapter (X 16) which contains the description of Rome The entire text of the London ms was published by Land in the third volume of his Anecdota syriaca, and there is now an English translation by Hamilton and Brooks (1899), and a German one by Ahrens and Kruger (Leipzig, 1800)

Of the other 6th-century Jacobite writers we need mention only Moses of Aggel (A c 550-570) who translated into Syriac some of the writings of Cyril, and Peter of Callinicus, Jacobite patriarch of Antioch 578-591, who wrote a huge controversial treatise in 4 books, each of 25 chapters, against Damian, patriarch of Alexan-

dria, as well as other less important works

The Nestonan writers of the 6th century were numerous, but as yet we know little of their works, beyond what 'Abhdīsho' tells us in his Catalogue. It will be sufficient to mention one or two Joseph Hūzāyā (i.e., of al-Ahwaz or Khūzistan), who came third in succession to Narsai as head of the school of Nisibis, was the first Syriac grammarian and invented various signs of interpunction Marūtha, who was Nestorian catholicus of Seleucia from about 540 to 552 (see Labourt, op. cst , pp 163-191), and a man of exceptional energy, made the only known attempt, which was, however, unsuccessful, to provide the Nestorians with a Bible version of their own. He was the author of many commentaries, homilies, epistles, canons and hymns Paul the Persian, a courtier of Khosrau Anosharwan, dedicated to the king a treatise on logic which has been published from a London ms by Land in the 4th volume of his Anecdota Bodh the periodeutes is credited with a philosophical work which has perished, but is best known as the author of the old Syriac version of the collection of Indian tales called Kalilah and Dimnah He made it doubtless from a Pahlavi version His translation, which was edited by Bickell with an introduction by Benfey, must be distinguished from the much later Syriac translation made from the secondary Arabic version and edited by Wright in 1884, of this there is an English translation by Keith Falconer (1884). Hannana of Hedhaiyabh, who nearly produced a disruption of the Nestonan Church by his attempt to bridge over the interval which separated the Nestorians from Catholic orthodoxy, was the author of commentaries

Decay in the 7th Century. "With the 7th century." as

Wright remarks, "begins the slow decay of the native literature of the Syrians, to which the frightful sufferings of the people during the great war with the Persians in its first quarter largely contributed." The same process of decay was greatly promoted by the Arab conquest of Persia, achieved through the victory of Kādisīya in 636-637. The gradual replacement of Syriac by Arabic as the vernacular language of Mesopotamia by degrees transformed the Syriac from a living to a dead language. Apart from a few leading writers-such as Jacob of Edessa, the anonymous historian whose work has passed under the name of Dionysius of Tell-Mahrë, Thomas of Marga, Dionysius bar Salībī, and Barhebraeus (qq.v) - there are few names of interest.

I. Theology.-Here we may first mention George, bishop of the Arabs (d. 724), who wrote commentaries on Scripture, and tracts and homilies on church sacraments, and finished the Hexaemeron of Jacob of Edessa. Bābhai the Elder, a leading Nestorian in the beginning of the 7th century and a prolific author, wrote many commentaries and theological discourses. Ishöyabh III., Nestorian catholicus from 647 to 657/8, wrote controversial tracts, religious discourses and liturgical works. Elias of Merv, who belongs to the 2nd half of the 7th century, compiled a Catena patrium on the Gospels and wrote many commentaries. Timothy , catholicus 779-823, wrote synodical epistles and other works

bearing on church law Moses bar Kepha (d 903), one of the most fertile of oth-century authors, wrote commentaries, theological treatises and many liturgical works. Other important contributors to this sphere of literature were Isho' bar Non (d. 827/8), John bar Zö'bî (beginning of the 13th century), Jacob bar Shakko (d 1241), and the great Nestorian scholar 'Abhdisho' (d 1318)

2 History -Besides the important writers treated in separate articles, we need mention only four Elias bar Shīnāyā, who in 1008 became Nestorian bishop of Nisibis, was the author of a valuable Chronscle, to which are prefixed numerous chronological tables, lists of popes, patriarchs, etc., and which covers by its narrative the period from AD 25 to 1018 Ot this work, which exists in only one imperfect copy, the later portion was edited by Baethgen m 1884, and the earlier by Lamy in 1888. Another important Chronicle is that of Michael I, who was Jacobite patriarch from 1166 to 1199. Its range extends from the Creation to the author's own day, and it was largely used by Baihebraeus in compiling his own Chronicle. Till recently it was known only in an abridged Armenian version which was translated into French by V Langlois (Venice, 1868), but the Syriac text was found in a ms belonging to the library of the church at Edessa, and has been published by J B Chabot A work rather legendary than historical is the Book of the Bee, by Solomon of al-Basrah, who lived early in the 13th century Lastly, acknowledgment must be made of the great value of the Catalogue of Nestorian writers, by 'Abhdisho' of Nisibis, the latest important writer in Syriac It was edited by Assemani in the 3rd part of his Bibliotheca orientalis, and has been translated into English by Badger.

3. Biography, Monastic History, etc.—Besides the important work by Thomas of Margā (q v) the following deserve special mention Sāhdōnā, who was a monk in the Nestorian monastery of Beth 'Abhe (the same to which Thomas of Marga belonged two centuries later) and afterwards a bishop early in the 7th century. wrote a biography of and a funeral sermon on his superior Mar Jacob who founded the monastery, and also a long treatise in two parts on the monastic life of which all that survives has been edited by P Bedjan (Paris, 1902). Whilst accompanying the catholicus Isho'vabh II. (628-644) on a mission to Heraclius, Sähdönä was converted, apparently to Catholicism (see H. Goussen, Martyrius-Sahdonas Leben und Werke, Leipzig, 1897), and thereby caused much scandal in the East. The chief events in his life are narrated by Ishō'děnah Another Nestorian who, a few years later, wrote ecclesiastical biographies and other theological works was Sabhrisho' Rustam, who lived at Mount Izla and other monasteries In the beginning of the 8th century David of Beth Rabban, also a Nestorian monk, wrote, besides a geographical work, "a monastic history, called *The Little Paradsse*, which is frequently cited by Thomas of Marga." A more important work is The Book of Chastity, by Ishō'dēnah, who according to 'Abh-dīshō' was bishop of Kasrā—but read Baṣrā—about the end of the 8th century. This work is a collection of lives of holy men who founded monasteries in the East, and is a valuable historical source. The work itself, or an abridgment of it, was discovered and published for the first time by J B Chabot (Rome, 1896) As the last under this head we may mention a late anonymous biography, that of the catholicus Yabhalāhā III. (1281-1317), which throws much light on the relations of the early Mongol kings with the heads of the church in their dominions Among other interesting features it contains information about the Nestorian Church of China in the 13th century.

4. Philosophy and Science - Special mention may be made of 'Ananisho' of Hedhaiyabh (middle of 7th century) well known as the author of a new recension of the Paradise of Palladius, and also the author of a volume on philosophical divisions and definitions; Romanus the physician (d. 896), who wrote a medical compilation, a commentary on the Book of Hierotheus, a collection of Pythagorean maxims and other works; Moses bar Kepha, the voluminous writer above referred to; the famous physician Honain ibn Ishāk (d. 873), who wrote chiefly in Arabic, but deserves mention here by his services to Syriac grammar and lexicography, and still more by his translations of Greek philosoph-

ical and scientific works into Syriac and from Syriac into Journal de la société finno-ouguenne, especially for 1903 Arabic, becoming in a sense the founder of a school of translators. and Jacob bar Shakko, whose work called the Diglogues treats of grammas, rhetoric, poetry, logic, philosophy and science

5 Grammar and Lexicography -Several of the authors in this department have already been mentioned. The more important. besides Jacob of Edessa and Barhebiaeus, are 'Anānīshō' of Hědhaiyabh, Honain ibn Ishāk, his pupil Bar 'Ali, Bar Sarōshwai (eaily 10th century), Bar Bahlūl (middle of 10th century), Elias of Tirhan (d 1049), Elias bar Shīnāyā (above), John bar Zō'bī (beginning of 13th century) and Jacob bar Shakko

Apart from the numerous editions of Syriac texts by Paul Bedjan, some of which have been cited above, nearly all the texts, recently edited are included in one or other of three comprehensive series now edited are included in one or other of three complemensive series now running—viz. (1) Patrologia syrace (Paus, 1894), (2) Corpus serie-torium christianorum orientalium—scriptores syrace (Paris, 1907). Patrologia orientaliu (Paris, 1907). See W Wright, History of Syrace torian Entimental Discourse Special States (Paris, 1907) See W Wright, History of Syr Literature (1805), R Duval, La Littérature syrique (3rd ed. 1907) A Baumstark, Geschichte der syrischen Literatur (1922). (N M'L)

SYRINGA, the common name applied to several cultivated ornamental shrubs of the genus Philadelphus, of the family Saxifragaceae (q v ). The name arose from the fact that the original generic name of these shrubs was Syiniga, which, however, propgerly belongs to the lilac (qv) The garden syringas, better known as mock-orange, are all species of *Philadelphius*. They possess conspicuous, usually strongly scented flowers and in a wild state are natives of the north temperate zone. There are about 40 species The common garden syringa (P. coronarius) is Eurasian, but is found in many horticultural varieties Noteworthy North American species are the scentless syringa (P. inodorus), the large-leaved syringa (P. grandiflorus) of the south-eastern U.S., and the western syringa (P. lewis), state flower of Idaho, found from Montana to British Columbia and Oregon.

SYRINGE, a hydraulic instrument, based on the principle of the pump, for the drawing up and ejecting of liquids. The ordinary form is that of a glass or metal tube ending in a pointed nozzle and fitted with an airtight piston-rod and handle. The nozzle is inserted in the liquid, which enters the cylinder by atmospheric pressure when the piston-rod is drawn up. On pushing back the piston the fluid is ejected in a jet through the nozzle. In sizes varying from the needle-pointed hypodermic syringe to the abdominal syringe, it is a common surgical implement used for the injection of fluids into the body or for the washing of wounds and cavities. A larger syringe of metal with a flat perforated nozzle is used as a garden implement for watering plants.

SYRINX, the Greek name for the pan-pipes. The pipes composing it were stopped at one end, so that the sound waves had to travel twice the length of the pipe, giving out a note nearly an octave lower than that produced by an open pipe of equal length. It consisted of a varying number of reeds, having their open ends in a horizontal line and their stopped ends, formed by the knots in the reed, gradually decreasing in length from left to right. Each pipe gave out one note, but by overblowing, i.e. increased pressure of breath and tension of lips, harmonics could be obtained The syrinx or pan-pipes owes its double name to ancient Greek tradition, ascribing its invention to Pan in connection with a wellknown legend of the Arcadian water-nymph Syrinx.

Syrinx is also a term used in medicine and anatomy, meaning (1) the Eustachian tube; (2) a fistula; and (3) a kind of secondary larvnx found in birds.

SYRYENIANS (also Sirianian, Syrjenian, Zyrenian, Zirianian, Zyrian and Zirian), a tribe of the Permian division of the eastern Finns. Their headquarters are at Ust-Ishma, at the junction of the Ishma and Pechora. Formerly they spread farther to the west. They are of moderate stature, blond and greyeyed, energetic and inclined to trade. They were converted to Christianity about 1350 and their language was reduced to writing. They call themselves Komi and are not sharply distinguished from the tribes known as Permian, the languages being mutually intelligible. The archaeological remains in the governments of Perm and Vyatka called Chudish by Russians are probably Syryenian. A grammar of the language was published by Castrén. and linguistic and other notices of the tribe are contained in the

SYZRAN, a town of the USSR, in the Kuibyshev region, in lat 53° 10' N, long 48° 33' E, near the right bank of the Volga Pop (1939) 77,679 It is on the Moscow-Kazan railway and has a branch going to Ryazan There are flour mills, leather factories and saw-mills Bricks and nails are manufactured and there is a biewery and a distillery. The town was originally a fort to protect settlers from Tatar and Circassian raids, but has developed, especially after the railway reached it, into a manufacturing centre, with river and rail trade in exported grain and imported timber and manufactured goods.

SYZYGY (si'zi-ji), in astronomy, either of the points at which the moon is most nearly in a line with the earth and sun The moon passes her syzygies, or is in a syzygy, at new and full

SZÉCHENYI, ISTVAN, COUNT (1791-1860), Hunganan statesman, the son of Ferencz Széchenyi and the countess Juhana Festetics, was boin at Vienna on Sept 21, 1791 Entering the army in his 17th year, he fought with distinction at the battle of Raab (June 14, 1809), and on July 16 brought about the submessage across the Danube to General J G Chasteler at the risk of his life Equally memorable was his famous ride, through the enemy's lines on the night of Oct 16/17, 1813, to convey to Blucher and Bernadotte orders for the impending battle of Leipzig In May 1815 he was transferred to Italy, and at the battle of Tolentino scattered Murat's bodyguard by a dashing cavalry charge. From Sept 1815 to 1821 he travelled widely, studying the institutions of the countries through which he passed A second-scientific-tour with his friend, Baron Miklos Wesselényi, In 1825, when he taught him much about trade and industry went to France to attend the coronation of Charles X, the canal du Midi attracted his attention and suggested to him the idea of regulating the rivers Danube and Theiss At the diet of 1825, when the motion for founding a Hungarian academy was made by Pál Nagy, who bitterly reproached the Magyar nobles for so long neglecting their mother-tongue. Széchenvi set the example by offering to contribute a whole year's income (60,000 florins) towards it The formation (June 1833) of the Danube Navigation Company, which eventually opened up the Danube from Buda to the Black Sea was the fruit of Széchenyi's imitative and personal study. Széchenyi was also the first to start steamboats on the Theiss, the Danube and the lake of Balaton

All this time Széchenyi had been following, with some anxiety the political course of Kossuth, whose extravagances he feared would plunge Hungary back into the chaos out of which he had helped to raise her The majority, indeed, sided with Kossuth, but neither this fact nor the gradual loss of his popularity restrained Széchenyi, both in the diet and at county meetings, from fulminating conscientiously against the extreme demands of Kossuth His views at this period are expounded in the pamphlet Politikai programm töredékek ("Fragments of a Political Programme"). He held the portfolio of ways and communications in the first responsible Magyar administration (March 23, 1848) under Bátthyány, but his increasing apprehension of a revolution, with its inevitable corollaries of civil war and a rupture with the dynasty, finally affected his mind, and on Sept 5 he was removed to an asylum Here he remained for many years, but recovered sufficiently to correspond with his friends and even to meditate writing fresh books; but the sudden death of his old friend Baron Samuel Jósika and the once more darkening political horizon led him, in a moment of despair, to take his own life (April 8, 1860). He richly deserved the epithet "the greatest of the Magyars" bestowed upon him by his political antagonist Kossuth.

See Antál Zichy, Biographical Sketch of Count Stephen Széchenyi (Hung.; 2 vols., 1896-97).

SZECHWAN, the largest province of China Proper, area formerly nearly 220,000 sq.mi., but after the institution of Sikang province on the western border reduced to 143,147 sq.mi. with a population of 46,403,006 (1939), very unevenly distributed. The heart of Szechwan is the plateau known as the Red basin, a region that continued as a gulf of the sea for some time, in later Palaeozoic period, after the north Mongolian region became land, and changed to a fresh-water lake during the Mesozoic, with deposition of the post-Rhaetic ied sandstones, later wrinkled and converted into land. The province is bordered on the west by the immense eastern Tibetan fault-zone, which gives a rapid rise from the Mm-ho (less than 1,500 ft above sea level) by broad terraces to great north-south mountain lines, the greater part of which is well over the 12,000 ft level Most of these western highlands were included in the province of Sikang. The density of population varies from 10 4 per sq mi. near Sikang to 2,392 in the 11ch rice regions near Chêngtu. There is much evidence of a long continuance of earth movement along this great fault line, and the river courses of the highland have adapted themselves to the changes involved, running southward between the ranges turning eastwards into southwest Szechwan and north Yunnan, eventually uniting in the portheastward course of the Yangtze Kiang. The mountain courses of the rivers are torrential; in the Red basin the rivers are generally navigable and afford the best means of communication On the northeast, the Red basin grades up to the Tapaling or Tapashan, beyond which, to the north, is the great west-east range of the Tsinlingshan

The Tapaling (Tapashan) end in a great fault against the Hunch basin, eastwards; and the latter is much lower than the Red basin The Yangtze Kiang makes its way from the one down to the other through the famous gorges of the northeast frontier of Szechwan to Ichangin Hupeh Von Richtofen thought that the sinking of the Red basin, as compared with the Tibetan highland, has continued until recent times, whereas that of the Hupeh basin, as compared with the Tapaling and the Red basin, ended earlier The result would be a tilt, lessening the slopes in the west of Szechwan, within the basin, but increasing them in the northeast: this furnishes at least a supplementary interpretation of the Yangtze Kiang (qv) gorges, which are so notable a feature of China's physical geography, and have played such a part in isolating Szechwan from Hupeh The Yangtze and its feeders within the basin in the west are less closely encased, so there are considerable alluvial plains, as around Chêngtu, the capital, where irrigation is highly developed. Beyond the Yangtæ Kiang, to the southeast, stands the limestone horst of the province of Kweichow, with its border towards the Red basin, often at an altitude of 4,500 ft, drained by streams which reach the deep channel of the Yangtze by narrow valleys The name Szechwan means four rivers, and the Yangtze Kiang is made up of the Min, To, Fu and Kialing, flowing north to south into the Red basin, where they meet the Kin-Sha or Upper Yangtze, which has also been formed of north to south streams and has then rounded the Liangshan and flowed north along its eastern side, really entering the basin at Sur-fu (Su-chow-fu) where the Min, from Chêngtu, joins it.

The climate of the Red basin may be studied from data for Chungkung, at the junction of the Kialing with the Yangue. The monthly average temperatures vary from 49° F in December and January to 80°-85° F. in Juyand August. The average minimum per month is not more than 3-x5° below the average, so, in the Red basin, snow and frost are not often lasting. The minfall is very low under the influence of the Central Asiatic anti-cyclene in December, January and February, but March has a minfall of 2 8 in., April a rainfall of 4 in, and so the amount increases up to a maximum of about 11 in, in each of the months of June and August. The early onset of rain before the summer monsoon has begun is probably epithaed by the beating of the monsoon from the consequent development of cyclonic, which thus midden the chinace of a region in the heart of a continue.

The winter is not too cold for growth of cereals (wheat, bairley, costs, millet) and the summer monsoon gives opportunities or almost tropical crops at low levels, and rice (especially on irrigated alluvium near Chéngiut), sugar, henpu, sesamum, pulses, mulbstry, oranges, maize and tobacco are thus grown. Wax trees are important around Kaitang-Ju. (See Sury-Ju. (See).

Until the last millennium B.c. Szechwan was entirely non-Chinese, and was under Indian culture influence, the results of

which pensist in the cultivation of sugal cane, the use of great water wheels for ringation, and the presence of the zebu and water buffalo. The Tsin dynasty incorporated Sectional within the emure, but its solation has often made it a basis for separatist movements. The population within the basin has become definitely Chinese, though almost forming a separate nationality within the Chinese group. The western highlands have a sparse Thetan population, while in the southwest are non-Chinese groups, Lolo, Sifan, Miautse, some probably of very long standing locally, others or relative late, it still pre-Chinese, entry

Millions of refugees from coastal provinces moved to Sechwan after the start of the Chinese-Jpanese war in 1937. They contibilated to a rapid modernization. With Chungking (population ε 1,000,000 in 1944) as wartime capital of China, Sechwan became China's political and economic centre. However, in spite of cities like Chingking, Chéngtin (ε 4,00,000), Wanhsien, Su-fu, Luchow, Shunking Fowchow and Huchow most of the population remained virus!

Coal, mainly bituminous and associated with iron, is mined by adits along the Yangitze valley, and supplies the river steamers plying the 348 mi. between Chungking and Ichang (Hipeh province). Oher coal and iron producing centres are the Min and Kalang valleys Copper is mined west of the Min river, where Ning-Yuan and Ya-Chow piefectures are the main producing districts Sall extraction by brine pumping is also a widely prevalent activity Gold, silver, lead and antimony are also mined, mainly west of the Min river.

The industrial development which started during the Chinese-Japanese war had led by 1943 to an investment of more than \$500,000,000 in industrial and mining enterprises. In many cases the location of new industries was kept secret. In the spring of 1940 the first iron and steel plant was completed. Along the To river alcohol distillenes were built to use the sugar cane, and blast furnaces and machine mudstries were established near the mines Some 300 new factories for textiles, drugs, dyeng, electrical equipment, machine repair shops, etc. were constructed Power was furnished by new plants with large possibilities for expansion.

Communications in Szechwan were handicapped by topography, and the easiest and most utilized roads were those of the tiver valleys. Chungking, which was until 1943 a treaty port (opened in 1890.), was a trading centre for silk, tea, rice and other goods of the Red basin and the area west of the Min river, which latter trade came through Chéngiu. The Great North road from Peiping via Sian to Chéngiu and the Little North road from Peiping via Sian to Chéngiu and the Little North road from Peiping via Sian to Chéngiu, and in 1943 the first motor road was completed from Chungking to Chéngiu, and in 1944, 3;00 miles of highway were open, linking Szechwan with all neighbouring provinces.

See F. von Richtofen, China, vol iii (Berlin, 1912); L. Richard, Geogr. de l'Empire de Chine (Shanghan, 1905).

SZEGED, capital of the county of Csongrád in Hungary and the second town in the country. It he just below the confluence of the Maros and the Tisa Pop (1939) 141,254 It is modern and well built, the old town having been almost destroyed by flooding of the Tisa in 1879. In early times it was important because it lay on the salt and timber route from Transpivana to the Adriatic. To-day it is essentially a market centre lying at the meeting point of four contrasted regions, viz:—the drift-sand Danube-Tisa sone, the loess-covered Backa, the garden region of the Koros-Maros interstream area and the cereal belt of the western Banat. It is the seat of a university.

SZÉKESFEHÉRVÁR, a town in Hungary, capital of the county of Feife; hes in a marshy valley connecting the loses-covered plains of the Danube with the Upper Hungarian Plant (Kis-Alfold). It trades in wine, fruit and horses and has tanneiss and shoe factories The town was the corneation and burnal place of the Hungarian kings from the roth to the roth century. The coronation church was built by St. Stephen, the first king of Hungary and in it were buried 1 s kings. At the end of the Turksh occupation, 7434–7686, the church, its tombs and archives

bishopric. Pop. (1930), 40,714

SZEKLERS (Magyar Székely), a people inhabiting the upper

valleys of the Mutes and the Olt in eastern Transylvania, They number to-day about 450,000, but are no longer distinguishable from the Magyars, with whom they are closely akin Their origin has been much debated According to their own tradition. reneated in Procopius (de bello Gothico, iv 18), they were descended from Attila's Huns, while others have seen in them Black Ugrians It is, however, now generally accepted that they are true Magyars, transplanted here probably by St Ladislaus to guard the frontier, their name meaning simply "frontier guards" For then history and bibliography, see Transylvania

SZÉLL, KOLOMAN (1845-1915), Hungarian statesman, was born on June 8, 1845. He studied at Budanest and Vienna and in 1867 became deputy for the district of St Gotthard Széll was one of Déak's intimates, whose ward, the daughter of the Hungarian poet Vorosmarty, he had married In 1875 he was finance minister in the Tisza cabinet, and began the task of restoring the shattered ciedit of Hungary In 1878 he concluded with Austria the first economic Ausglesch At that time the single Austrian bank was changed, in conformity with this arrangement into the dualistic Austro-Hungarian bank, and Széll consulidated the Hungarian sentes, and nearly succeeded in balancing the State finances. As he feared that this balance would again be upset by the occupation of Bosnia and Heizegovina, he resigned from the cabinet, incurring thereby the displeasure of the Crown At the beginning of the eighties Széll founded the Hungarian Mortgage Credit Bank, of which he was governor until the end of his life. He opened entirely new sources of credit for Hungarian agriculture. He declined repeated offers of the portfolio of finance. Széll became prime minister after the fall of Bánffy in February 1800. On the basis of the so-called Széll formula the new Ausgleich with Austria until the year 1907 was concluded after long negotiations. He was forced to resign on June 16, 1903 Széll was one of the Liberal seceders in 1904 Under the Coalition cabinet of Wekerle, he was chosen president of the Constitutional Party He tried continually, but in vain, to bridge the opposition between Tisza and Andrassy He died on Aug 16, 1915.

SZILAGYI, DESIDER (1840-1901), Hungarian statesman and jurist, was born at Nagy-Várad (Grosswardein) on April 7, 1840 He studied law at Budapest, Vienna, and in Germany As head of a section in the Hungarian ministry of justice he went to England to study the conditions of the administration of justice there, and took a conspicuous part in the codification work of the ministry of justice Deputy in 1871, professor of public

were destroyed. The town is a very old see of a Roman Catholic one of the leaders of the opposition, which, however, he left in 1886 In 1887 he was returned to parhament by Pozsony (Pressburg) as an independent member. He became minister of justice in 1880 From this time to 1894 he directed his efforts principally towards a radical reform of the whole administration of the courts His name is connected with the changes in ecclesiastical legislation made in 1804, notably with article XXXI of the law of civil mailiage, and articles XXXII and XXXIII on the religion of the children and on State registration Szilagyi was president of the house of deputies from 1895 to 1899 He died on July 3, 1901. See Szilagyi's Speeches (4 vols, in Hungarian, ed. Fayer).

SZINYEI-MERSE, PAUL DE (1845-1920), Hungarian painter, was born at Szinyeujfalu and studied art at the Munich Academy His pictures were characterised by gay and graceful colouring and a lyric view of nature In 1873 he finished the masterpiece of his life "May Festival" He gave successful exhibitions at Munich (1909), Berlin (1910) and Rome (1911) In 1905 he was appointed director of the Hungarian National Academy of Arts He died in 1020

See Béla Lázár, Paul von Szmyei-Merse (1911), Alexius Petrovics, Szmyei Pál (Aits Lexicon, 1926).

SZOMBATHELY, a town in western Hungary, that has lost, by the rearrangement of the frontier between Austria and Hungary in 1920, a large portion of the area it served as a market It occupies the site of the Roman capital of Pannonia, Sabaria Savaria and many remains of the Roman period have been excavated, some of these are preserved in the museum at Budapest, the remainder in the municipal museum. The town lies in the centre of a rich wine-producing downland and is an important agricultural centre with steam flour and saw mills and factories producing agricultural machinery and textiles in addition to foundies and a state railway workshop. It has been the see of a Roman Catholic bishop since 1777 and possesses a beautiful cathedral and several other ecclesiastical buildings Pop (1930) 35,758 About 5 m S hes the village of Jak which has an 11th century Dominican convent whose church is reputed to be one of the finest examples of Romanesque architecture in the country.

SZYMANOWSKI, KAROL (1883-1937), Polish musician, was born at Timoshovka, Russia, of Polish parents, and studied under Sigismund Noskowski at Warsaw. He became one of the leaders in the revival of Polish national music, but his early works owe much to the German tradition. He composed songs. orchestral works and chamber music, but a large proportion of his compositions were for the pianoforte. He also composed an opera "Hagith" written in 1912 and produced at Warsaw in 1922, which has won many admirers. In the works written law and politics at Budapest university in 1874, he was in 1877 after 1914 Szymanowski adopted new and ultra-modern methods



THIS letter corresponds to Semitic tau, the form of which on the Moabite stone was X. In all Greek alphabets, as well as in the Lydian and the Latin, the form was T. Etruscan had a form Y, from which probably were derived the Umbrian form X and the Faliscan † and Y.

Latin cursive gives a form that leans to the right Carolingian T is based upon uncial T. Generally speaking, in mediaeval miss the letter did not rise above the line and it is sometimes difficult to distinguish from a minuscule c In modern

NAME OF FORM	APPROX- IMATE DATE	FORM OF LETTER	
PHOENICIAN	B.C 1,200	Χ	
CRETAN	1 100-900	Т	
THERAEAN	700 600	Т	
ARCHAIC LATIN	700 - 500	Т	
ATTIC	600	Т	
CORINTHIAN	600	Т	
CHALCIDIAN	600	Т	
IONIC	403	Т	
ROMAN COLONIAL		17	
URBAN ROMAN	PRE-	T	
FALISCAN	CLASSICAL AND CLASSICAL	r	
OSCAN	TIMES	1 T	
UMBRIAN		† † 1	
CLASSICAL LATIN AND ONWARDS		T	

THE DEVELOPMENT OF THE LETTER "Y" FROM THE PHOENICIAN THROUGH THE CLASSICAL, DOWN TO THE PRESENT FORM

handwriting and printing it is the custom to extend the vertical stroke above the horizontal.

The sound represented by the letter throughout its history has been the unvoiced dental stop. In English this has become more alveolar than dental, that is to say, it is pronounced by the tongue pressing upon the gems rather than the teeth. Modern unvoiced stops are probably also to be distunguished from the corresponding sounds in ancient Greek by the addition of a slight pull of breath following the sound, thus bringing the sound near to being an aspirate. Greek would perhaps have transliterated the English unvoiced stops by the letters  $\theta_t$ ,  $\Phi$  and  $\chi$  rather than  $\tau_t$ ,  $\pi$  and  $\kappa$ . This tendency towards aspiration is carried to much fatther lengths in the Irish dislates of English. (B. F. C. A.)

TAAFFE, EDUARD FRANZ JOSEPH VON, COUNT [11th Viscount Taaffe and baron of Ballymote, in the peerage of Ireland] (1833-1895), Austrian statesman, was born at Vienna, Feb. 24, 1833, second son of Count Ludwig Patrick Taaffe (1791-

1855), who was minister of justice in 1848 and president of the court of appeal As a child Tansfe was one of the chosen companions of the young archduke, afterwards emperor, Francis loopen In 1852 he entered the public service, in 1867 he was Statthalter of Upper Austria, and minister of the interior in Besut's administration. In June he became vice-president of the ministry, and at the end of the year he entered the first ministry of the newly organized Austrian portion of the monarchy For the next three years he took a very important part in the consultance of the control of the con

On the breakdown of the Liberal government in 1879 he was again called to office, becoming minister-president in July, and held office until July 1893, when he was defeated on a proposal for the extension of the franchise and resigned, dying at Ellerschau, Bohemia, on Nov 29, 1895 For the history of Tanfe's administration, see AUSTRIA, EXEPTER OF ESENTIALI'VA in Opportunist, he maintained office for many years by an unprecedented employment of the principle devide et impera Usually resting on the Slavs, and clericals, he was accused by the German Liberals or thing Austria; but he unted a deep devotion to the emperor with a singular grif for managing men and at least prolonged the life of an impossible system.

By the death of his elder brother Charles (1823–1873), a colonel in the Austrian army, Taaffe succeeded to the Austrian and Irish titles. He married in 1862 Countess Irma Tsaky, by whom he

left four daughters and one son, Henry

See Wurzbach, Biographisches Lexicon Oesterreichs Memoirs of the Family of Taaffe (Vienna, 1856), privately printed, and Taaffe's Political Correspondence issued after his death.

TAAL, a municipality (with administrative centre and 48 barrios or districts), of the province of Batangas, Luzon, Philippine Islands, on the Pansipit river, opposite Lemery, with which it is connected by a bridge. It is about 50 ml. south of Manila and near to Lake Taal Pop. [1948) 56,044

and near to Lake Taal. Pop. (1948) 25,044
On an island in the lake of Taal is a volcano which has erupted
many times, notably in Jan. 1911. The consequently fertile surrounding lands produce palay (the), maize (corn), sugar and
other crops. The manufacture of baskets, mats, hainess, shoes,
shippers, embroddery and bolos is extensive, while horse and catthe breeding and fishing are also carried on. Tagalog is the vernacular

Of the inhabitants aged 6 to 19 inclusive, 37.5% attended school in 1939, while 54.9% of the population 10 years old and over was literate. (C. S. L.)

TABACO, a municipality and port of entry of the province of Albay, Luzon, Philippine Islands, on Tabaco bay, a protected herbour about so mi N. of Albay (Legsaph), the provincial capital, with which it is connected by the railway. Population (1948) 32 2000.

The chief agricultural produce is abacá (Manila hemp). Cloth, baskets and mats are woven by the women. Tabaco is a port of entry in Albay province and has considerable trade. Bikol is the vernacular. Of the inhabitants aged 6 to 19, 30 1% attended school in 1939, while \$5.7% of the population 10 years old and over was literate. (C. S. L.)

TABARÎ [Abû Jafar Mahommed ibn Jarir ut-Tabarī] (838-923), Arabian historian and theologian, was born at Amol Tabarastan and studied at Rei (Rai), Baghdad, and in Syrna and Egypt. Cast upon his own resources after his father's death, he was appointed tutor to the son of the vizier 'Ubaidailân ibn Yahyā. He journeyed to Egypt, but soon returned to Baghdad, where he remained as a teached of tradition and law until his schools, and ended by establishing a school of his own, in which he incurred the wrath of the Hanbalites

he incurred the whath of the Ambountes.

Two of his works are very extensive The one is the Tärikh urRund usul-Middle (Thistory of the Prophets and Kings), generally
reply The is a history from the Creation to Air 197 and Boyeraphy. Thus is a history from the Creation to Air
raphy. Thus is a history from the Creation to Air
raphy. Thus is a history from the Creation to Air
raphy. Thus is the Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air
raphy Thus the Creation to Air vol. (with extra index volume) at Cano, 1902-1903.

TABASCO, a state of southeast Mexico. Area 9.780 sq mi. Pop (1950) 351,106 The surface is generally low and flat. laigely covered with lagoons, watercourses and swamps. In the south and southeast there is an area belonging to the rough higher formation of Chiapas Dense forests cover the whole region, and there are valuable fine woods and dyewoods There are several large largons on the coast, two of which are called Santa Ana and Tupico bays. Two large rivers, the Grijalva and Usumacinta. traverse its territory. The Gijialva, also called Tabasco, the upper course of which is known as the Chiapas, is navigable for 93 miles. The Usumacinta forms the boundary between Guatemala and Chiadas until the frontier of Tabasco is reached, where its northwest course turns to the north and then northwest to a junction with Grualya-the two rivers having a common outlet. The Usumacinta. including its head streams, is about 500 mi. long, excluding them about 330 mi; for about 270 mi it is navigable and for about 180 mi it is navigable by large steamers. There are few good roads, and those rivers and the navigable channels of the Cuxcuchopa, Soledad, Cocohital, Tulas and Tortuguero are the principal practical thoroughfares in the state. The capital is Villahermosa (pop 1950, 33,588), on the Grijalva river The next most important town is Alvaro Obregón (Frontera) (pop. 1950, 8,449), a port 3 mi within the mouth of the Grialva.

TABERNACLE, the name given in the English Bible to the portable sanctuary, erected by Moses in the wilderness as the place of worship of the Hebrew tribes (Exod xxv sqq) It stood within a rectangular court, measuring 100 cubits by 50, say 150 feet by 75, which formed the centre of the camp in the wilderness Of the two equal squares into which the court may be divided, the more easterly was that in which the worshippers assembled. In the centre of this square stood the altar of burntoffering, a hollow chest of acacia wood overlaid with bronze In the western square stood the tabernacle itself. The essential part of the structure was that termed in the original the mishkan, ie, dwelling. It was formed of ten curtains, in two sets of five, of the finest linen with inwoven coloured figures of cherubim spread over a series of open frames of acacia wood overlaid with gold. each 10 cubits in height by 12 in breadth These frames, 48 in all, were so arranged as to form the southern, western and northern sides of a rectangular structure, 30 cubits in length and 10 in breadth and height, whose eastern end, forming the entrance, was closed by a special portière suspended from five pillars. The dwelling was divided into two parts by a second hanging, the "veil," 10 cubits from the western end. These two parts were termed respectively the holy place, and the most holy place or "holy of holies" Within the latter stood the ark of God, in which were deposited the two stone tables of the decalogue or "testimony" On the ark lay a solid slab of the finest gold, the propitiatory or mercy-seat, from which rose the figures of two golden cherubim, forming the innermost shrine of the wilderness sanctuary, the earthly throne of the God of heaven.

The furniture of the holy place consisted of the table of shewbread, the altar of incense—both, like the ark, of acacia wood overlaid with gold—and the golden "candlestick," or sevenbranched lamp-stand As a protection the delicate and artistic curtains of the dwelling were covered by two similar sets of goats'-hair curtains; these, in their turn, were protected by a double covering, the one of rams' skins dyed red, the other made of the skins of a Red Sea mammal, probably the dugong (Exod, xxvi. 14).

The aim of the "priestly" writers, to whom we owe this concep-

death. A Shāū'ite in law, he claimed the right to cuticize all tron of the tabernacle, was to provide a sanctuary and a ritual worthy of the higher conceptions of the Deity, which had grown up as the fruit of the discipline of the exile The thought of the almost unapproachable holiness of the Deity underlies not only the gradation of the parts of the tabernacle-court, holy place and holy of holies, each marked by an ascending degree of sanctity-but also the careful gradation of the materials employed in its construction. The whole is to be regarded as the expression of a religious ideal Building on the traditions of the simple Mosaic "tent of meeting," the priestly idealists followed the example of Ezekiel, and elaborated a sanctuary to serve as the model for the worship of the theocratic community of the future "Let them make me a sanctuary, that I may dwell among them" (Exod.

BIBLIOGRAPHY -See "Tabernacle" by Kennedy in Hastings' DB, BIBLIOGRAPHY—See "Tabernacte" by Kennedy in Hassings DB, with which may be compared the corresponding articles in the Ency. Bib by Benzinger, and in the Jewish Encycl. by Konig, also the commentaries on Exodus

In architecture, the term loosely expresses a niche for a statue, with a canopy (q v) over it, especially in the mediaeval styles When niches are arranged in vertical rows, with the canopy over one statue acting as the pedestal for the one above, the whole composition is often termed tabernacle work. The same term is also used for any richly decorated tabernacle or canopy-like forms, whether true tabernacles or not

TABERNACLES, FEAST OF. A famous Jewish festival which commences on 15 Tishri (five days after the Day of Atonement), and lasts seven days. Of these the first two (Tishri 15 and 16) are full festival days, the last five (Tishri 17-21) half-holidays. The "eighth day" Festival (Shemmi Aisereth), which like other festival days is doubled (Tishri 22 and 23, the second day in this case is called Simchath Torah), closes the celebration The whole nine days bear one descriptive designation, "season of our rejoicing" The festival is one of venerable antiquity. Its observance is commanded in the Mosaic Law (Lev. xxiii. 34), and its purpose is there explained as to commemorate the way in which the Israelites dwelt in booths (sukkoth) in the wilderness

Every Jew who owns a court or garden is required to erect a booth or something more or less equivalent, and to dwell in itor at least have meals in it-while the feast lasts. In order that the character of the original booth may as far as possible be retained, the modern counterpart is very lightly constructed. It "must not be covered with fixed boards and beams or with canvas. but with detached branches of trees, plants, flowers and leaves, in such a manner that the covering is not quite impenetrable to wind and rain or starlight" (Friedlander). The booths are required to be made during the days that intervene between the Day of Atonement and the Feast itself, they are adorned with garlands, flowers, and the like; often the text "Ye shall dwell in booths seven days" (Lev xxii 42), is displayed in a prominent place within the booth. On the eve of the Feast the members of the household attend Synagogue, and on returning assemble in their booth and partake of a meal. On this evening (the first of the Feast) the meal (as in the case of the weekly Sabbath on Friday evening) is preceded by Oiddush or the solemn sanctification, first over a cup of wine which is then handed round, all drinking of it, and then over two wheaten loaves, specially baked and placed on the table covered with a cloth; these the head of the family then proceeds to cut into pieces, which are distributed to and eaten by all present. A special blessing-which is repeated before every meal during the seven days-follows ("Blessed art Thou, O Loid . . . Who hast commanded us to dwell in a booth"). At the conclusion of the meal, and on leaving the booth the following prayer is said by the head of the household:

May it please Thee, O Lord my God, and God of my fathers, that in like manner as I have this time obeyed Thy command and have been sitting in the booth, so in the coming year I may be counted worthy to sit in the booth of Leviathan.

It should be observed that the Leviathan plays a prominent part in haggadic legend, especially in connection with the Messianic time. The monster is to be killed and the flesh is to furnish food for the righteous (at the Messianic banquet). From the hide tents will be made by God for the prous of the first rank

This last feature will explain the allusion in the text of the prayer On the occasion of the ceremony, the Synagogue is decorated with plants and fruits and certain ceremonies are caused out, viz. palm-branch processions culminating on the seventh day at the Musef or additional service. For further details see Oestelley and G. H. Box, Religion and Worship of the Synagogue (2nd ed. TOTT) (GHB)

TABLE (Lat tabida), in furniture, a flat, oblong slab supported upon legs or pillars. Of the many kinds of tables according to their uses, the following are outstanding as pieces of furniture and in artistic possibilities. (1) artist's table, (2) billiard table (qv), (3) breakfast table, (4) card table. (5) china table. (6)

console table, (7) dining table, (8) dressing table, (9) library table, (10) side table, (11) sofa table, (12) tea table, (13) wine table, (14) work table, (15) writing table The table was known. in a small and rudimentary form to the Egyptians, who used wood for its construction, the Assyrians certainly employed metal and possibly other materials in its manufacture Grecian tables were also often of metal, with three or four legs and of consid- of ART OF THE METROPOLITAN MUSEUM



erable variety of form, they were ENGLISH CHIPPENDALE small and low. By Roman times TABLE WITH TILT TOP, 1760-1770 the table had apparently become somewhat more common The favourite form was the tripod, but one and four legs were also used (See Pirte I, Bronze and Brass Ornamental Work ) Already the shape varied considerably, and in addition to wood, there were tables of marble, 19019, bronze and the pregious metals. The more costly examples were carved, inlaid or otherwise ornamented. cedar and the finely marked or grained woods generally were much sought after As in Greece the tables were low, they were intended for reclining, rather than sitting; their legs were those of wild beasts, or were formed of sphinxes, termini and other figures. Some of those which remain are of extreme grace and most delicate workmanship; to them the Empire style is enormously indebted In antiquity tables of any kind can only have been the appanage of the rich In the early middle ages, although there was variety of form-the circular, semi-circular, oval and oblong were all in use-tables appear, save in rare instances, to have been portable and supported upon trestles fixed or folding, which were cleared out of the way at the end of a meal. The custom of serving dinner at several small tables, which is often supposed to be a very modern refinement, was certainly followed in the French châteaux, and probably also in the English castles, as early as the 13th century. For persons of high degree, fixed tables were reserved. Even at a period when domestic furniture was of a very primitive character and few modern conveniences had been evolved, costly tables were by no means unknown-some dim traditions of Rome's refinements must necessarily have filtered through the centuries. Thus Charlemagne possessed three tables of silver and one of gold-no doubt they were of wood covered with plates of the precious metals Before the 16th century the number of tables properly so called was small; hence very few of earlier date than the middle of that century have come down to us In the chapter-house of Salisbury cathedral is a restored 13th century example which stands practically alone. In point of age it is most nearly approached by the famous pair of trestle tables in the great hall at Penshurst.

When the table became a fixed and permanent piece of furniture the word "board," which had long connoted it, fell into disuse save in an allusive sense, and its place was taken by such phrases as "joyned table" and "framed table"-that is, jointed or framed together by a joiner; sometimes people spoke of a "standing" or "dormant" table. They were most frequently oblong, some 2 ft. or a ft. 6 in. wide, and the guests sat with their backs to the wall, the other side of the table being left free for service. Sometimes

they were used as side-tables, or furnished with a cupboard beneath the board, they were supported on quadrangular legs or massive ends and feet, full of Gothic feeling, and were several inches higher than the dining-table of the 20th century Heavy stretchers or foot-rails were fixed close to the floor-for the avoidance, no doubt, of draughts. Oak was the usual material, but elm, cherry and other woods were sometimes used Soon the legs became bulbous, and were godrooned or otherwise ornamented, and the frame began to be carved The introduction. before the 16th century closed, of the "drawing table" marked the rapidity with which this piece of funiture was developed. This was the forerunner of the "extending dining table". Of the three leaves of which these tables were composed two were below the other; they diew out and were supported by brackets, while the slab proper dropped to the same level. Somewhat later legs became excessively bulbous; this ugly form gave place soon after the middle of the 17th century to baluster-shaped legs. Hitherto tables had, generally speaking, been large and massive-little in the nature of what is now called the "occasional table" seems to have been provided until some years after the Restoration About that time small tables of varying sizes and shapes, but still of substantial weight, began to be made, many of them were flaptables, which took up little room when they were not in use These, however, had been known at an earlier date. Charles II had not long been on the throne when the idea of the flap-table was amplified in a peculiarly graceful fashion. Two flaps were provided instead of one, the result being the rather large oval table of the "gate-leg" variety that has remained in use ever since. n which the open "gate" supports the flap (See Interior Decoration; English Furniture, Plate IX) Towards the end of the reign tables began to have the graceful twisted legs joined to the flat serpentine stretchers, which produced, almost for the first time in English furniture, a sense of lightness and garety. The walnut tables of the end of the Stuart period were often inlaid with marquetry of great excellence The number and variety of the tables in well-to-do households were now increasing rapidly, and the console-table was imported from the Continent contemporaneously with the common use of the mahogany side-table

As mahogany came into general use, about the beginning of the second quarter of the 18th century, an enormous number of cardtables were made with plain or cabriole legs and spade or claw and ball feet, often with hons' heads carved upon the knees, the top folded up to half its size when open The Chuppendale school introduced small tables with carved openwork "galleries" round the edges (to protect china and other small objects), and clustered legs: Gothic forms and Chinese frets were for a time fashionable Later in this century, so prohic in new forms of furniture, tables were frequently made of rosewood and satinwood, side-tables, often highly elaborate, adorned with swags and festoons and other classical motives, supported by termini or richly carved legs, were gilded and topped with marble slabs or inlaid wood. (See INTERIOR DECORATION; English Furniture, Plate XI) The Pembroke table, of oblong form, with two semi-circular or oblong leaves, with edgings of marquetry, was a characteristic feature of late 18th century English furniture, and still retains its popularity. During the Empire period the taper was replaced by the round leg, rosewood grew commoner, and brass mountings became the rule (For further illustrations see Interior Decoration: European; Early American; Modern; also, Modern Tendencies IN APPLIED ART.)

TABLE MOUNTAIN (Dutch Tafelberg), a name frequently given in South Africa to flat-topped hills and mountains, which are a characteristic feature of the scenery Occasionally such hills are called plat, ie, flat, bergen. Specifically Table Mountain is the mountain, which rises from the shores of Table bay, Cape Town lying at its seaward base and on its lower slopes. The mountain forms the northern end of a range of hills which terminates southward in the Cape of Good Hope. It is formed of gently inclined sandstones and quartzites of the Table Mountain Sandstone series, resting unconformably on granites, which are intruded into shales of the Malmesbury Series. The sandstones descend toward sea-level on the shores of False bay.



BY COURTESY OF (1, 3, 5 3) THE METROPOLITAN MUSEUM OF ART, HEN YORK, (2) THE SPANIER ART GALLERY, LONDON, (4) THE HISPANIC SOCIETY OF AMERICA, (5) THE DIRECTOR OF THE VICTORIA AND ALBERT MUSTUM, (16) THE RESPER OF THE WALLACE COLLECTION, (11) ARRESTED CLARKE, LTD

## TYPES OF TABLES

- 1. Table of Egyptins wood, XVII.—XVIII. Dynatly, Drah abv!
  2 Writing table of carred wood, English, lata Iciti century
  3. Gata-leg table, American woods, 1576-27000
  4 Sananh table, 1710 century
  5 Corred Haltan table of the 15th century
  11. Table in the order and table, 15th century
  12. Table in the modern most of glit bronze
  12. Table in the modern most of glit bronze

arrived from Cairo).

but are too high to be accessible as building stone for Cape Town. The northern face of the mountain, overlooking Table bay, extends like a great wall some two miles in length, and rises precipitously to a height of over 3,500 feet. The face is scored with ravines, a particularly deep cleft, known as The Gorge, affording the shortest means of access to the summit East and west of the mountain and a little in advance of it are lesser hills. the Devil's Pcak (3,300 ft ) being to the east and Lion's Head (2.100 ft ) to the west Lion's Head ends seaward in Signal hill (1.100 ft ). The western side of Table Mountain faces the Atlantic. and forms an escarpment, with a broken sky line, known as The Twelve Apostles: to the south Hout's Bay Nek connects it with the remainder of the range, on the east the mountain overlooks the Cape Flats. On this side its slopes are less steen, and at its foot are Rondebosch, Newlands, Wynberg, and other residential suburbs of Cape Town. The ascent of the mountain from Wynberg by Hout's Bay Nek is practicable for horses.

The south-east winds which sweep over Table Mountain frequently cause the phenomenon known as "The Table-cloth." The summit of the mountain is then covered by a whitish-grey cloud, which is being constantly forced down the northern face towards Cape Town, but never reaches the lower slopes. The clouds (not always caused by the south-easter) form suddenly, and the weather on the mountain is changeable. Rainfall on the summit is heavy, 72 14 in a year being a 13-year average. This compares with an average of 54 6 in at Bishop's Court, Newlands, at the foot of the mountain on the east, and with 24 3 in. at Cape Town (q.v.) at the northern foot of the mountain.

TABLES, MATHEMATICAL: See MATHEMATICAL

TABLE TENNIS, an extremely fast indoor athletic game, which, like lawn tennis, apparently descended from real or royal (indoor) tennis about 1880. It was known also under various trademarked names ("Gossima," "Ping-Pong," etc.) until 1926, when its name was adopted by the International Table Tennis federation of 20 national associations, which conducts world championship matches for individuals and men's and women's teams under modernized rules. The game is played by striking a pale, hollow celluloid ball (41-41 in circumference, 37-39 gr weight, or 37-49 gr. in USA) with a racket over a net (6 in high, 6 ft long) fixed across a dark, nonreflecting table top (9 by 5 ft, 30 in high) Modern tackets are of wood, faced on both sides with stippled rubber to control the ball and impart spin in chop and drive strokes, Server's racket hits the ball behind his end of table so it bounces over the net, first on his side of the table, then on his opponent's side; ball is then struck to and fro directly over net after bouncing (volleying is illegal) until a point is scored by failure to make a good return. Service alternates after every 5 points and winner is he who first scores 21 points; but at score 20-all service alternates after each point and winner must score two points more than his opponent. In doubles. partners alternate in hitting the ball. One close law in the U.S. prevents strictly defensive play to encourage hard hitting and deep defense 20-25 ft. from table; another prohibits server's imparting spin to ball except by means of his racket. (See Laws of Table Tennis and Table Tennis Topics, U.S. Table
Tennis association monthly). (C. Z.) Tennis association monthly).

TABLINUM, in archifecture, one of the most important rooms of a Roman house, usually of large size, opening off the atrium  $(q, \alpha)$ , in the centre of the side opposite the entrance. At its rear there was frequently a large window looking out on the peristyle  $(q, \alpha)$ , or colonaded inner court. It was frequently decorated with basts or pictures of the family ancestors, and took the place of the modern, formal drawing rooms after the properties of the family ancestors, and took the place of the modern, formal drawing rooms after the properties of the family ancestors, and

TABOR, a small town in Bohemia, on the Lufinice, occupied by Germany in 1939, is mainly of historical importance since it was founded in 1420 by the more advanced Husstes, who came to be known as Taborites. Standing on the summit of an isolated hill, separated from the surrounding country by the Lufaice and protected by marshes, the market place in the centre of the town is approached by very narrow streets to

render the apposeds difficult in time of war. In this market places stands a salute of Zikka, one of the most famous Husste leaders. Here also are the early 6th century diaconal church and the town hall with its museum of Husste memorials. The district around Tabor is not particularly fertile, producing mainly the hardier cereals and notations. Por (iros) 14.251.

cereals and potatoes. Pop. (1932) 14, 251.

TABORA, a town of Tanganyaka Territory, Africa, in the Unyamwear country (known officially as the Tabora district). Pop. (1936) 6,565, including 16-Europeans and 1,540 Assattes It is the headquaters of Westen province. Tabora is on the railway (completed in 1914) from Dar-es-Salaam to Kigoma, on Lake Tanganyaka, being 530 ml from the occas and 212 ml from the lake port. Another railway, 23 ml long, links Tabora to Mawaga, on Lake Victoria. Tabora has severed line government offices, churches, hospitals and schools. There are large railway workshops and an aerodrome (first used in 1920, when aeroplanes

The modern town was founded by Zanzibari Arabs, about 1820. His central position and good water supply made it an important trading centre and a place of strategic importance. The Germans bull a strong for there During World War I it was captured by the Belgan Congo troops (Sept 1916), and later passed to the British, (See UNYAMEWEZ and TANGANYIKA TREBUTORY,)

TABRIZ, chief city of the province of Azerbaijan and second largest city of Iran, lies in the valley of the An Chai (the Bitter river, which flows into Lake Urmia) at an elevation of 4,400 ft., in 38° 4' N , 46° 18' E., and 400 mi N.W. of Tehran. Overlooking the valley on the south rises the volcanic cone of Sahand (12,000 ft ). There are two runed monuments: the famous Blue Mosque (1468) with its mosaic faience, and the colossal mass of the Mosque of 'Alı Shah, locally known as the Ark or Citadel, which looms over the city like a dun-colored cliff. The marblepaved court was 937 ft. by 350 ft. and included a pool 150 ft square in the centre The vaulted sanctuary was 215 ft deep by oo ft. 10 in wide, the widest vault ever built. The building was faced in polychrome mosaic faience, the internal walls of polychrome stucco. Both were enriched by gold inlaid marble and alabaster and further ornamented by coloured marbles and silver inlaid bronzes. The walls were 26 ft. thick and the minarets probably nearly 200 ft, high. For the rest, the city consists of yellowish-gray, uniform houses intersected by a labyrinth of narrow lanes. Recently the main streets have been widened On the outskirts are beautiful gardens and the modern country houses of the wealthy. The maximum summer temperature is 100°

August, minimum in watter —15°; minfall about 9 in.
Tabriz was for a long period the great emporium of European
trade with Persia, situated as it was on the main route from
Trebizond and Erzerum, but since the opening of the Suez Canal
it has lost much of its activity. Much commerce has been diverted
by way of Bapthad. It is nevertheless a principal trade centre
and point of local distribution and collection for N.W. Iran. The
railway from Tabriz to Julia (So mil.), built by the Russians in
1916 and transferred to Persia in 1921, connects with the Caurailway from Tabriz to Julia (So mil.), built by the Russians in
1916 and transferred to Persia in 1921, connects with the Cautarily and the sedquenters of an important in grinder of the
There is a baanch of the Impe. ial Bank of Persia, a telephone
service, and the town is lighted by electricity. There is also a large
modern grain storage elevator, leather, spinning and match factories. The chief imports were textiles, sugar and tea.

Tabitz (Tauria) was probably an old city when it became the capital of Tridtes III, king of Amenia, in An. 297. In 88, in the reign of the tenth Abbasid Calipb, it was almost destroyed yearthquake, and again in roat. In 1392. Thuru took and sacked the city and, later, it fell under the sway of certain Turkana princes, from whom, in 1500, Ismali, first of the Safavis, took it; but it remained under Persia only till 1522 and then fell intermittently under Turkish tule. In 1678 Shah Abbas I won it back to Persia. In 1721 the town was again in great part destroyed yearthquake and again passed, after a sangulnary struggle, under the Turks who held it until 1730, when it was retaken by Nadir Shah.

In 1908, the revolution against the shah started at Tabriz and

the arrival of Russian troops in 1909-nominally to save Russian subjects from famine-marked the commencement of a Russian occupation of this as well as other Persian towns Tabriz became involved in World War I owing to Turko-Russian conflicts and was occupied by the Russians in 1915 and again by the Turks for

as short period in 1918 Population (census of 1940) 213,544.

Bixilooraphy — G N Curzon, Perso and the Person Question (1802). A V Williams Jackson, Person Pass and Present (1905). A C Waitslaw, "Turbulent Tabra," Blackwood, Mag. Jan 1923, see also Draids A U Pope (ed.) Survey of Persian Art, vol u, pp 1056-61; vol 1v, pls 377, 378, 379 and 452-457

(P Z C: X) TABU. Tabu, one of the few savage words that have struck

root in the English language, is of Polynesian origin and has dialectical forms (tapu, kapu, tambu) in Polynesia and Melanesia; but the form tabu (or taboo) is the one which has become popularized, because it was as tabu that Capt. Cook first discovered the notion and its associated customs at Tonga in 1771.

### I. MEANING OF TABU

Literally an adjective, meaning "marked off" (perhaps from the Polynesian ta-mark, pu-exceedingly), tabu implies that certain persons or things are unsafe for casual contact or use in ordinary life, "not to be lightly approached" (Codrington, The Melanesians, p. 188) because of supernatural penalties which would thereby be incurred There is always some occult, magicoreligious significance present Another Polynesian word, mana (q.v.), expresses conveniently its positive aspect. Mana implies the mysteriously-efficient, transferable force recognized in all remarkable, impressive, wonder-working things as well as in striking human personalities "Negatively, the supernatural is tabu, not to be lightly approached because (positively) it is many instinct with a power above the ordinary." Thus, for the Ilaspeaking peoples of northern Rhodesia, we are told, vaguelydefined forces pervade all things, neutral in themselves, but available for those who have "the secret of manipulation." forces, however, "are dangerous things to interfere with They are tonda (tabu) For an ordinary person, under ordinary circumstances, to interfere with them is forbidden; it is dangerous to himself and the community. By saying certain things, doing certain actions and eating certain foods, he may liberate these energies with fatal results to himself and his neighbours. Persons in certain conditions and things put to certain uses, come into intimate contact with these forces and are therefore tonda." (Smith and Dale, Ila-speaking Peoples of N. Rhodesia, ii. 83.)

Tabu may be either (1) inherent or (2) imposed.

(1) Inherent, Tabu .- Some things or conditions are intrinsically tabu, and infringement of their character brings its own penalty without external aid. Such inherent tabus are those associated permanently with women, the sick, the dead, strangers or temporarily with women in childbirth or warriors on campaign. Here inherent energy is discharged on all who break the tabu-

(2.) Imposed Tabu.—A common thing may become tabu through the action of a god, priest, king or chief, and the sanction of the restriction is his own power for avenging its violation. Thus, when Cook wanted to set up an observatory in the Sandwich islands, the priests tabued the place for him by setting up wands. Persons and things, places and times could be tabued. The power of imposing a tabu was a characteristically Polynesian prerogative, bound up with the theocratic powers of a prince or noble, which probably attained the highest development in New Zealand. The noble or chief, partaking of the divine essence of which he was the incarnation, was able to communicate his contagious holiness so that the objects in question could not be appropriated by anyone but a superior in rank. He might stop traffic on a river or cause great inconvenience to his people by tabuing a forest. This was generally done by putting up a pole with a bunch of rags or leaves or by erecting some corresponding noticeboard. On the other hand, just as the priest or chief could impose the tabu, he could also remove it. Thus, at Hawaii in 1819, King Rihoriho at one stroke abrogated the laws of tabu, though only to make way for le tabu, the British Sunday.

However, these two aspects of tabu are considerably involved,

for religion makes common cause with law and government, resulting in a theogratic system of controls, spiritual injunction backed by temporal power

(3) Derivative Tabus .-- A third class of tabus arises from the contagiousness of tabu It is transmitted by contact and the person or thing thus tabued becomes a new source of infection Sometimes the infection may be removed by ritual means, such as an ablution. Sometimes it is too deeply ingrained to be removed To discriminate between "things tabu," the primary sources of such contagion and "things tabued," in which tabu infection is derivative, is not always easy, since tabus as primarily matters of custom form part of the social inheritance. Thus, the clothing and discarded food of the king derive the tabu quality from his person. Further, not only what he touches, but what he sees also becomes tabu

The Ambivalence of Tabu.—Of extreme importance in the study of tabu is its ambivalent character. Either that which is tabu is holy and to be feared as the seat of mystic, supernatural power, and therefore to be avoided lest harm befall from contact with it, or lest it be defiled by human touch and its divine essence be affected, or the object is unclean and therefore tabu lest it infect man with its own evil nature. Thus from this single root sprang not only uncleanness but also holiness

# II MAJOR TABUS

(a) Tabus on Priests, Kings, Chiefs, etc.-Sir James Frazer has collected in the Golden Bough evidence of the tabus with which the semi-divine potentates, chiefs and priest-kings of primitive communities are surrounded. Thus, at Shark Point, West Africa, the king lives alone in a wood. He may never leave his house, he may not touch a woman, on no account may he quit his royal chair, even to sleep, for in that case the wind would die down and all navigation would stop. The supreme ruler at Congo is regarded as a god on earth. No subject may taste of any crop until the first-fruits have been offered to his majesty When he leaves his residence, to visit other parts of his territory, all married persons are under obligation to observe the strictest laws of continence, any violation of which would prove immediately fatal to him. Were he to die a natural death, the world would be annihilated "Among the Todas of southern India, the holy milkman who acts as priest of the sacred dairy, is subject to a variety of burdensome restrictions during the whole time of his incumbency, which may last many years. Thus, he must live at the sacred dairy and may never visit his home or any ordinary village; he must be celibate; if he is married, he must leave his wife. On no account may an ordinary person touch the holy milkman or the holy dairy, such a touch would so defile his holiness that he would forfeit his office. . . . Further, the holy milkman never cuts his hair or pares his nails so long as he holds office, he never crosses a river by a bridge, but wades through a ford and only certain fords."

The sacred person must be guarded from haim without, but others must be protected also from hurt from him as a centre of contagion. Thus in a higher civilization, should anyone wear the mikado's clothes without his knowledge, he would have swellings all over his body. The touch of the king may remove the tabu caused by his own contagion. The Tongans were subject to a form of scrofula, which they often attributed to having inadvertently touched the chief or his belongings, and the touch or pressure of the chief's foot was sought as a cure for the malady The sick man "sat down before the chief, and taking the chief's foot pressed it against his own stomach, that the food in his belly might not injure him, and that he might not swell up and die." It is possible that scrofula may have obtained its name of "king's evil" in 17th century England from the belief that it was caused, as well as cured, by contact with the majesty of kings.

In short, "the chief has mana, and is therefore feared. Men do not dread contact with the king lest they become kingly, but lest they be blasted by the superman's supermanliness.

(b) Tabus on Women,-In the "classic, well nigh universal" major tabu of the "woman shunned," the ambivalent nature of the emotion underlying tabu is especially seen. Full of mystery, especially at certain periods of het life, she is now worshipped as a goddess, now dieaded as a witch The power to bring forth children indicates the possession of mana hence the almost universal avoidance of the pregnant woman of the aborigines of the Amazon, it was ance of the pregnant woman Ut the aborigance of the Amazon, it was said "They believe that I a woman during her penganny cats of the ment, any other animal partaking of it will suffer, if a domestic animal partaking of it, will die, if a do, it will be to the future major than being, it will die, if a do, it will be to the future major than the sum of pain for the future. In Pin, a pregnant wife may not wait inpon he husband Among the Australian aborigances, women as escluded at childhirth and menstrutanion and all vessels used by them during at childbuth and menstruation and all vessels used by them curring his seclision are burned. Their very glance is poston and in some places girls, when table, are made to west broad-hummend that lest may result in "sure death" hough right, as in the case of the Aus-tanian black fellow who, when he discovered that his wife had lain on habhack during het fabled period, wholly accumbed to terror and

died within a fortnight

(c) Tabus Between Relations.—The Kirghiz woman does not look upon the face of her husband's father or elder kinsman and must never utter their names, even if they contain names of common must hever futer taret names, even it ney contain names of common objects but must use paraphirases, and, in describing a wolf carrying off a lamb through the rushes, would say "Look yonder, the howling one is carrying off the bleating one's young through the unstitude on the other side of the glytening one". There is no suggestion of hostility between the talued relatives, the stites bong entirely upon

the mutual respect shown

This avoidance between relatives of opposite seves has been closely This avoidance occurrent relatives of opposite seves has been cooseny associated with the general tabu on women. No doubt a mutual shyness between the sexes underlies these avoidances which are strongly reinforced by an admixture of the fears involved in the woman-tabu, But the tabu applies to both sexes. Woman is not avoided as woman other sentiments, especially the horror of incest, are involved

(d) **Tabu on Strangers.**—The almost universal tabu on strangers is evidence of the fear of the unknown "To guard against the baneis evidence of the feat of the unknown. "To guard against the bare-ful influence cented voluntaily or involuntarily by strangers," says Frazer, "is an elementary dictate of savage paudence," but they may be admitted after a purificatory cemony, to nearly all tabus may be neutralized by some ceremonal device Westermarck has shown how both the tabur on strangers and the widely-spread practice of hospitality can ultimately be traced to the same root The stranger is dangerous, it is therefore necessary to secure his good will at once is dangerous, it is therefore necessary to secure his good will at once for the blessing of the stranger within the gates has exceptional power, his blessing is sought as urgently as his curse is feared (e) "Sympathetic" Tabus.—Much of the attention of the sav-age is directed to the food he eats. The belief that the qualities of the

eaten pass into the eater, is an explanation of the food tabus and prejudices of savage peoples. Thus the hunter will not eat the heart of the deer he has killed lest he become timed like that animal, while of the deer he has killed lest he become time like that animal, while to eat the heart of a lon would be to gain all the fierce courage of that beast Such examples, however, do not warrant the definition of tabu as "negative mage," failing to cover the characteristics of many well-known fabus "Sympathetic tabus" many of them cermany well-known tabus "Sympathetic tabus" many of them cer-tanly are up to a point, as are also the tabus on knots at childburth, which must be observed lest delivery be impeded But if tabu were a form of mage, the penalty for its infraction would be definite and measurable, whereas the distinguishing characteristic of tabu every-where is the "infinite plate of awithness" always accompanying its viowhere is the "minute plus of awfulness" always accompanying its vio-alaton There may be certain definite results, such as preservined pun-public opinion, to which the savage is at least as keenly sensitive as covinced man. But the "minute plus," always attached to the viola-tion of tabu puts it into the realm of mystical, immeasurable dread The threat is the more dree, because left to the imagnation. "Do not meddle, or, if you do . . .

# III. TABU AS A FACTOR IN MORAL TRAINING

While excessive development of tabus m any given society forms insuperable barrier to progress, the code of tabu has an obvious Willie excessive development of noise in any given some or an insuperable barrier to progress, the code of table has an obvious ethical value. It helps men to realize that they are under obligation to the community of which they are a part. Young people begin to learn this lesson of social life at the very beginning of puberty and morporation into the life of the tribe. The tabus and probabilions with which they are surrounded, touch every phase of social, family and individual life from childbirth to burial.

Some have held that tabu is the origin of all ethics and morality. It is true that tabu has legalized and strengthened morally; and, when tabus come to be regarded as the will of the gods, a rational element so introduced and the fear element, which now contains wonder and humility, is ready for transmutation into the loving reverence of the higher religions.

Inger raigions.— General J. G. Fraeze, Golden Bough its vols.
2014-15, engenuly vol. ill. Thône on die Perül is of the Soul; for his general theory, see vol. i, The Magic Art, i, iii, if; also titel, shorded ed. (1923); W. Robeston Smith, Religion of the Soulist's burded of the Soulist of the Soulist of the Soulist of the history of the Soulist of the Soulist of the Soulist of the (1926); B. Durkhelm, Elementary Forms of the Religions Life (Eng. Trans. 1926). Il Special Aspects (o) Woman and Sec Tabus—E.

Westermatch, Morrage Ceremonies in Morocco (1914); M M Knight, I L Peters and P Blanchard, Teboo and Genetics (1921); B C Cawley, The Myster Row (2017); R L Royal (1921); III For a psychological study of Tubu E S Ames, The Fsychology of Religious Experience (1921); R E Marett, The Threshold of Religion (1921); L Levy-Bruhl, How Natures Think (Eng train of Let French Remisley, 1920). J Murphy, Primitive Morn 181 Eco. 182 (1921). (S R B)

TABULARIUM, the technical name of the second office or national archives building of ancient Rome, which dominates the west end of the Forum It is built along the side of the Capitoline hill and was boildered, on the side toward the Forum, by two stories of long arcades, the lower decorated with engaged Doric columns, and the upper with engaged Ionic columns Each bay of the arcade is covered by a square, cloistered or four-sided vault. The tabularium is ascribed to Ountus Lutatius Catulus (c 78 BC). It thus offers one of the earliest Roman examples of the use of engaged columns in connection with an arcade

TABULATING MACHINES are mechanisms controlled by perforated cards which are used as mechanical aids to business methods. The first modern device of this class was designed for the automatic tallying or tabulation of statistics; but with extensive development modern tabulating machines are capable of automatically figuring and printing a report based on the information given to it in the form of perforations in cards or tape Soon after the introduction of the Jacquard loom, in which the hooks lifting the warp threads were controlled by cards perforated to the desired pattern. Charles Babbage applied the principle to a calculating mechanism. Between 1834-54 he designed and partly built an "analytic engine" in which both the amount to be operated upon and the nature of the operation were entered by perforated cards

His machine was never completed. Development of the modern tabulating machine was accomplished by H Hollenth Hollerith's first contribution was a means of tallying census ieturns

Hollerith's first contribution was a means of tallying census letturns in though electrical reading of the data punched on cards and accumulating the totals in separate registers. The system was successfully used in the US, census of 1890. During the next decade notable improvements were made including automatic feeding of the cards under provements were made including automatic leading of the cards ranged provided for reading and a mandine for sorting the cards rapidly into results for reading and a made of the reading the cards rapidly into maked particulally outstanding ovidence of the possibilities of the system. The population volume was ready 1 year and 7 months from the start of enumeration, whereas it was estimated that hand tabulation of the 3 factors alone of sex, nativity and occupation would have required the services of 100 clerks for 7 years and 11 months. Since 1901 its commercial utility has been greatly increased. Whenever a transaction involves a number of amounts which are subsequently to be used as units two or more times in compiling various totals, it has been found to be generally economical to "translate" it on to a per forated card. If, for instance, the data connected with the cost of production of a certain part are recorded on a card this can then be used in computing totals of individual wages, department costs, machine costs, productive hours, etc. The tabulating method is now to found in general use throughout the world

The card upon which the data are recorded in the form of forations has a column for each number or symbol to be entered. The digits o to 9 are denoted by holes punched proportionate distances from the bettern the state of the state lagis of to g are eleuted by noise punched proportionate distances from the bottom edge of the card starting with the position. Above the o position is space for two additional perforations which are used principally for actuating certain control operations of the machine. These additional positions may also be used for special classification. aumbers, does not be to the control of the control accomplished by different machines. Three separate mechanical devices are necessary to the system: a perforating machine or punch, a sorter and a tabulator. The ordinary form of perforating machine has a set of 12 punches under which the card is advanced a column has a set of 12 punches under which the card is advanced a column at a time. By means of a skip har or stops, certain fields can be skipped where no punching is to be done. There are also more complete types of perforating machines arranged to permit automatic duplication of information already on one card on to others, to "gang" punch any predetermined number of cards with identical data, "gang" punch any predetermined number of cards with nuemical data, to number cards consecutively as they are punched. The speed with which trained operators can perforate the cards depends on the nature of the information being recorded as well as its extent. An output of 350 punched cards per hour might be considered an average perform-

Sorting the cards into the desired groups for tabulation is done at the rate of about 400 cards per minute for each digit of the class number One well-known form of sorting machine has 13 pockets, one for each possible columnat perforation and one for "rejects" The tabulator, or accounting machine, which totals the amounts perforated in given fields is capable of several different applications. The simplest form of this device consists of a set of counters actuated through a reading mechanism. Two methods of reading the caids are in use electrical and mechanical. In the former, brushes make electrual contact through the perforations thereby actuating magnets to trip the counters. The mechanical method employs a full set of pins which are brought down upon the card momentarily at rest and which penetrate the perforations to actuate the counters mechanically Pinting tabulators are arranged to either total the cards at high speeding tabulators are arranged to either total in the cards at high spectomabut 150 per minute—and then pint the total, oi list each card individually at slower speed followed by a total for the group. By means of special control features the machines automatically take totals of several fields after each sorted group and also store the amounts for grand totals. A great deal of flexibility is attainable in the way the items and totals may be made to appear on the printed sheet. Mechanism has lately been incorporated accomplishing direct subtraction without the necessity of perforating the complements of the numbers as formerly required. This permits of reports showing total credit and debit amounts and net balance. By using combinations of two or more holes in a column it is possible to list alphabetical characters as well as num-bers. With alphabetical printing, addition or subtraction automatically sensed by the machine and devices added to the printing section for handling report and bill forms, tabulating machines have become automatic accounting and billing machines (B To)
TACANAN, a small group of tribes of South American In-

dians, constituting an independent linguistic stock. The Tacanas, from whom the stock takes its name, and their related tribes, live in northwestern Bolivia, in the region just east of Cuzco, on the upper Madre de Dios river and its tributaries, and extend eastward, between 13° and 15° S. lat, as far as the Beni. They are an agricultural as well as hunting and fishing folk, of the sedentary type, showing, apparently, considerable differences in cultural development between the different tribes. In spite of their close proximity to Cuzco, no significant study of this group has ever been made

See A D'Orbigny, L'Homme Americain (Paris, 1839); N. Armentia, Navigacion del Madre de Dios (La Paz, 1887).

TACHEOMETRY, a system of rapid surveying by which the positions of points on the earth's surface-both horizontal and vertical-are determined without using a chain or tape, or a separate levelling instrument. The ordinary methods of surveying with a theodolite, chain and levelling instrument are fairly satisfactory when the ground is clear of obstructions and not too precipitous. When the ground is much covered with brush or broken by ravines, chain measurements are both slow and hable to considerable error, the levelling, too, is carried on much slower though without serious loss of accuracy. These difficulties led to the introduction of tacheometry, in which, instead of the pole formerly employed to locate a point, a staff similar to a level staff is used, having heights marked from the foot and graduated according to the form of tacheometer in use. The asimuth angle is determined as formerly. The horizontal distance is determined by two methods (1) from the vertical angle between the welldefined points on the staft and the known distance between them, or (2) fixed wires in the diaphragm of the telescope. The difference of height is computed from (1) the angle of depression or (2) elevation of a fixed point on a staff and the horizontal distance already obtained. Thus all measurements requisite to the location of a point, both vertically and horizontally with regard to the point where the tacheometer is centred, are determined by an observer at the telescope without any assistance other than that of a man to hold the staff, (See Surveying.)

TACHIENLU: see Tatsien-LU.

TACHINID FLY, the name given to any member of the family Tachinidae, of the order Diptera (q.v.). The tachinida play an extremely important part in keeping other insects under control and certain kinds have been transplanted from one country to another to help control imported and native pests. Among those imported into the United States is Compsilura concinnata for control of the gypsy moth; it attacks a large variety of na-tive caterpillars; Centeter cinerea has been introduced from Japan for control of the Japanese beetle; Microphthalma michiganensis has been introduced into New Zealand from Canada for control of white grubs; Archytas cirphis, from Mexico to Hawaii

for control of army worms; Ptychomyia remota, from Malaya to Fin for control of Levuana caterpillars in Fin Many other successful importations have been made, but the great value of tachinids is found in their attacks upon native insects. They attack chiefly, caterpillars, beetle larvae and adults, sawfies, true bugs and earwigs. Their method of reaching the host is most varied, some scatter over grass thousands of eggs, which are eaten by the host, some lay eggs on the host, often inside it: some deposit living maggots, which attach themselves to passing victims Those that lay eggs on adult beetles usually have a piercing ovipositor Some tachinids are associated with army ants, apparently attacking insects fleeing the ants. Many species fly only at dusk, a few are nocturnal, most of them are sun lovers and are found on foliage; many visit flowers and are important in their pollination The size ranges from three-eighths to three-quarters of an inch in length. While most are dull coloured, or shiny black, many are marked with red and yellow, and some are metallic green or blue Some authors recognize several families and many subfamilies but there is no good way to separate them The Dexiidae, with plumose arista, are the most frequently separated group

The classification is highly technical and many of the species difficult to separate The literature is voluminous and contained in many publications. The tachinids are one of the largest families of flies, more than 5,000 species being known from all parts

of the world, and many new ones are added each year.

BIBLIOGRAPHY —For British species see C. J. Wainwright, "The British Tachinidae," in Trans. Entomological Soc. of London (1928), for European species see P. Stein, "Die Verbreitsten Tachiniden Mittel-European species see P Stein, "Die Verbreitsten Tachimiden Mitteleuropas nach ihren Gattungen und Arten," in Archiv fur Naturge-sichta, vol 90 (1974). See also C H T Townsend, Manual of Mysology, Parts I–XII (Brazil 1934–44), tontaining keys and descriptions of Lamilies and genera of the world (C H Cx)

TACHOMETER, an instrument for measuring the speed of rotation of shafts and machine elements. Most tachometers have a rotating part which must be connected with the element whose speed is to be measured. With the hand-type this driving relation is maintained only long enough to take a reading, while with the types that are mounted on a machine the instrument is permanently connected to the rotating part and indicates the speed as long as that part is in motion. The hand-operated type usually has a stem provided with a vulcanized rubber tip of conical form which can be pressed into the centre-hole of the rotating shaft Permanently mounted tachometers are driven by belt or flexible shaft, or through a mechanical coupling

There are quite a number of different principles upon which the design of a tachometer may be based. All of the principles used in speedometers (qv) lend themselves equally well to the design of tachometers. In fact, a speedometer is a tachometer placed in driving connection with a road wheel and graduated in miles per hour instead of in revolutions per minute. Thus, there are centrifugal, magnetic diag, clockwork and magneto-type tachometers. In addition there is the principle of vibrating reeds which seems to have been used for tachometers only. It is based on the fact that in most machines having large revolving parts, such as steam turbines and electric generators, vibration of the frame is synchronous with rotation of the revolving part

The Frahm vibrating reed tachometer consists of a series of calibrated steel reeds of different lengths, having one of their ends mounted in a brass block and a short length at their other end turned at right angles and enamelled white These enamelled ends are located side by side in a rectangular opening in the case With the instrument mounted on the machine (or merely held against it by hand), and the machine in operation, one or more of the reeds will respond visibly to the vibration of the machine The speed of rotation of the shaft can be gauged to a much closer limit than the difference between the speeds indicated by adjacent vibrating reeds, usually 50 revolutions per minute. Reed tachometers are made for speeds of from 800 to 12,000 revolutions per minute. Preferably the range of any particular instrument should not exceed an octave, as if it does, and the actual speed corresponds to a reed near the lower end of the scale, both the seed located there and a reed corresponding to twice this speed will vibrate.

TACHYLYTE or TACHYLITE, in petrology the glassy variety of base ignous rock as basalt or doleret Tachylytes are black in colour, with a pitch-like or resmous listic, and in the thinnest sections are typically brown and translucent, the glass being crowded with gianules of magnetie. They are found only under conditions which imply rapid cooling, and are much less common than the corresponding said volcarie glasses, putrupally on account of the greater fluudity and greater power of crystallization which basic lawas possess. The principal mode of occurrence of tachylyte is as a chilled edge or selvage to thin dikes or sills of basalt or dolerite. This edge may be only a fraction of an inch intheness and merges inward unto crystalline basalt. Tachylytes of this nature are common among the Tertiary igneous rocks of the Western 181se of Socialnd (Skye and Muji).

Exceptionally, tachylyte constitutes almost entire lawa flows, as in the Hawaian saland. The lapid cooling of the highly find laws of this region has inhibited ciystalization, grung use to vast floods of basaltic glass containing only minor amounts of crystaline material. Lastly, tachylytes occur as scoria or bombs thrown out by basaltic volcances These are well known at Stromboli. Etna and in Iceland Tachylytes readily undergo weathering and alteration, and are converted by oxidation and hydration into palagonite, a red, brown or yellow cryptocrystal-ine material

TACITUS, CORNELIUS (c. 55-120), Roman historian, lived through the reigns of the emperors Nero, Galba, Otho, Vitelhus, Vespasian, Titus, Domitian, Nerva, and Trajan All we know of his personal history is from allusions to himself in his own works, and from II letters addressed to him by his very intimate friend, the younger Pliny The exact year of his buth is a matter of inference, but it may be approximately fixed near the close of the reign of Claudius Plmy indeed, though himself born in 61 or 62, speaks of Tacitus and himself as being "much of an age" (Pliny, Epp vii 20), but he must have been some years junior to his friend, who began, he tells us, his official life under Vespasian (Hist II), no doubt as quaestor, and presumably tribune or aedile under Titus (80 or 81), at which time he must have been 25 years of age at least Of his family and birtholace we know nothing certain; we can infer nothing from his name Cornelius, which was then very widely extended; but the fact of his early promotion seems to point to respectable antecedents, and it may be that his father was one Cornelius Tacitus, who had been a procurator in one of the divisions of Gaul, to whom allusion is made by the elder Pliny in his Natural History (vii 76) But it is all matter of pure conjecture, as it also is whether his "praenomen" was Publius or Gaius The most interesting facts about him to us are that he was an eminent pleader at the Roman bar, that he was an eye-witness of the "reign of terror" during the last three years of Domitian, and that he was the son-in-law of Julius Agricola. This honourable connection, which testifies to his high moral character, may very possibly have accelerated his promotion, which he says was begun by Vespasian, augmented by Titus, and still further advanced by Domitian, under whom we find him presiding as practor at the celebration of the secular games in 88, and a member of one of the old priestly colleges, to which good family was an almost indispensable passport. Next year, it seems, he left Rome and was absent till 93 on some provincial business, and it is possible that in these four years he may have made the acquaintance of Germany and its peoples. His father-in-law died in the year of his return to Rome In the concluding passage of his Life of Agricola he tells us plainly that he witnessed the judicial murders of many of Rome's best citizens from 93 to 96, and that being himself a senator he felt almost a guilty complicity in them. With the emperor Nerva's accession his life became bright and prosperous. and so it continued through the reign of Nerva's successor, Traian, he himself, in the opening passage of his Agricola, describing this as a "singularly blessed time"; but the hideous reign of terror had stamped itself ineffaceably on his soul, and when he sat down to write his History he could see little but the darkest side of imperialism. He was an academic republican, like many of those who perished in that reign of terror They were innocent

in many cases of plotting against the emperor's life; and, no doubt, many of the plots were imagnary. But some had been ted, and Domitian was determined to take no risks. Hence academic sympathizers with republican ideals fell under suspicion and were involved in the misscriminate slaughter of those three

vears He was apparently convinced that Tiberius had been a ruler of the same type as Domitian, and that prejudiced him against the great, but gum, successor of Augustus Moreover, some of the memoirs, contemporary with Tiberius' reign, were not likely to depict him in a favourable light, and on those Tacitus had laigely drawn (For the value of this evidence see Furneaux, Tac, Ann vol 1 D 20 ad fin For Tacitus' judgment on Tiberius see sbid Introduction ch viii ) But, apait from personal prejudice, the Romans of the upper classes who lived in Rome or resorted thither tended to dislike impenal rule both socially and politically, and did, as a fact, see so much of the worst of it that they failed to appreciate the blessings it had conferred on the world outside. To his friend, the younger Pliny, we are indebted for the little we know about his later life. He was advanced to the consulship in 97, in succession to a highly distinguished man, Verginius Rufus, on whom he delivered in the senate a funeral eulogy In 99 he was associated with Pliny in the prosecution of a great political offender, Marius Priscus, under whom the provincials of Africa had suffered grievous wrongs The prosecution was successful, and both Tacitus and Pliny received a special vote of thanks from the senate for their conduct of the case It would seem that Tacitus lived to the close of Trajan's reign. as he seems (Ann ii 61; 1v 4) to hint at that emperor's extension of the empire by his successful Eastern campaigns from 115 to 117 Whether he outlived Trajan is a matter of conjecture. It is worth noticing that the emperor Tacitus in the 31d century claimed descent from him and directed that ten copies of his works should be made every year and deposited in the public libraries He also had a tomb built to his memory, which was destroyed by order of Pope Pius V. in the latter part of the T6th century

Pliny, as we see clearly from several passages in his letters, had the highest opinion of his friend's shulty and wouth He consults him about a school which he thinks of establishing at Comum (Como), his hithplace, and asks him to look out for suitable teachers and professors. And he pays (Epp. vin 33) him the high compliment, "I know that your Histories will be immortal, and this makes me the more anxious that my name should appear in them".

The following is a last of Tacitus' remaining works, arranged in their probable chronological order, which may be approximately interred from internal evidence—(1) the Dutalgue on Orators, about, for vr; (2) the Life of Agricale, 90 or 98; (3) the Germany, 98, published probably in 99; (4) the Histories (Histories), completed probably by 115 or 115, the last ventor of Trajan's reign (he must have been at work on them for many vents); (5) the Amusla, his latest work probably, written in part perhaps along with the Histories, and completed subsequently to Trajan's reign, which he may very well have outlived.

The Dialogue on Orators discusses, in the form of a conversation which Tactius professes to have heard (as a young man) between some eminent men at the Roman bar, the causes of the decay of eloquene under the empire There are some interesting remarks in it on the change for the worse that had taken place in the education of Roman lads. The style of the Dialogue is far more Ciceronian than that of Tactius' later work, and critics have attributed it to Quintilian; but its genumeness is now generally accepted. It is noticeable that the mannerisms of Tactius appear to develop through his lifetime, and are most strongly marked, in his latest book, the Annals

The Life of Agricola, short as it is, has always been considered an admirable specimen of biggraphy. The great man, with all his grace and dignity, is brought vividly before us, and the sketch we have of the history of Britain under the Romans gives a special interest to this little work.

The Germany, the full title of which is "Concerning the geog-

raphy, the manners and customs, and the tribes of Germany," describes with many suggestive hints the general character of the German peoples and dwells particularly on their fierce and independent spirit, which the author evidently felt to be a standing menace to the empire The geography is its weak point, much of this was no doubt gathered from vague hearsay Tacitus dwells on the contrast between barbarian freedom and simplicity on the one hand, and the servility and degeneracy of Roman life on the other

The Histories, as originally composed in 12 books, brought the history of the empire from Galba in 69 down to the close of Domitian's reign in 97. The first four books and a small fragment of the fifth, giving us a very minute account of the eventful year of revolution, 69, and the brief reigns of Galba, Otho, and Vitellius, are all that remain to us. In the fragment of the fifth book we have a curious but entirely inaccurate account of the Jewish nation, of their character, customs and religion, from a cultivated Roman's point of view, which we see at once was a strongly prejudiced one.

The Annals-a title for which there is no ancient authority, and which there is no reason for supposing Tacitus gave distinctively to the work-record the history of the emperors of the Julian line from Tiberius to Nero, comprising thus a period from AD 14 to 68 Of these, nine books have come down to us entire; of books v., xi. and xvi. we have but fragments, and the whole of the reign of Gaius (Cahgula), the first six years of Claudius, and the last three years of Nero are wanting Out of a period of 54 years we thus have the history of 40 years
The principal mss, of Tacitus are known as the "first" and

"second" Medicean-both of the 10th or 11th centuries The first six books of the Annals exist nowhere but in the "first Medicean" ms, and an attempt was made in 1878 to prove that the Annals are a forgery, by Poggio Bracciolini, an Italian scholar of the 15th century, but their genuineness is confirmed by their agreement (see Introduction to vol i, of Furneaux's edition of the Annals of Tacitus, Clarendon Press series, 1884) in various minute details with coins and inscriptions discovered since that period. Moreover, Ruodolphus, a monk, writing in the 9th century, shows that he is acquainted with a ms of Tacitus containing at least the first two books. Add to this the testimony of Jerome that Tacitus wrote in 30 books the lives of the Caesars and the evidence of style, and there can be no doubt that in the Annals we have a genuine work of Tacitus

Much of the history of the period described by him, especially of the earlier Caesars, must have been obscure and locked up with the emperor's private papers and memoranda. As we should expect, there was a vast amount of floating gossip, which an historian would have to sift and utilize as best he might. Tacitus. as a man of good social position, no doubt had access to the best information and must have talked matters over with the most eminent men of the day. There were several writers and chroniclers, whom he occasionally cites but not very often; there were memoirs of distinguished persons-those, for example, of the younger Agrippina, of Thrasea, and Helvidius. There were several collections of letters, like those of the younger Pliny; a number, too, of funeral orations; and the "acta senatus" and the "acta populi" or "acta diurna," the first a record of proceedings in the senate, the latter a kind of gazette or journal. Thus there were the materials for history in considerable abundance, and Tacitus was certainly a man who knew how to turn them to good account. He has given us a striking, and on the whole doubtless a true, picture of the empire in the 1st century. The rhetorical tendency which characterizes the "silver age" of Roman literature gives perhaps exaggerated expression to his undoubtedly strong sense of the badness of individual emperors, but he assuredly wrote with a high aim, and we may accept his own account of it (Ann. iii., 65): "I regard it as history's highest function to rescue merit from oblivion, and to hold up as a terror to base words and actions the reprobation of posterity," He is convinced of the degeneracy of the age, though it be relieved by the existence of truly noble virtues; and he connects this degeneracy more or less directly with the imperial regime. But it is difficult to dog-

matize as to Tacitus' political ideals. He is primarily concerned rather with ethics than with politics; though he may feel that the world is out of joint-with whatever sentimental sympathy he may regard the age of "liberty" and admire the heroic epoch of the republic-yet he appears to realize that the empire is a practical necessity, and to the provinces even a benefit. Like the Stoics, with whom otherwise he has little in common, he censures rather individual rulers than the imperial system. But "the key to the interpretation of Tacitus," it has been well said. (Dill. Roman Society from Nero to Marcus Aurelius, Bk i ch 1.) "is to regard him as a moralist rather than a politician." Perhaps the strongest work in the Annals and Histories is the delineation of character

Tacitus gives us no certain clue to his religious belief. His expressions of opinion about the government of the universe are difficult to reconcile with each other. There seems to have been a strange tinge of superstition about him, and he could not divest himself of some belief (Ann. vi 21,22) in astrology and revelations of the future through omens and portents, though he held these were often misunderstood and misinterpreted by charlatans and impostors. On the whole he appears to have inclined to the philosophical theory of "necessitarianism," that every man's future is fixed from his birth: but we must not fasten on him any particular theory of the world or of the universe. Sometimes he speaks as a believer in a divine overruling Providence, and we may say confidently that with the Epicurean doctrine he had no sort of sympathy

Tacitus' style 15 discussed in the article LATIN LANGUAGE. Whatever judgment may be passed on it, it is certainly that of a man of genius, and cannot fail to make a deep impression on the studious reader. Tacıtean brevity has become proverbial, and with this are closely allied an occasional obscurity and a rhetorical affectation which his warmest admirers must admit He has been compared to Carlyle, and both certainly affect singularity of expression. But they are alike only in the brevity of sentences; and the brevity of Carlyle is not that of an artist in enigram Tacitus was probably never a popular author; to be understood and appreciated he must be read again and again, or the point of some of his acutest remarks will be quite missed

of some of his acutest remarks will be quite missed
Tactus has been many times translated, in spite of the very great
difficulty of the teak; the number of the versons of the whole or
part is stated as 300 no (we should call it a paraphrase) was for long
one of the best known; it was published early in the 19th century,
on this was based the so-called Oxford translation, published by
Bohn in a revised edition Messrs. Church and Brodrubb's translation
and Professor Annany's (1904) (the latter of sirral i-w) are
dey's (1879); Herius's (Histories, 1889); Furneaux's (Annals, i.vi.,
1884; xi. xvd. 1891; Germania, 1894); Sponoris (Histories, 1891).
The last two editors' miroductions are particularly useful. By
if the best edition of the Agreeo'ds in English is that of Furnesux
is the strong of t

TACITUS, MARCUS CLAUDIUS, Roman emperor from Sept. 25, A.D. 275 to April 276, was a native of Interamna (Term) in Umbria. In the course of his long life he held various civil offices, including that of consul in 273. Six months after the assassination of Aurelian he was chosen by the senate to succeed him, and accepted by the army. During his brief reign he set on foot some domestic reforms, and sought to revive the authority of the senate, but, after a victory over the Goths in Cilicia, he succumbed to hardship and fatigue (or was slain by his own soldiers) at Tyana in Cappadocia. Tacitus, besides being a man of immense wealth (which he bequeathed to the state), had considerable literary culture, and claimed descent from the historian.

See Life by Vopiscus in Historiae Augustae Scriptores; also Eutropius, ix 10; Aurelius Victor, Caesares, 36; Zonaras xii. 28; H. Schiller, Geschichte der romischen Kaiserzeit, i. 1883.

TACK: SEE NAIL MANUFACTURE.

TACNA, department of Peru, to which by the terms of the 1929 settlement of the Tacna-Arica question it was transferred by Chile, Bounded north by Moouegua and Puno, east by Bolivia.

south by Tarapacá, Chile, west by the Pacific Area 4,930 sq mi Pon (1050 est ) 43,696 It belongs to the desert region of the Pacific coast There are a few fertile spots near the mountains, where mountain streams afford irrigation and drinking water and support small populations Few of its streams cross the entire width of the department, most are lost in desert sands. The climate is bot, and earthquakes are frequent and sometimes violent One railway in the department runs from the city of Tacna to Arica (a.v.), and another, constructed by the Chilean government, from Auca to La Paz, Bol The department is part of the former area, Tacna and Arica, which once formed part of the Peruvian department of Moquegua Its capital is Tacna (pop 1805, 9,418, 1940, 11,378), a small inland town 48 mi. by 1ail from Auca, in a fertile valley among the footbills of the Andes Existence is made possible in this oasis by a small mountain stream. also called Tacna, which supports a scanty vegetation. The town is the residence of a number of foreign merchants (For the Tacna-Arica question see CHILE, PERU )

TACOMA, a city of Washington, U.S., on Commencement bay, one of the arms of Puget sound, 30 mi, by water south of Seattle and 151 nautical miles from the Pacific ocean, a port of entry and the county seat of Pierce county It is on federal highways 99 and 410, and is served by The Milwaukee Road, the Great Northern, the Northern Pacific and the Union Pacific railways, by motorbus lines and by more than 50 steamship lines, with sailings to the orient, Alaska, South America, Australia and Europe, and to Atlantic and Pacific ports of the United States, The population was 143,673 in 1950, in 1940 it was 109,408 and in 1030, 106,817

The fine natural harbour is 4 5 mi. wide at its entrance between Brown's point and Point Defiance and about 25 mi long There is no bar or other natural obstruction at the entrance, and the waters are deep throughout. The climate is equable and the precipitation moderate, about two-thirds of the rain falling in the four months November to February. From the tidelands the city rises gradually to a plateau 300 ft. high The area is 52 6 sq m1, of which 5 25 sq mi are water The Olympic mountains are visible to the west and Mount Rainier (14.408 ft. high), in Ramer National park, 56 mi. S.E., seems to stand at the city's doorway. Near by are many fresh-water lakes, surrounded by evergreen forests The city's parks cover 1,617 ac , including 640 ac on Point Defiance In the heart of the city is the state historical building and museum, containing a collection of pioneer, Alaskan

and Indian relics In the north end of the city is the 40-ac. campus of the College of Puget Sound (Methodist; 1888). Two of the transcontinental railroads have extensive terminals on the water front, and other wharves have been constructed by industrial concerns. The physical development of the harbour by the public and the administration of facilities owned by the Port of Tacoma district (a municipal corporation conterminous with Pierce county) are under

the junisdiction of a port commission

The piers owned by the municipality cover 280 ac. With one of
the five finest salt-water harbours in the world, and originally established as an important lumber-production and grain-export city, Ta-coma became an important industrial centre. Among leading indus-tries are chemical and metallurical manufacturing, food processing and a great diversity of the forest products industries such as plywood and a great diversity of the forest products industries such as phywood, doors, furniture, pulp and milliwork. Total nonagricultural employment for July 1350 was 68,460. Heavy basic chemicals are produced as well alloys are among ornels in possessed. The city, in addition to being an important candy cente, a size recognized as the largest producer of pleasure and commercial boats on the Pacific costs. Near by are Fort Lewis, McChord an force base, Mt. Rainler ord-mance depot and Madigan General hospital

History,-Tacoma harbour was visited by Capt. George Vancouver INSUTY—LECOME harbor was visited by Capt. George Vancouver in 1793, and 30 years later the Hudson's Bay company established a trading post at Nisqually Commencement bay was surveyed for United States in 1844 by Lleut. Charles Wilkes. Settlement began in 185 when Nicholas Delin, a Swede, took a claim on the south shore to the bay and set up a small sawmill, from which in 1851 he singped the only and set up a small sawmill, from which in 1855, he shipped lumber to San Francisco. In 1855, the sethlers were frightened away by the opening of the Indian war, taking refuge in Ft. Stellacoom (12 mi S.W.) which had been built in 1849; but in 1864 Job Carr and his two sons, from Indiana, took claims on the west shore of the bay. Developsons, from indiana, took claims on the west shore of the bay. Develop-ment of a city dates from the arrival from Portland in 1868 of Gen Morton Matthew McCarver. He induced settlers to come; persuaded two of them to erect a sawmill, and planned a town site, confident that a transcontinental railway would soon reach Puget sound name he chose for the town was Commencement City, but this was soon dropped for the Indian word meaning a snow-covered mountain In 1873 the Northern Pacific established its terminal on Commencement bay and named it New Tacoma

A town was organized in 1874, becoming the county seat in 1880, ad in 1883 the two settlements were consolidated and incorporated as the city of Tacoma In 1880 the population was 1,098, in 1887, when the railroad was completed across the Cascades it had grown to about A boom immediately set in, attracting land speculators from all puts of the country, and three years late: (1890) the population was 36.006 There was little increase in the next decade, but between 1000 and 1910 the population give from 37,714 to 83,743, and the total microsse of the 20 years 1900 to 1920 was 157%. The impact of World Wai II, bringing new shippard and army developments, caused big

gains in population which were retained in the postwar period. TACONITE. The name taconite was applied originally to an iron-bearing formation of supposedly Taconic age (Cambrian to Ordovician) Though this was an error the name was associated thereafter with iron-bearing tocks on the Mesabi range in northern Minnesota consisting of chert (fine-grained quartz), magnetite, haematite, several silicates as minnesotaite, greenalite, stilpnomelane and amphibole and siderite. The rocks were originally chemical precipitates which now form beds of a maximum thickness of 750 ft and a length of about 100 mi along the strike Their extent down the dip is unknown In this taconite are found the high-grade iron-ore bodies which have supplied most of the iron of the U.S. As all taconite contains on an average 27% of chemically combined iron, it is considered the largest potential reserve of ore in the U.S. About 5,000,000,000 to 6,000,000,000 tons of it are near enough to the surface and contain sufficient amounts of magnetite so that its magnetic concentration to a highgrade product was in an advanced stage of development by the 1950s, ready to be shipped to the blast furnaces in significant

See J W Gruner, The Mineralogy and Geology of the Taconites and Iron Ores of the Mesabi Range, Minnesota (1946) (JN W. G.)

TACTICS. Tactics is the art of fighting battles. It is concerned with the dispositions for combat and the execution of combat It includes the employment of all the military forces on the field of battle, the execution of strategic movements prior to battle, and the use made of the different arms Thus, there is a tactics of the battle as a whole and likewise an artillery tactics, a tank tactics, an aviation tactics and many others which can be discussed separately in connection with the same battle. Military strategy is the art of concentrating forces in the theatie of operations under favourable conditions for battle. The term grand tactics came into being just prior to the time of Napoleon and was used to designate the regulation of the march of the different divisions and corps of the army in preparation for battle. It is rarely used in the 20th century, although it supplies a convenient connection between the fields of tactics and strategy

The nature of the tactics used in battle often is dependent upon the strategic dispositions of the forces, and the tactical possibilities of the forces involved will influence the strategic plan of operations. Consequently, there is no well defined line between strategy and tactics; strategy aims at assisting tactics and, in its turn, the sim of tactics is the development or completion of the strategic movement. The terms tactics and strategy, as now used, are of comparatively recent origin. Their meanings are not precisely defined. In general, however, tactics is the conduct of battle, including marches, and strategy covers the operations leading up to battle.

Tactical Objectives .- In any type of conflict one opponent overcomes the other either by superior force, by attacking him at a weak or vulnerable point, or by demoralizing or disorganizing him by surprise. From these the main tactical objectives may be deduced to attack with superior force at the point of attack; to attack a weak or vulnerable point; and to effect surprise. Surprise aims at confusion, demoralization and disorganization, It is an attack aimed at the mind and morale

At certain periods of warfare, when ideas of chivalry and of "fighting like gentlemen" were predominant, tactical skill was scorned. It would have been cowardly to suprise and deceve the opponent at such times. At other times the lattical problems involved in reaching a weak point have been too complex for soldiers to solve. This was the case during a part of World War I, when the continuous front inhibited the classic enveloping movement designed to neight the hostic perior.

Elements of Tactics—Weapons, movement and protection are the elements from which tactics are constructed and which govern the evolution of combat. Throughout history two main types of weapons have been used in attack and defence, namely missale weapons and shock weapons. Missale weapons include slings, arrows and hrearms, shock weapons are the weapons of hand-fighting, and instruments such as tanks which overcome by their crushing force.

Cavalry was said to have had shock power when cavalry charges could run down the enemy and when it attacked with sword had lance. The historical fact about the shock power of cavalry is, however, that shock almost never took place. One opponent on the other field or turned back. Shock power in that sense has always been almost nonevestent, although for centuries it will be always been almost nonevestent, although for centuries the the habit of military writers to speak of the shock power of cavalry. Elephants had shock power. Tanks have shock powebut it is not their most effective method of combat. Tanks also depend upon fire and movement.

Armies have been characterized by organizations having different rates of movement. Until the advent of motor transportation, movement was confined to the two speeds of the man on foot and the man on the horse. It was the suppernor mobility of the horsemen which made cavalry the arm of decision in warfare for a thousand years. Cavalry was able to extend negably around the flank and reach the rear, because of its superior speed Cavalry lost its pre-emmence because of its vulnerability to firearms. With the development of armoured track-laying vehicles, cavalry no longer is the most rapid moving fighting element in armies. Motor-driven track-laying vehicles, thus book over the role of cavalry as the element of decision in armies. The armour protects them from small arms, their speed is great enough to move around the flank of an enemy, and their own fighting powers enable them to break through a weak point and speed destruction.

With the motorization of foot solders and the large use of mechanized forces, cavalry was reduced to the slowest element of armies where once it was the most rapid. It still retained a superior mobility to motorized and mechanized troops in rough country, and still was useful for certain reconnaissance purposes in war. In general, however, the evolution of war practically eliminated horse cavalry.

Protection is provided by armour, earthworks oi terrain. The easiest protection to obtain is that gained by digging in the ground, but since this protection can be had only while the soldier remains in the trench, it is usable only for delensive operations. Protection by armour, on the other hand, can be used either for offensive or defensive purposes. Cavalry at one time was armoured so that it was reactically invulnerable to infantry weapons.

Armour, again in World War II and the Korean war resumed its importance in the offensive on the battlefield. The armough soldier sat behind the 14-in, chilled-steel plates of the tank he drow. Tanks tended to become the armoured offensive industry, while the foot soldier for a while assumed the role of defensive infantry.

The Evolution of Tactics—Armament determines the method of combat The man with a gun fights at a distance from his adversary, while the man with a sword must close. The method of combat determines the manner of deployment and entry into battle. This in turn determines the maner of deployment and entry into battle. This in turn determines the march dispositions which precede it. The choice of the point of attack depends upon the amament and faculties for movement and supply. Scence and invention, industry, transportation and communications influence the manufacture and the quantity of armament and munitions at the disposal of armies. Thus, the evolution of tactics fundamentally is a result of science and invention, and the evolution of industry and transportation. Armies rely heavily on tradition,

and the evolution of methods of fighting usually has been resisted by them. The few bulliant commanders who have taken advantage of the unodifications in factics made possible by the progress of armaments, industry and transportation in their time have achieved astounding successes. Napoleon is one example of this, and Napoleon was wise enough to say that tactes must be rhanged every ten years, while the German aimy of 1939 was another example.

Offensive and Defensive Action -To attack presupposes offensive action and this in its turn introduces defensive action. either to protect the attack or to resist it. When the art of wai is of high order, the offensive and the defensive are so interwoven as to be inseparable, but as this degree of perfection has throughout military history been the exception rather than the rule, these two modes of fighting may be considered separately Throughout history the relative power of attack and defence has varied. This has been due to the varying pre-emmence of weapons, movement and protection. In general, missile weapons have favoured the detensive. In the war of 1914-18 the ultimate in missile weapons, the machine gun, combined with the protection of entrenchments, immobilized the offensive. The development of the aeroplane, the tank and armoured weapon-carrying vehicles reversed the trend of defensive domination By the time of World War II, the offensive had regained its dominance as was proved by the lightning German victories in Poland and France, the Allied invasion of Europe and U.S. victories in the Pacific

Throughout history the offensive and defensive have dominated alternatively. New defensive methods usually are devised to counter new offensive weapons. Firepower ended the offensive power of armoured cavalry. The tank, in turn, countered the defensive dominance of machine guns. The great cycles of offensive or defensive supremacy formerly lasted for hundreds of years. Science and invention have speeded up the rate of swing. In World War II the offensive was supreme, after the war the power of the defensive was once more in the assendance.

Tactical Methods—Both offensive and defensive types of ormbat are worked out by inter definite tactical methods, depending upon the age under consideration. Vegetius (q,v) listed seven different formations in which an army could be charmed the common offensive tactical methods were the penetration, envelopment of one or both flanks, the turning movement and pursuit. Penetration consists of breaking through an enemy line at the chosen point with the object of creating flanks so that mobile forces can reach the rear. Envelopment consists of overtical control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the conposition of the control of the control of the control of the control of the conposition of the control of the conposition of the control of the control of the conposition of the control of the conposition of the control of the control of the conposition of the control of the conposition of the control of the conposition of the control of the conposition of the control of

Defence may be either cordon, passave or mobile In cordon defence the forces are thinly dispersed over a long line with few reserves. This method is rarely used except in the defence of rivers and coast lines Passive defence is conducted with the intention of holding in place. It may be in great force, as frequently was the case of the war of 1914-18, but does not presuppose extensive use of offensive methods such as counterstacks. The mobile, or elisatic, defence is based on the theory that any defensive position can be broken into, but that the least prepared at that time to resist them. This type of defence was developed by the Germans in 1916 and 1917 and adopted by the Allies in 1913. It has become the standard defensive method of all armies. It takes advantage of the offensive to accomplish defence

Delaying action is a defensive action intended to gain time Delaying action is conducted either on one line or two lines. The delaying force holds its line long enough to require the attacker to deploy, then withdraws to the next position before becoming seriously engaged in combat. When delaying action is conducted on two lines, the troops from the forward position withdraw through the second line and this is done successively. The distance between lines in delaying action is great enough so that the attacker's artillery will be forced to displace forward in order to bring fire to bear on the second line. The defensive-offensive sequence, or active defence, as it is usually called, which consists of the occupation of a position with a view to persuade an enemy to attack it, and then when he has exhausted himself, to counterattack from it, has played an important part in war. One form of active defence consists of withdrawing to induce the enemy to follow, and then of counterattacking This is dangerous. since the forces withdrawing may become disorganized and the planned withdrawal may be turned into a rout

Tactics and the Continuous Front,-Development of the continuous front in the war of 1914-18 was the outstanding tactical feature of that war. When the Germans invaded France in Sept 1014, they attempted to envelop the left wing of the French army and finally were stopped and thrown back at the Maine Both contenders then attempted to extend their lines and overlap the exposed flark of the other This period of operations, known as the "race to the sea," finally resulted in the extension of the front to the sea so that a continuous line almost 400 miles long was occupied by the opposing forces, from Switzerland to the English channel The former solution of attacking the enemy's rear by envelopment of an open flank could be applied no longer Soldiers were faced with an entirely new and unforeseen tactical problem to be solved. This was to break through a front with no flanks and more effectively protected with automatic weapons and entrenchments than any field fortification in all previous worfore

The continuous front was made possible by the multiplication of transport facilities and industrial capacity to supply millions of men, together with the decreased density of battle lines permitted by the fire power of 20th century armaments. It now has become a necessity as each contender strives to hold all his territory, since every national resource is required for war-making purposes No longer will any nation make its surface the manneuvre ground for marching hostile armies if it can stretch the defenders to cover the entire length of the threatened borders Due to the enormous amounts of supplies required by machine warfare, the rear of armies has become more vulnerable than ever before An interruption of a week will find a fighting army out of ammunition and helpless. If there were such a thing as an exposed and undefended flank, the rear of the armies is within a very short striking distance of air forces. No matter how the forces may be attenuated to form the continuous front, it is the one and indispensable essential to defence before which all other considerations give way

It is a complete defence to the historical solution of getting to the hostile rear by envelopment

The continuous front is not synonymous with the stabilized front. Certain military writers since the war of 1914-18, arguing from the clumsy Allied offensives of 1915-16, assumed that stabilization is inevitable. Although this was disproved by the German offensives in the spring of 1918, a whole school of military thought grew up in England and France after World War I which held that the power of defence had become so great that in any future war stabilization would occur very shortly after the commencement of the war. Two solutions were proposed. the first, by those who believed that they would not permit the continuous front to be formed again, although they were rather nebulous as to the means by which formation of fronts could be prevented; the second, composed of those who believed that the only solution was to permit the enemy to exhaust his strength attacking the supposedly impregnable defensive of their own front. Neither solution had any validity and both overlooked the new powers given the offensive by aeroplanes, tanks and increased use of high-angle fire cannon to support the infantry attack

In actuality, continuous fronts were already being formed while these theories were current The French Maginot line was a continuous front formed and garrisoned in time of peace. It was paralleled by another line, the German Westwall. In the Spanish Civil war a continuous, or perhaps discontinuous, front

more than a thousand miles long was formed almost immediately. When World War II commenced Sept 1, 1939, the German and Polish aimies both were on a continuous front

Between great nations the continuous front had become a distinguishing feature of war.

# GREEK AND ROMAN TACTICS

The Phalanx and the Legion.—There is so much difference between ancient arms and armies and modern armaments that few tactical lessons can be learned from ancient warfare Certain fundamental principles of combat may be deduced which remain permanent throughout the ages, but principles which are so fundamental that they are applicable to a boxing match, a football game or a battle between a few champions have little value in explaining tactics in the 20th century The evolution of Greek and Roman tactics proceeded from the



identical causes which force the evolution of tactics in the 20th century Armament determines the manner of fighting and the manner of fighting determines tactics The invention of powder gave missile weapons a much more important place than in the past, but their role was far from being insignificant in ancient times The ancient historians did not like to mention

FIG 1-BATILE OF them and preferred to give precedence to MARATHON (490 BC) citizen warriors who fought with the lance showing TACTICS of and sword They had little but contempt CONCENTRIC ATTACK for the auxiliary armed with a bow or

sling Attention is fixed on phalanxes and cohorts, and this has given a false idea of Greek and Roman combat The phalanx and the legion never constituted the ancient armies by themselves They were transformed continually in accordance with the progress of material means and new necessities. The ancients have deplored the decadence of tactics in various times in history, but there never has been any real decadence except from the romantic point of view

The decline of hand-to-hand fighting spoiled the iomance of combat, but it answered real needs and the reforms adopted were imposed by necessity

Cavalry was scarce in Greece and Italy because of limited numbers of horses. The infantry of the line which fought in closed ranks was organized to fight against a similar type of soldier, not against cavalry. It was formed in a phalanx of eight or twelve ranks, but this was not, as is commonly supposed, an immobilized and compressed formation. Intervals between the combatants were between three and four feet and permitted them to manoeuvre their pikes freely Such phalanxes are mobile. They can charge vigorously. Their depth is not



intended to give force to shock action. which in the sense of crushing power has always been nonexistent. On the contrary, it was necessary to have a sufficient number of combatants in each file to replace those who fall while fighting in the front ank In the ordinary battle the fronts came into contact and hundreds of duels took place during which many of the FIG. 2 -BATTLE OF fighters were exhausted, but ordinarily

(371 B C), large numbers were not killed SHOWING TACTICS OF THE The vulnerable parts of the phalanx are OBLIQUE ORDER its flanks and rear. The smallest attack

there causes disaster If the phalanx is split the number of flanks is increased, and the lightest troops could penetrate into the openings and kill the warriors with their pikes. Thus the phalanx was never subdivided It could not manoeuvre for fear of losing its unity. It was necessary to arrange it in order of battle completely before action Thus, mobile troops, either light auxiliaries or cavalry, usually decided the success of ancient combat by their

Even early cavalry without saddles or stirrups often was the element which gave victory on account of its mobility.

In the absence of cavalry it was light infantry. The heavy infantry of the phalanx was the solid holding element

The early Roman phalanx went through several transformations, first becoming the maniple legion, which was a semilight infantry, since it had abandoned the ancient pike for the pilum and the sword Its division into maniples made it more supple than the Greek phalanx It also was completed by archers and slingers who prepared and ended the action The later organization of the Roman legion into cohorts made the legion a

maneouvre unit almost equal to Fig 3 -xenophon's idea of the BATTLE OF THYMBRA (546 B C ), SHOWING TACTICS OF EX-CENTRIC the modern division. Classical Cavalry.-Cavalry entered the scene with the orientals and the Macedonians and then with the Carthaginians. It held first place in their armies with both heavy cavalry, armed with the cuirass and lance, and light cavalry, armed with bows and spears It was the active offensive element and was the arm

(e) CHARKIES

A BOOY GUARS

ILI HEAVY FOOT

(cl) JAVELIN MON

(d) ARCHEBS

(/) ARTILLERY

(A) BAGGAGI

(1) CAVAUR

(1) CAMELS

(A) BAGGAGE GUARD

of decision both for Alexander and Hannibal The phalanx could not resist it except by main force and increased its weight to the point of becoming nothing but a human fortress with ranks closed to the extreme Macedonian phalanz was able to stop the charge of cavalry but it became paralyzed, unfit to conduct offensive operations by itself. The same evolution took place throughout history after that time.

The offensive spirit of the Romans led them to avoid making the legion heavy. Having been vanquished by Hannibal's cavalry, the Romans procured them- Fig selves cavalry equal to that of (331 BC), showing tactics of the Carthaginians. Scipio crossed REAR ATTACK

LEFT OF PANA LIGHT SHART CAVALRY HEAVY CAVAL LIGHT INFA 4 -BATTLE OF GAUGAMELA.

to Africa, not only to carry the war to his adversary, but also to get the Numidian cavalry of Massinissa. It was this that triumphed at Zama.

In the armies of Caesar, the archers and slingers were more numerous than the legionaries. They mingled with them in the cohorts and large bodies were formed from them on the wings At Pharsaha they were the larger part of the army. The empire recognized this state by admitting the archers and slingers into the legion, and the legion was reinforced still more by war machines throwing heavy darts and large stones. The Roman soldiers carried palisade planks and these were used to break the charge

The Decline of Infantry.-Cavalry was equipped with saddles and stirrups and covered itself with coats of mail and then with armour in order to protect itself from missile weapons and for cavalry combat. It had the decisive role without question. It attacked and it manoeuvred, while the infantry, massive and paralyzed, no longer had any mission except to arrest the cavalry charges. This was the condition of the Roman armies after the Antonines, and these relationships continued until the 16th and 17th centuries.

Belisarius (c. 505-565) covered his immobile phalanxes with an entrenchment. They awaited the charge of the enemy cavalry, which was showered with missiles, and then the Byzantine cavalry charged in its turn. The English operated in the same manner at

Crecy (1346) and at Poitiers (1356) For the offensive to succeed, it had to take the enemy in the flank or draw the defenders out of their prepared position. It was by these methods that the Goths were the conquerors of the Romans at Adrianople (378), the Arabs of the Byzantines, the Greeks of the Saracens (833), the crusaders of the Turks at Dorylaeum (1097) The infantry became powerless to force armoured cavalry as was shown at Hastings (1066), and at Bouvines (1214) They could not hold except behind an entrenchment and by making use of their missile weapons

Ancient battle was won by envelopment Since the defender operated on interior lines, the envelopment had to be inade by a force of superior mobility, and this force was cavalry Alexander directed his numerous cavality on the flank of his adversary while his infantry attacked the front. Hannibal crushed the Roman armies at Cannae by closing his two wings of cavalry on their flanks The infantry was too slow and too immobile to exercise enveloping manoeuvres It rarely



could do it without breaking its lines and thus exposing addi tional flanks to the attack of light troops It was cavalry alone which, thanks to its speed, could manoeuvre on the flanks It could act in many separate groups which could manoeuvre

SHOWING TACTICS OF REAR B C ). without risk, since the infantry was not able to take advantage of the openings in its more mobile foe. The centre of an army could not be penetrated The only manoeuvre was the enveloping manoeuvre and this manoeuvre was the function of the only

## mobile troops-the cavalry. THE CAVALRY AND INFANTRY CYCLES

The Evolution of Cavalry.-Under Diocletian (245-313) cavalry rose from one-tenth to one-third of the infantry and numbered some 160,000, but this great mass of horse was withdrawn from the infantry, and by being formed into a frontier guard lost its offensive spirit and, generally speaking, was no match for the barbarian horsemen who invaded the empire in the 3rd century. By the 6th century, infantry took little or no part in battles fought on ground over which cavalry, which took to armour, at this time, could move. In 814 a chronicler writes of Charlemagne and his host, "Then appeared the Iron King, crowned with his iron helm . . and round him and before him and behind him rode all his men armed as nearly like him as they could fashion themselves; so, iron filled the fields and the ways. and the sun's rays were in every quarter reflected from iron 'Iron, iron everywhere,' cried in their dismay the terrified citizens of Pavia"

The cavalry cycle reached its zenith in the 11th century. At Hastings (1066) and at Dyrrachium (1081), the English axemen were powerless against armoured horsemen. All that the infantry could do was to remain behind entrenchments and use missile weapons. To the knight of the middle ages stability was no longer afforded by the infantry mass, but by the armour he wore, his mobility being provided by his horse. As long as he was not met by equally well mounted and armouned antagonists, this combination of mobility and stability proved irresistible in the melee, the one and only end of mediaeval tactics.

With the advent of plate armour in the 13th century, mobility was sacrificed to protection, and though it still was possible to dismount the knight, so heavy had his armour become that once dismounted he was unable to move over muddy or broken country. At the battle of Tagliacozzo (q v.) in 1268, Conradin's Ghibelline knights were so heavily armoured that Charles of Anjou's cavalry. after exhausting them by repeated charges, rolled them out of their saddles by seizing them by the shoulders. As armour increased in weight, natural obstacles played a more and more important part on the battlefield. At Bannockburn (q.v.) in 1314, Bruce took up his position behind a stream, and Edward II's knights were bogged just as in Flanders tanks were ditched 603 vears later

The Influence of the Bow .-- A definite change in tactics now set in At Dupplin Moor (q v ), in 1332, Bahol and Beaumont did not heat the earl of Mar by reckless charges, but by skilful weapon co-operation. The majority of their knights were dismounted and formed into a phalanx, the flanks of which were protected by archers, while only 40 mounted knights were kept in icserve for the decision. The earl of Mar charged the phalany, which remained stable, his knights were immobilized by the archers on the flanks, and annihilated by Baliol's squadron This battle is the birthday of a new era in tactics-the tactics of the bow, pike and lance combined It forms the mould in which all the English operations of the Hundred Years' War (q v ) (1338-1453) were cast, a war which proved disastrous to the gallant but insubordinate chivalry of France, as Ciecy (qv), Poitiers (qv) and Agincourt (qv) testify From the battle of Poitiers onwards cavalry falls into a rapid decline, and as the bow and pike destroy them a new weapon arises in the crude bombards of the 14th century, which are about to revolutionize the whole art of war and introduce the infantry cycle

The Influence of Gunpowder,-The rise of infantry was due as much to social as to military reasons. Feudalism, which restricted its use, was attacked by trade as well as by gunpowder The increasing wealth of the 14th century had brought the cities into conflict with the barons, and the result was not only a widespread series of burgher wars but a steady increase in the infantry arm which was, however, powerless to attack the feudal strongholds until artillery came to its assistance. During the second half of the Hundred Years' War this difficulty was overcome, for it was due to the artillery of Charles VII more than to the visions of Joan of Aic that the English were ultimately driven out of France This monarch provided himself with a train of artillery against which mediaeval fortifications proved a poor protection, and next we find cannon used in the open field, as happened at Formigny (q v) in 1450 To all intents and purposes this battle closed the Hundred Years' Wai

Meanwhile the handgun, or Couleuviine, was being turned to advantage by Žižka, in the Hussite Wars For long it had been the custom to laager the baggage wagons in rear of the battles of knights. Žižka now turned this laager into a mobile fortress which he garrisoned with archers, crossbowmen and handgunners Once the knights had shattered themselves against it, he would issue out with his cavalry and destroy them. Thus the Hussites won the battles of Deutschbrod (1422) and Aussig (1426)

The Influence of Artillery .- While the Swiss maintained their pikes and then phalangeal formations which had proved so effective since the battle of Sempach (1386), during the second half of the 15th century such extraordinary progress was made in artillery that the wagon fortress (wagenburg) proved useless. The dismounted English and French knights once again took to horse, and as ordnance began to accompany infantry, more and more could foot soldiers work independently of cavalry and wagon forts The close of the 15th century and the opening of the 16th saw the three arms, namely, cavalry, artillery and mfantry, assuming tangible form In France the infantry were poor on account of the strength of the feudal system. In Switzerland they became decadent as they refused to change their shock tactics. In Spain they became highly efficient, a result of their struggle with the Moors, and under Córdoba, who armed his foot with sword and buckler; against the Swiss and the German landsknechts, in 1502, near Barletta, he repeated the Roman tactics of Pydna: for as Machiavelli says: "By the help of their bucklers and the agility of their bodies, having got under their pikes, and so near that they could come at them with their swords, the Spanish had the day with the slaughter of most of the Swisses."

The Development of the Musket .-- As artillery forged ahead it broke away from close support of infantry. At the battle of Ravenna (q v.) in 1512 it took the enemy in the flank, playing a decisive part in winning victory for the French under Gaston de Foix. At the same time a rapid evolution of the handgun set in. In 1520 the Spanish adopted the portable arquebus fork which stood them in good stead at Pavia in 1525 In this battle fought between the French under Francis I and the Imperialists under Lannoy, we



THE

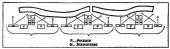
find a remarkable tactician, namely, the marquis of Pescara, diawing up a skirmishing line of 1,500 Basque arquebusiers who, according to Brantôme, "most wonderfully, though cruelly and villainously, discounted with much ease the power of the French cavalry "

In the wars between Charles V and Francis I the bow and crossbow disappeared Artillery, owing to the development of firearms, was neglected, and seldom more than one gun to 1,000 men was found As fighting in extended order was or developed, the musketeers rapidly grew in

SQUARE INTO THE number The French adopted the line as their tactical formation; the Spanish and Austrians maintained squares, normally of 3,000 men, 25 ranks deep The squares possessed a central corps of pikes, with bas-

tions of musketcers at their corners. Later on, these solid squares were replaced by hollow ones, and at times their four sides manoeuvred as separate bodies This is the beginning of the linear formation which definitely took form during the Thirty Years' War

Gustavus Adolphus and the Thirty Years' War .-- The 15th and 16th centuries were a period of transition, broadly speaking, from the cavalry to the infantry cycle of war. Progress was remarkable in spite of the opposition against which new arms always have to struggle. Maurice of Nassau formed regiments of two battalions, each consisting of 500 men in ten ranks. Pikes were placed in the centre and the musketeers on the flanks; by successive use of small bodies he wore his opponents down, and



FROM CAPT HART, "GREAT CAPTAINS UNVEILED" (BLACKWOOD)
FIG 7 —FORMATION ADOPTED BY GUSTAVUS ADOLPHUS, WITH BAT-TALIONS DIVIDED INTO COMPANIES OF MUSKETEERS AND PIKEMEN

yet kept a reserve in hand. He reduced the numerous calibres of field guns to 24-, 12- and 6-pounders, and substituted iron balls for the hailshot hitherto used. He used his heavy artillery to commence the battle and the light to accompany the infantry and support them closely

Gustavus Adolphus reduced the ranks of musketeers to six. organized his army into brigades, each consisting of two regiments of two battalions each 1,000 strong Each battalion was divided into eight companies, each of which had 72 musketeers and 53 pikemen. In his order of battle the infantry was in the centre and the cavalry on the flanks. In the Thirty Years' War (q v.). he used his artillery to break up the Imperialist squares by overwhelming fire from a distance and then charged home. These tactics, combined with the skill of his troops in manoeuvre, won him his two great battles, namely, Breitenfeld (q.v.) in 1631, and Lutzen (q v ) in 1632. After Gustavus' death, cavalry started to discard its armour and the lance was laid aside in favour of the sword and pistol. Cavalry again became the arm of manoeuvre by falling upon the flank, or rear, of the enemy, and delivered the decisive attack To assist cavalry mobility, frontal fire was necessary, and consequently skirmishers vanish and a rigid line is formed The improvement in firearms, and the introduction of the socket bayonet by Vauban in 1687, reduced infantry to one type. The distinction between pikemen, musketeers, fusiliers and grenadiers was given up, and during the war of the Spanish Succession (1701-14) all foot were armed with the flintlock and the bayonet. Mobility was reduced to a minimum and battles were decided by order and cohesion followed by the cavalry charge.

Frederick the Great .- Marshall Saxe was the precursor of

742 TACTICS

Frederick the Great. He reorganized his armies into brigades and divisions and used this organization through entire campaigns. He made use of artillery to an extent unequalled since the days of Gustavus Adolphus He attempted to open up the dense forma-

tions of his time and ridiculed the results of infantry charges in mass formation. He also introduced the use of redoubts to break up the enemy charges and located his redoubts so that they Fig 8 -MARSHAL SAXE'S COMBI supported each other by fire



FANTRY AND CAVALRY Frederick the Great divided his infantry into companies, established a definite drill, and formed his line of battle in three ranks. His cavalry was deprived of its firearms and was taught to charge boot-to-boot and to rely on the arme blanche Initially, he attempted to forbid his soldiers to fire in the attack. But in 1758, he commenced to write that "to attack the enemy without procuring oneself the advantage of superior, or at least equal, fire is to wish to fight against an armed troop with clubs, and this is impossible." Ten years later, in his Military Testament, he wrote "Battles are won by superiority of fire" A decisive word, remarks Captain J Colin, which marks a new era of combat. He invented the "oblique order" to attempt to wash around the enemy flank without splitting his formation. Leuthen (qv) (1757) is probably the finest example of the Frederician tactics. This was modelled on Leuctra (qv). Like Alexander, he refused one wing and assaulted with the other, the refusing wing acting as a reserve to that part of the line not used in hand-to-hand combat

Not only did Frederick realize that artillery should prepare the infantry attack, but that it should search out the enemy where the terrain concealed him, and consequently he increased his

howitzers to one-third of his total guns and massed them against the defender's flank Frederick breathed only the offensive, the offensive always, in every situation, in the whole of the operations as well as on the field of battle, even in the presence of a superior enemy. He brought the art of ancient war to the highest degree it attained. It remained for Napoleon to take advantage of all the new possibilities of warfare which had been developing during the 18th century and FLANK ATTACK to commence an entirely new cycle of tactics.



NAPOLEON AND 19TH-CENTURY TACTICS

Napoleon.-Napoleon fought more battles than Alexander, Hannibal and Caesar combined. With the French Revolution, all tactical shibboleths were cast to the winds; cohesion disappeared, and man took to natural fighting, that is, skirmishing. Marshal de Broglie (q.v.) had adopted a permanent divisional organization in 1759 and had concentrated his army rapidly by the as-sembly of these units. The divisional organization and marching in small columns permitted rapid deployment on the battlefield. whereas the old procedures had required from six to eight hours to form a line of battle. Marshal de Broglie had developed the principle of dispersion with units within supporting distance, in camp and on the march, and concentration on the field of battle Gribeauval had reduced the weight and increased the mobility of artillery so that it could manoeuvre with infantry Accurate maps were becoming general, an important matter in handling dispersed forces.

The theories by which all these changes could be utilized had been expounded by Guibert, du Teil and Bourcet. Napoleon appreciated the importance of artillery. He massed his guns to deliver the decisive attack. After Aspern-Essling (q.v.) in 1809 he increased his guns from two to three to each 1,000 infantry. He also created a central artillery reserve with 126 guns, and

allotted a reserve artillery to each army corps From Wagram (1800) onwards "it is the number of pieces rather than that of battalions which henceforth serves as the measure of the relative strength of armies

Napoleon wrote "The better the infantry, the more one must husband it and support it with good batteries The invention of nowder has changed the nature of war, missile weapons The power of infantry have now become the principal ones . hes in its fire

Napoleon's tactics and strategy were intertwined. Whereas in former wars the armies could refuse or give battle as they chose. since it took so long to form the order of battle. Napoleon's march formations and high speed of marching permitted him to march toward the enemy with his plan of battle already prepared and to force the battle when he chose. His strategical scheme was to march past the enemy by a series of forced marches, protecting his flank with a natural obstacle and then to come up in the rear of the opponent, forcing him to turn and give battle at a disadvantage. His tactical scheme, or system of battle, was based on a holding attack against the enemy's front to keep him occupied. a wide envelopment or turning movement on the enemy's rear with a small force to spread dis-



TACK OF A DEMI-BRIGADE

may and confusion in their ranks. and then the decisive blow This was given by a powerful attack, usually against a flank and was prepared by the concentrated fire of a mass of artillery

The Influence of the Rifle.—Napoleon taught the armies of Europe how to fight, but none ever equalled him. With the improvements made in the rifle they continued to attempt to fight battles in the massed formations practicable in Napoleon's time Two important inventions influenced tactics tremendously, namely, the percussion cap invented in 1814, and the cylindro-conoidal bullet invented in 1823. Previously, lifles and muskets had been fired by a flint and steel, and in rainy weather frequently misfired

The percussion cap increased the rate of fire to such an extent that it signed the death warrant of the cavalry charge. The conoidal bullet revolutionized artillery tactics. In 1839 the percussion musket was issued to the British infantry, and in 1851 they were equipped with the Minié rifle, with an effective range of 1,000 yards

In 1815, cavalry, artillery and infantry were in close contact, and were operated by the general-in-chief as easily as a platoon is today. The guns frequently were placed in front of the infantry and the cavalry close behind them. All this was changed by the rifle The cavalry could no longer attack infantry, unless completely broken The guns had to retire well in rear of the infantry, and as the range of the rifle was increased so was the distance between them and the infantry they were supporting. Thus the old battle order, which in idea had changed but slightly since the days of Gustavus Adolphus, was completely thrown out of joint. To operate an army as Wellington did at Waterloo was impossible; to render its separated parts co-operative demanded intelligence and not merely a powerful voice. The Prussians seeing the difficulty attempted to overcome it by replacing the general by an army fashioned like a clock, which once wound up was expected to tick out victory. The English maintained their fox-hunting generals, and the French, contemptuous of others, since they had produced one of the greatest geniuses in history, shrouded their ignorance in the glamour of his fame

Tactics from 1849 to 1870 .- This period was noteworthy for the increasing importance and effectiveness of artillery, continual improvement in the rifle, and the failure of armies to adapt their mass formations to cope with the effects of fire. Likewise, fire was not used to its full advantage. In 1859, the French made extensive use of skirmishers in the war against Austria and Italy This was due, however, to the inferior rifle of the French The broken nature of the ground favoured these tactics In 1859, the Austrian tactics were of a defensive nature, in 1866 they were diametrically opposite, that is, they were offensive, and with these tactics they decisively defeated the Italians under La Marmora, masses of Austrians who, almost unprotected by skirnushers, attempted to rush the Prussians armed with the needle gun were decimated

The Prussian army neglected the combined employment of the different arms. It considered that the bulk of its artillery should he held in reserve for the final act of disruption, and that the mitial destruction best could be attempted by a methodical infantry fight. One-thard of the guns were used to support attack. one-third to reinforce it and the remaining third were held back in reserve. Thus the battle of Trautenau fought on June 27. 1866. and that of Nachod, on the same day, were fought almost entirely without artillery But at Koniggratz the methodical attack was replaced by the manoeuvic battle, and artillery instead of being held in reserve for some problematical decision was brought forward

In the American Civil Wai (q v ) (1861-65) the most prominent tactical lessons were the power of the rifle on the defence and the ever-increasing use of entrenchments to enhance this power It was a common saying in the Civil Wai that one soldier behind entrenchments was worth three assaulting him. And Grant, when held up by Confederate breastworks in front of Richmond, said that they were so perfect and so extensive that the power of the defence was as five to one The battles of the American Civil War were models of the enveloping manoeuvre It has been said that the Civil War was fought with Jomini's Summary of the Art of War in the pockets of all the high commanders The American Civil War also was notable for the effective use of cavalry which. instead of following the European model and attempting to imitate days of chivalry, was used as mounted infantiy. In the American Civil War, influence of railroads on the supply of armies first became important. Field telegraph and observation balloons likewise enabled commanders to issue orders to widely dispersed armies and to watch the enemy more closely

European soldiers, in general, were contemptuous of the Amerıcan Cıvıl War because very quickly the American soldier learned that massed formations were deadly and impracticable and fought habitually as skirmishers. The Europeans considered the American Civil War to be a battle of armed mobs and unworthy of study It was not until the publication of Colonel G F R Henderson's Stonewall Jackson in Great Britain in 1898 that the Civil War commenced to be carefully studied in Europe. After the war of 1914-18, it was realized that the American Civil War could have supplied many lessons for the conduct of that struggle. and the tactics of this war were studied in the years before World War II more than in any period.

In 1870 the Prussians possessed the superior gun and the French the superior rifle. Although Moltke attempted to spread his armies and conduct enveloping manoeuvres, his generals, in spite of orders, led their troops into enormous huddles in which the casualties were appalling. The battles actually were won by enveloping manoeuvres, and in spite of the army commanders. And here again the soldiers instinctively spread out as skirmishers, to fight and not to die The persistence with which armies maintained close combat formations and resisted dispersion on the field of battle probably was due to the difficulty of control of dispersed formations

Artillery had become a stable element in the war of 1870. It was shown that massed defenders could be so completely broken by gunfire that the infantry attack consisted merely of occupying the ground. It was found that infantry armed with the breech-loading rifle had nothing to fear from cavalry. It was proved essential that all the artillery should be in line to initiate the attack, and must not only crush the enemy's artillery but prepare the infantry advance by a long bombardment. Throughout the war neither the French nor the Germans succeeded in taking a single position by a frontal attack.

Tactical Theories, 1875-1900 .- In 1870-71 the French lost battle after battle, yet they came out of the war as oblivious of its lessons as did Frederick's mule after its tenth campaign From 1875 to 1900 French regulations maintained the complex system of firing line, supports, local reserves and reserves in echelon. The

at Custozza (qv) In Bohemia it was otherwise, for the solid infantly regulations did not even mention artillery, which was supposed to have completed its task by the time the infantry attack was launched. The power of fire was recognized, and in order to develop it to the full, about 1895, whole battalions were moved forward in single rank without intervals between the men, and were called "skiimishing lines". Behind these walls of rifle fire 'decisive attacks," whatever these might mean, were to be launched forward by brigades and divisions in mass. In an official report written in 1875 can be read "Troops massed in column, or in line in close order, can no longer manoeuvre, fight or even remain in position under fite." Twenty years later, this lesson having been forgotten, the regulations extol dense formations, not for marching and manoeuving only, but for the attack itself "Tromes de choc." "masse de manoeuvie" and such like metaphysical terms were invented. It was considered that well-led troops must overcome all obstacles. A ventable spell fell not only upon the army of France but on all the armies of Europe

The South African War, 1899-1902 .- The South African War did little to dispel this hallucination. Aitillery action was negligible, and infantry formations, which at first were dense, were thinned out into a line of men at from 10 to 50 paces between individuals. To command such a line was impossible. To those who could read tactics aright the outstanding lesson was the power of the rifle on the defensive At Modder river (1800) the British had 3,000 men on a front of 7,000 yd , at Colenso in the same year 4,500 on a front of 13,000 yd, and at Magersfontein (1899) 5,000 on a similar frontage. These fronts could not be pierced Again, as had been learned in 1870, frontal attacks even against weakly held positions were no longer possible. The wai ended through the gradual attrition of the Boers

The Russo-Japanese War, 1904-05.-The Russo-Tapanese

War (q v ) was characterized by increasing use of entrenchments The machine gun, when efficiently handled behind entrenchments, added enormously to the defence and the uselessness of the frontal attack was demonstrated clearly. The Japanese army followed the German doctrine of enveloping manoeuvre. Artillery was driven further and further back by the bullet until the gunners were compelled to seek cover and adopt indirect firing tactics With the increasing power of the defence, it was demonstrated that artillery had become a decisive arm of battle. No other weapon was able to disorganize the system of machine-gun fire and entrenchments In broken ground the Japanese made use of moderately thick skiimishing lines, but in open country they had the wisdom to thin them out from five to ten paces between men, the men being rushed forward in twenties, 20 to 30 paces at a time In the period between the Russo-Japanese Wai and World War I, the professional armies of Europe, with customary soldier conservatism, failed to evaluate the lessons provided by the Russo-Japanese War concerning entrenchments, machine guns and artillery.

### THE EVOLUTION OF TACTICS IN WORLD WAR I. 1914-18

French and German Tactical Doctrines Prior to World War I .- In France there was a remarkable variance between the official doctrines as published in regulations and the unofficial doctrines taught at the French general staff college Official doctrine recognized the effects of fire and the danger of fire to massed troops, but it failed to realize the extent to which fire slowed down the operations of battle The infantry was expected to fight as skirmishers, but the men were to be deployed only at one-pace intervals The mobile defence was not considered, on the defensive the infantry unit was ordered to "resist to the end; each man will die in place rather than give ground" Cols de Grandmaison and Foch were the high prophets of the unofficial doctrine of the "offensive a outrance," the headlong offensive This was the moral school of war whose object was battle "Hence the idea of shock," declaimed Foch to his students, "composed of two terms: mass and impulsion." The impulsive force was morale With enough morale the shock became irresistible. But sadly, the unarmoured bodies of the French infantry were not irresistible to machine-gun fire. In the general staff college the defensive was so stigmatized that instructors did not dare to present a defensive cavalry divisions. The attack broke down in front of the second situation in a map exercise, much less in a manoeuvic on the

Like the Fiench, German doctime sought the destruction of the enemy by offensive battle German doctrine emphasized the spirit of initiative and the enveloping manoeuvre by units of whatever size Germany adopted the line of skirmishers as the battle formation but the regulations added "It should be considered that the abandonment of close-rank formations is an evil which should be avoided whenever possible " German adherence to these formations presented the French artillery with superb targets during the early part of the war. German doctrines recognized the effect of fire and insisted upon the gaining of fire superiority in the offensive. Frequent use of field works was prescribed for the infantry and after 1011 it was required to participate in numerous fortress manoeuvres conducted in accordance with the regulations for the attack of fortified places.

To sum up, the French, as well as the German official doctrines. maintained the ascendancy of the offensive, but in a more reasonable and methodical manner in Germany than in France Both made every effort to provide the offensive with superior power by economy of force for other purposes, to gain surprise, to combine the action of all arms, to pursue vigorously and rapidly, and finally both emphasized the importance of moral superiority. Neither appreciated the effect of fire fully and neither was prepared for the use of entrenchments on the scale which developed

The Period of Manoeuvre Warfare.-The battle of the Marne showed the results of a clash between two magnificently trained armies, both imbued with the doctrine of the offensive, German losses including Jan 1915, were 747,465 men killed, wounded and missing French losses in the same period were 854,000 men, while British losses were about 101,000 The German troops had better training in manoeuvre, and hence their losses were about 25% less than those of the French and British combined. The machine gun reigned mistress of the battlefield by its material and moral effect. The second phase of the battle of the Marne was characterized by continuation of the enveloping manoeuvre on a grand scale. The initiative of the movement passed alternatively from the French to the Germans The result of this was the contest for speed which was to end toward Oct. 20 when fronts were extended to the sea

Beginning of Position Warfare.-This period covers the winter of 1014 and the year 1015. The German army commenced extensive field fortifications with trench lines protected by barbed wire entanglements and other traps before the French gradually established themselves in some sort of fashion in holes they had been forced to dig to escape the effects of fire. Thus was born a new form of war, stabilization on a continuous front. The use of field fortifications revived the old struggle between projectiles and protection, with the defender continually striving for better protection from fire, and with the attacker increasing all his efforts to crush such organization by putting into service matériel of greater and greater number and power.

The Allied offensives of 1915 showed a steadily increasing dependence upon artillery. It was the amount of artillery which determined the scope of the attack, not the numbers of infantry In the first attempt to break the German front at Perthes between Feb. 15 and March 18, the frontal attack was limited to four and one-half miles because only about 100 heavy guns were available In the Artois offensive an effort again was made to break through on a front of nine miles by five corps, with 400 pieces of heavy artillery supporting the attack with a four-hour preparation This attack showed that the rupture of a solidly organized front consisting of a single position of resistance was feasible The German realization of the same conclusion led to the development of several successive defensive lines, so the continuous front was evolving from one line to a whole series of lines to which troops could withdraw and toward which reserves could flow to block an attack

In simultaneous attacks in Champagne and Artois 1,140 pieces of heavy artillery, 500 trench mortars, caliber 53, and 30 trench

German position after having progressed 3,000 or 4,000 yd on a 12-mile front. The final check resulted from the inability of the attack, which had been disorganized by the first assault, to go up against the second position. It was clear that the capture of the second position presented difficulties which the leaders of the armies did not know how to overcome. The offensives of 1915 cost the French 1,292,000 casualties, of whom 391,000 were killed, missing or pusoners. It was strange that it was not realized what a large proportion of these losses was due to such an easily correctable mistake as the excessive density of the attack formations German losses on the French front were approximately 507,000 during the same period, a tribute to the better tactical adaptability of the German army to new conditions. Even so, the German army at this time still was attempting to hold first lines to the last man

1916-Development of Tactical Methods,-The offensive of Sept 25, 1915 had brought out the difficulty, if not the impossibility, of carrying successive hostile positions, whose depth now exceeded the effective range of artillery, in one effort. The doctrines of 1016 considered the offensive battle as a series of attacks of successive positions and not as a single and brutal action Hence, the battle was to be conducted methodically from objective to objective and always included a minute artillery preparation Minute preparations for the offensive were recognized as necessary It was finally understood that the engagement of large cavalry units, after the first phase of offensive action, had become impossible. The necessity for team work between the different arms was recognized, but no steps were taken to ensure the permanent assembly of combat teams of the combined arms in units smaller than the division

The two great offensives of 1916 were the German offensive against Verdun from Feb 21 to July 11, and the Franco-British offensive on the Somme from July 1 to the end of November. Verdun developed into a battle of attrition in which the German attackers lost 278,000 men to the French defenders' loss of 442,000 Tactical surprise was obtained by the power and rapidity of the artillery preparation which used 2,000 cannon firing for nine and one-half hours Allied offensive methods on the Somme paralleled the German methods at Verdun They hoped to wear down the enemy as well as to break the front. They failed to secure the mitial surprise such as the Germans had effected. The Germans lost as many men defending in the first two months on the Somme as they had lost attacking for five months at Verdun and had put into action nearly the same number of divisions on each front.

Here appeared definite proof of the growing power of the offensive. At the same time, troops on the defensive were beginning to make use of offensive methods, ie, the counterattack, in order to maintain the defence Although it seems unreasonable that troops in the open attacking should have fewer casualties than troops in trenches defending, this apparent paradox is not difficult to explain. It is due to the effect of artillery fire. The attacker assembles secretly a greatly superior mass of artillery, destroys the hostile machine gun emplacements, eliminates much of the defensive artillery, and thus prepares the way for his own infantry to move forward in relative safety. Although the evidence was there that the offensive was regaining the supremacy which it had lost to defensive organization and the multiplication of automatic weapons, the methods of attacking effectively and of keeping attacks going after the initial assault had not been discovered. It was not until the German offensive in the spring of 1918 that advantage was taken of the powers of the attack.

In 1916 it was first recognized that air advantage had become a new condition for success. The use of gas-filled projectiles was generalized quite extensively in 1916 British tanks made their first appearance on the Somme on Sept. 15, but they were too few in number and the infantry which accompanied them did not know how to operate in liaison with them. The offensive power of the infantry itself also had been increased by wider use of automatic rifles, hand grenades, and the 37-mm. gun. Artillery was perfecting the mechanism of fire and, starting in June at mortars, caliber 248, were used with 53 infantry divisions and Q. Verdun, the rolling barrage, regulated by the rate of the infantry TACTICS 745

and preceding its advance, was introduced. Motor transportation was used on a large scale for the first time at Verdun, then on the Somme. The "sacred road" carried a daily capacity from 5,000 to 6,000 trucks which represented a density of about one vehicle every 15 seconds.

The necessity of a mobile defense was recognized for the first time. The Germans recognized the excessive density of troops in them first lines as one of the principal causes of their excessive losses on the Somme, and prescribed greater echelonment in depth on the defense so as to constitute a fortified zone 5; to o km deep, capable of hemming in an attempt to penetiate it. The conduct of the defense was to consist of real manourier. Local attacks were to be launched to disrupt offensive preparations. Artitley fine was to be used to destroy hostile artillery. Reserves were to be used defensively in the form of complete counterattacking divisions held in the rear beyond artillery range.

1917—The Year of Extreme Solutions.—The use of artilleny was increased to save the infanty from its paritysis in front of automatic weapons and barbed wire. In the Asine offensive in the spring 2,000 pieces of heavy artillary, 172 155,5mm GPF guiss and 1,650 pieces of trench artillery were employed on a 25 m front, but the attack broke down against the secondary positions. Tanks were used under unfavourable conditions and suffered severely from German artillery. The elephaniass of shell fire reached its zenith in the third battle of Ypres (g v). This battle slated approximately three and one-half months, and each square mile of mid genied cost the British army 3,22 casualties states of Aug. 20, north of Verdon, reached the figure of one gun per seven yards of front, while at Malimano, Oct. 25, the density was one zun per sa yards of front.

In the Cambrau offensive of Nov. 20, the British used large numbers of tanks and finally attained surprise by completely dispensing with artillery preparation and commencing the battle with a tank attack. The initial success was very great, but methods of co-operation between infaintry and tanks had not been well developed. Tanks left the infaintry behind, while the cavalry, which was supposed to enter the gap, was held up by solated resistances passed over by the tanks. It was shown at Malmason that hostile artillery could be neutralized more effectively by short and intense bombardment by persistent gas than by days of attempted destruction with high explosives. This lesson, however, was to be learned by the Germans more effectively than by the Allbes and used by them in their offensives in the spring of 1918.

1918—Breatking the Continuous Front.—In the battle of Picardy, which commenced March 21, 1918, extreme measures were taken by the Germans to ensure surprise. Fifty divisions marched nine nights. Camouffaged rest areas hundreds of yards square were constructed to concest the divisions marched nine nights. Camouffaged rest areas hundreds of yards square were constructed to concest the divisions in the daytime. Wheels of all vehicles approaching the front were wrapped to make them silent. False activity was conducted at many other points equal to the necessary visible activity behind the front of the attack. Troops marching at night had orders to face about and reverse their direction of march if they were discovered by flares dropped by aerosphanes. There were 6,475 cannon and 3,532 trench mortars assembled on a 4,4 mi. front for the artillery preparation of five hours and ten minutes.

As to notical procedures, the battle was divided into two phases. Durng the first phase, or battle of position, the infantry advanced under the cover of the rolling barrage. The artillery first and plans of advance were all munutely co-ordinated by the higher commanders. The second phase commenced as soon as the limit of the rolling barrage was reached; or whenever the infantry lost its liaison with the artillery. During this phase the initiative was to be assumed by the battlelion and regimental commanders and they were to move forward searching out weakness and passing by strong points as rapidly as possible and without regard to units on either side of them. In order to make it possible for the smaller infantry units to advance, they were organized into small combat teams, each battalion having accompanying artillery and engineers so that the infantry commander would have under

his own control the power to ieduce minor resistance beyond the

Although this attack was an outstanding success and succeeded in tearing a great hole in the front between the Bittsh and French armies, the Geimans were unable to exploit the gap rapidly enough German initial superiority was roo divisions to Allied 175, or eight to seven. The actual numerical superiority was less than this Ludendouff had not counted on the slow highly more produced by the first three days, while the actual advance amounted to a fam. The lack of rapidity in forward movement gradually wore out the effects of suprises in the break-through, and French testress arrived in time to re-establish the continuous line.

The German offensive of May 27 on the Aisne repeated the initial success of the offensive of March 21 This attack also was The French had not followed General Pétain's prea summe scriptions which required that the forward defensive line should he lightly held and the main resistance should be made on a line to the rear The result was that the French reserves attempting to flow forward to support the heavily occupied front lines were en-The attack progressed from 15 to 25 km all along the front Had forces for exploitation been available early in this offensive, the road to the rear of the Allied armies was wide open again, but these did not exist The Germans had used 42 infantry divisions in this offensive by June 4, had advanced 50 km. The new military problem posed in World War I-the break-through of a continuous front-had been solved by the Germans though they had been unable to exploit its success (T. R PH ; X)

## EVOLUTION OF TACTICS UP TO WORLD WAR II

Two schools of thought concerning the power of defense grow up after World War I. One contended that the defensive was constantly growing more impregnable and that it was hopeless to attempt to break through barriers of obstacks, automatic weapons and cannon that science, invention and industry would produce. The other interpreted the lessons of 1918 to mean that a produce, the produced and conducted offensive could overcome whatever defensive advantages may have developed

While French official doctrine continued to maintain its faith in offensive operations, the general public's reaction from the casualities of World War I, which mistakenly were blamed on the offensive, supported a defensive theory. This led to the construction of the Maginot line which, according to one French general mentality of the French nation was defensive, even though the official doctrine was offensive as of the property of the proper

German doctrmes after the war developed in an entirely different way. Whereas the French doctrme prescribed the utmost in prudence and centralization, that of Germany emphasized speed in the attack and the maximum in intuature, boldense and decentralization. Every unit was expected to manoeuvre independently and the enveloping attack was stressed as the most effective form of manoeuvre. The counterstack was emphasized as the most important element in the defense.

Theories of Tank Employment—The evolution of theories for the employment of tanks went hand m hand with the evolution of tactical doctrines. The tanks of World War I had scored one great success at Cambria, although it had not been exploited and led to no result Schools of thought in tanks were represented by those who beheved in the tank as a sort of modern cavalry going off on independent missions by itself, and by those who believed that the tank was purely an infantry auxiliary, incapable of independent action.

In France the doctrine was consistently held that tanks primarily should support the infantry. The French scheme of employment was to have the artillery prepare the way for the tank attack, much as it had prepared the way for the infantry attack in World War I; then they would move out in successive waves with 300 or 400 yd. between waves The infantry would receive no artillery support but would depend upon the tanks to destroy any resistance that held it up. The French scheme did not take advantage of the speed of the tanks but instead tied them to the

ınfantry

Development of Mechanized Forces of All Arms -Ougnal conceptions of tank forces had visualized them either as iron cavalry units with some attached artillery canable of making raids but incapable of undertaking any serious operations, or as infantry supporting weapons incapable of independent action. In Germany these conceptions were discarded and a large percentage of the tank forces were organized into complete high-speed mechanized teams of all aims. Called the panzer (armoured) divisions, they consisted of one brigade of about 450 light and medium tanks and another of infantry in cross-country motor vehicles with half tracks, motorized artillery and motorized machine guns, anti-tank guns, etc Here was the first development of a fighting team with a speed different from any hitherto used in warfare. The German armoured division had a composition which made it capable of defensive as well as offensive action. It not only could overcome fair resistances with its own means, but it had enough infantry and supporting weapons to hold Aimoured divisions in Germany were organized into armoured corps. These might be composed of one armoured division and two motorized divisions, or of two armoured divisions and one motorized division, depending upon the task to be accomplished

In France the conception of armoured divisions was present. The official Instructions for the Toucacle Employment of Long Units, published in 1937, recognized in the foreword that there should be two types of teams (1) the ministry division moving at the speed of foot marching, and (2) the mechanized division moving at the speed made possible by motor. French doctrine, however, was ahead of French practice and at the outbreak of World War II in Sept 1939, France had only three mechanized divisions, whereas Germany had ten.

Cavalry .- In Germany, the cavalry was finally reduced to a single brigade of three regiments in East Prussia, and this was included as a minor element in the general German organization of "fast troops" Horses, likewise, were used in the organization of squadrons whose purpose was to conduct the close-in reconnaissance for the divisions and corps. In Great Britain, after much discussion, cavalry was almost entirely disbanded. In France, it was retained both in the metropolitan army and in the colonial annies The USSR, and Poland likewise maintained large numbers of cavalry In the United States, the development of mechanized formations was assigned to the cavalry, which much preferred the horse, with the result that horse cavalry was retained in considerable proportion in the U.S army, while mechanized development was behind that of any other great nation in the world When the German mechanized formations proved themselves so formidable in Poland, the United States was confronted with the paradox that the greatest industrial nation on earth had the least industrialized army.

Spanish Civil War.—The Spanish Civil War (July 17, 1936— March 19, 1939) was proving ground for theories and weapons developed, since the close of World War I. It was so used deliberately by Germany and Italy, and by the U.S.S.R. to a lesser extent. Other autions were inclined to discount the lessons to be learned in Spain because relatively small forces and limited amounts of matériel were used

The principal lessons from the Spanish war were: the vulnerability of light tasks to anti-tank weapons; the enormous assistance that aviation supplied to ground forces by bombing operations similar to artillery support on hostile lines and rear areas; the failure of bombing to destroy civil morale, the extreme difficulty of bombing roads and railrosads with sufficient intensity to disrupt their functioning; the vital importance of a well-trained infantry; the tremendous assistance that tanks could brung to the infantry stack; and proof that fighter aviation still was able to overcome bombers in combat.

The Doubet Theory.—Another outgrowth of the belief in the impregnability of defensive lines was the so-called Doubet theory, Gen. Giulio Doubet of Italy contended in his book Mastery of the fir that future wars would be fought on a continuous front, and that both defensive fronts would be so strong that neither contender would be able to break through. His solution to the sup-

posed invulnerability of the fronts was to pass over them with bombing planes and destroy the hostile industrial and transportation systems. General Doubet carried his theory far enough to include terioristic hombing of the civil population as a legitimate objective in the effort to make the enemy was for posace.

It was noteworthy in Germany, wheie the Doubet theory had considerable support for a time, that when the Pohish war was lought in Sept 1939 German avantion confined itself to attacks on objectives that would assist the advance of the ground forces. These objectives included Pohish avaistion and Pohish transportation facilities, as well as troops and services directly in the lear of the ground armies.

Tactical Doctrines on the Eve of World War II —The great latical problem confronting the aimes of the world after Wold War I had been to estore mobility to the battlefield. Even before the Armstre of 1918 the stalemate which had followed the appearance of the machine gun and great quantities of artillery had already seemed to be on the wase. The first use of the armound tank was one portent of future trends. The Alhes, however, had used tanks in pecceneal fashion, so that no new tactical concerv were immediately formed. Another portent was the Ludendorff attack by infiltration in March 1918. The driver failed ultradiction to the state of the process of the state of the process of the state of the process of the state of the

The development of mass-production methods for the manufacture of reciprocating engines provided the real means for restoring mobility to the battlefield. The years between World Wars I and II saw the growth of facilities for the quantity production of aeroplanes, armoured vehicles and cargo carnets. Armies no longer had to rely on the mustel power of men and animals. Relative quantity and quality in planes and tanks and the soundness of actual season of the comparative strength of the world's armies on the tacts deviated for their employment were the main criteria for assessing the comparative strength of the world's armies on the national expiration of the world's armies on the national expiration and the production of the world's armies of the world's armie

All the major nations stressed the offensive in their official doctunes But doctrine was often contradicted in actual practice. The French in particular, as mentioned above, relied on defensive measures, the Magnot line was a dominant element in tactical thinking. French plans were to hold in place defensively with infantry and artillery until the enemy wore humself out by repeated efforts, at which time the French were to launch an overwhelming offensive

In Great Bittain national apathy and small budgets retarded the development of tanks and armoured forces until the very eve of the wai. The same was true of the United States. The air forces of the two nations after World War I showed strong tendencies toward independence and separation from the airny In Great Britain this organizational change was made within a few years.

The Soviet Union, with its wealth of manpower, made vigorous efforts to mechanize at least a part of its army. The Russans experimented with light and heavy tanks and their air force was closely integrated with the ground army. It was strong in a trillery, mostly horse-drawn. The real strength of the Red army continued to be its masses of infantry.

The Japanese army was built around its infantry. Tanks were light and designed to accompany infantry units; its air force was tactical in composition and was part of the army.

When Adolf Hitler began to rebuild Germany's armed strength in volation of the treaty of Vessailles, his general staff was able to start afresh, unburdened with weapons and transport of an earlier generation. They could create an entrely new army, designed to harness the aeroplane and the armoured tank into powerful offensive weapons. The result was the Paneer-Stuka team. But at the same time the Germans did not neglect infantry. The mass of the combat force was organized into infantry divisions, The weight and firepower of the infantry-artillery team gave the German army power; the shock and speed of the Paneer-Stuka team gave it mobility. Its enemies were soon to be discomfitted and discredited by the early successes of the Wehrmacht. The

fectiveness of the army they had built so rapidly

#### EVOLUTION OF TACTICS IN WORLD WAR II

Campaigns in Poland and Western Europe, 1939-40 .- The German army's tactics in Poland in Sept 1939 and in France and the Low Countries in May-June 1940 were to be followed in the main by all the armies taking part in the war. In Poland, the German attack began with a conventional infantry-aitillery oftensive. When the Polish line had been penetrated, the armouned divisions poured through with orders to deepen and widen the break with all possible speed In World War I such penetrations normally failed to become more than shallow salients. Now the speed of armoured vehicles permitted the Germans to pass rapidly through Polish lines and stuke deep into the Polish year. These penetrations were followed by many separate engagements involving small forces of Poles which were systematically isolated and destroyed by hard-hitting German units

Meanwhile the German air force attacked communication lines and centres, troops concentrations and other targets of opportunity with light and heavy bombers and fighter planes aimed with machine guns This prevented the Polish command from reacting in time to cope with the penetration. The campaign was a brilliant justification of the air-armoured team, a Polish army of almost 1,000,000 men was destroyed in less than a month

The campaign against France and the Low Countries in the

spring of 1040, following the occupation of Norway and Denmark. combined conventional and unconventional tactics and techniques Despite the months of waiting between Sept 1939 and May 1940. the Allies had failed to cover the exposed left flank of Belgium and the Netherlands When the Germans attacked the Netherlands, Alhed reaction was not fast enough to close the corridor. Actually the German effort in the Low Countries proved to be a feint designed to lure French forces away from the Ardennes where the main effort was to be made. German success was due in part to their employment of parachute and glider-borne troops About 4,000 parachutists seized Dutch airfields, bridges and crossroads The Belgian strongpoint, Foit Eben Emael, was invested by both glider-borne forces and by a frontal attack of specially trained engineers armed with flame throwers and explosives These operations had historical importance as the first uses, on a large scale, of the tactics of vertical envelopment

While the Allies were attempting a defensive stand in the Low Countries, the Germans prepared to unleash their main effort through the Ardennes, an army group with an available strength of 86 divisions of all types was given this mission. The first movements, more like an approach march than a tactical operation, were made by three panzer corps, arrayed, according to B H Liddell Hart, in three tiers, the first two comprising armoured divisions and the third motorized infantry divisions. The advance across the forested Ardennes hills was more a logistical than a tactical achievement. However, it achieved tactical surplise. The first armour in the sector crossed the French frontier on May 12 and pushed forward without waiting for infantry to come up The leading units reached the Meuse river and that night reserves closed up On the following day, while armoured infantry began the crossing, the Luftwaffe appeared with about 1,000 aircraft to protect the effort. There, as in Poland the previous year, German dive bombers performed the functions of artillery for the leading German units Crossings were made at three points against little opposition. A gap of 50 mi was cut in the French lines behind the Moselle, and the panzer divisions drove behind the backs of Allied forces in Belgium. Fears of a French counterattack on the German left flank led the German commanders to hold their armoured and mechanized units in check for several days, and to insist that the pace be that of the slower moving infantry units. whose mission it was to protect the open flank. No counterattack materialized. The French command had paved the way for the German success when it rushed its left-wing forces into Belgium to meet the German feint.

Following the evacuation of the British at Dunkirk, 40 German divisions were turned toward the French. Facing them were 37

German generals themselves were sometimes surprised by the ef- divisions but their deployment lacked the depth and effective orgamzation needed against the swift and relentless attacks Maginot line was struck from the rear, while German infantry made holding attacks in front of it. The end of organized resistance in France soon became mevitable

The speed and completeness of this victory surprised the Allied and neutral world, and even the Germans The offense seemed to have gained ascendancy over the defense to a far greater degree than ever before The whole lesson of this operation was not immediately understood. Blame for the disaster was placed on French leadership, military and civilian, during the years between wais, while much credit was given to the new and brilliant operations of the Panzer-Stuka teams There was a tendency to overlook the great masses of German infantry and artillery which had held the French in place while mechanized units were pushing to the vital rear areas German infantry also had the important consolidating role of destroying strong points by-passed by the mechanized units, and of protecting the flanks of the armoured columns

A prime cause of the dramatic successes of German armour was Allied weakness in anti-tank weapons The occasional real successes by scattered French and British anti-tank units in destroying German armour supports this view A more imaginative high command, a better national esprit and a large quantity of modern anti-tank guns and land mines might have brought a far different decision in the battle of France Instead, the campaign created a conviction of German invincibility on the battlefield, a conviction that influenced western thinking until nazi reverses on the soviet front demonstrated that the Wehrmacht was mortal after all,

German Campaigns in the U.S.S.R.; Red Army Tactics .-The Polish and western European campaigns introduced the world to blitzkreig or lightning war Against Soviet Russia, beginning in June 1941, German successes were at first as great as those in western Europe a year earlier

The eastern campaigns of 1941 had as their objective the annihilation of the Red army. For a time, German application of the Cannae tactics of double envelopment on a larger scale than ever before were particularly effective. Large segments of Red army forces were encircled and destroyed, they were forced into such great sahents as that of Minsk, which was 250 mi deep. But two factors worked against blitzkreig poor roads, and the almost inexhaustible reserves of Russian manpower. Despite gloss errors in defensive tactics (or lack of any tactics at all) the Red army was not annihilated The ability of the soviet forces to trade space for time and their willingness to employ a scoiched earth policy in their homeland saved the Red army in the early months of the war The campaign in Russia became a war of attrition which the Germans could not hope to win With winter approaching, Hitler obstinately refused to permit the extended and isolated German forces to withdraw This was a blunder of the first order. its ultimate effect being to weaken German strength with no possibility of benefit

After an unusually severe winter marked by Russian counteroffensives against German defensive fortified areas, the Germans launched a new campaign in the summer of 1942. These attacks, tremendous in terms of distances involved, were now aimed at the economic sources of Red army power. The Red army having proved too deep in reserves for annihilation in set battles, the new strategy was to destroy its means of sustenance Tactically the campaigns were a continuation of penetration and infiltration, with German armoured columns making deep and rapid advances But Russian distances, the crude state of Russian communications and Hitler's strategic errors combined to leave the German aimies. as the second winter approached, deep in Russian territory with Red army forces on all sides.

Two campaigns in the following summer blunted the German blitzkreig for all time. But Red army opposition must be given less credit for the German failure than Russian geography, and its poor roads and railways; the Red army's defensive tactics ment little attention The stolid, unimaginative bravery of the individual Russian soldier also must be taken into account. The red partisan or guerrilla forces which attacked unceasingly and ferociously at any and all points from the Russian frontier to the most eastward penetration of the German columns were pastucially effective. In the early stages of the campaging the Red amy soldier was expected to hold inst and fight the attacker to the end. Later, as the Red army took the instantive, simple team factics of manoeuver and fine were used and there was greater and bolden use of combined arms. During the war Red army propagands often insisted that new tactics and strategy were being created by the soviet forces. Late evidence faeled to support thus claim. The Soviet Dinion fought a war of attitution, tactically unmanagnative and essentially primordial, ptiting its weight of numbers against every obstacle. Its artillery (including a great number of mortias) was used exterior to proper the production of the properties of the properti

Search for a Defense to the Tank-Plane Team—In 1914—13 the machine gun had driven infinitely info deep trenches, while attillery had greatly reduced the attacker's speed and impetus. The campaigns of 1930—5 demonstrated that the machine gun and artillery no longer dominated the battlefeld. The tank was immune to machine-gun, rine and unfanty mortar fire and could also travel over ground torn and blasted by artillery fire. The close-support aeroplane increased this new mobility. Bombing and strafing attacks on artillery communications and fire direction centres hampered the necessary laison between guns and front lines, mfantry reserves rushing up to plug a weak or penetrated sector could be delayed or even destroyed by air attacks on its columns. Thus mobility was restored; trench warfare and the continuous front almost disappeared.

The defense sought answers to the German blitzkreig. The answer to armour was defense in depth, land mines and front-line guns that could penetrate the armoured hulls of tanks. The answer to the attack aeroplane would be found, so airmen insisted, in achieving complete air superiority and driving the enemy air force out of the sky. Other defensive measures like increased anti-arcraft fire and better camoulates also proved effective

The first field gms to be used by infantry as anti-tank weapons were of small calibre (about 37 mm.). They could penetrate only very leph armour Heavier guns of 57 mm., 75 mm. and even too 3 mm. eventually appeared as infantry weapons. Special units were organized to fight tanks. In the U.S army these were known as tank-destroyer units. Essentially direct-fier artillery, they were armed with lightly-armoured, high-velocity guns, either self-propelled or towed. The self-propelled weapon was highly mobile (usually it was a half track, the rear wheels being replaced by an endless track like that on a tank). Its armour gave ittle protection and its high silhoutte made concealment difficult. The towed gm had a low silhoutet, but lacked armoured protection and speed of movement on the battlefield. U.S doctrine called for tank-destroyer gms to be massed and emplaced to over natural approach routes of hostile tanks. They were intended to ambush rather than pursue tanks.

Until late in the war (about 1904), the use of tanks to fight tanks was generally held to be undestrable. Tanks were considered to be offensive weapons primarily, and their employment against other tanks wasteful and hasardous. Atmoured commanders felt that to disperse tanks on anti-tank missions involved a risk of their not being available for counterattacks. However, the campaign rilay (and in fact wherever the terrain was ususited to deep and rapid penetrations by armoured units) was to demonstrate the defensive usefulness of tanks as anti-tank weapons. Before the war ended the principle that tanks should not fight tanks was generally abandone.

Another defense against the tank, long known as an antipersonnel and anticavalry weapon, was the land mine. To protect itself from armoured attack, a defensive force would plant these mines in front of its position, especially along natural approach rouse. Mines were not used by attacking forces except when forced into a temporary defensive position.

5. The infantryman feared the charging tank. His best defense being the ground itself, all armies taught their foot soldiers to dig the deep but narrow foxholes in which a man could crouch in com-

parative safety even though a tank rolled directly over his position. The holes also gave excellent protection from small arms, mortain and artillery fire. Only a direct bit was thirdly to be fatal. Chief weapons of the rifle-carrying infrastryman against the tank were such explosives as greandes (notably the Molotov cocktail), rockets firing basooks semploying the hollow charge and, near theen doff of the war, recoilless rifles, which in effect were light artillery press carried by one or two men.

Development of these techniques and weapons gradually resulted in defensive and offensive tactics that were quite similar in all armies Defense in depth to meet penetiations or envelopments largely replaced the stable trench warfare and continuous front of World War I Mobility and mechanization of the forces meant that centres of communication took on new importance for both attacker and defender, since advance or withdrawals necessarily followed roads and established lines of communications. The high degree of mobility made penetrations and envelopments commonplace while all-around defense became an essential factor of security No longer was it safe merely to rely on outposts to the front, the rear and flanks became equally vulnerable. This was true even of units not in the front lines when conditions were fluid, as during a major attack or break-through A variety of defensive positions was developed, all having the common virtue of affording protection from every direction

Task Forces and Other Special Combat Groups.—The appearance of weapons and techniques able to cope with tasks and close support aircraft re-established infantry as the arm of decision. The principles of infantry attack (fire and movement remained But the mobility and firepower of the aeroplane and tank altered the application of these principles. Dispersion became a cardinal rule of the battlefield, the tight and firm close formations of earlier days had to be abandonic

Cover and concealment also became factors of survival for the individual solder. The smaller units of infantry achieved more and more independence as evidence mounted that success depended largely on the initiative and skill of subordinate leaders in close contact with the enemy. Field armies of all nations tended to be divided into relatively small combat teams or task forces, equipped and organized to perform missions assigned by higher headquarters. This system put a premium on leadership, skill and initiative at all levels and decreased to some extent the control exercised by higher commanders on the course of the battle once his forces had been committed. The degree of independence varied with the policies of the high command, the nature of the task force, its mission and its ability to maintain contact with friendly forces on its flanks and to its rear.

Task forces were normally composed of small units of combined arms Some task forces were virtually small armse composed of elements of all the combat arms (infantry, artillery, engineers and communications); are power was either attached to or made an organic part of a task force, depending on the doctrine and organizational customs of the country concerns.

Assaults on fortified enemy strong points, amphibious operations and other special missions usually were given to task forces whose units were specially trained and equipped for the task because the special proceded their commitment, until everyone in each unit knew what he was to do and why The previously mentioned German assault on Port Eben Email was among the first to be performed by a force that had been assembled and intensively trained for a single specific combat task.

Eventually the composition of such forces became more or less standardized. The familiar combat team of the infantry division was a kind of task force. It was composed of a regiment of infantry, a battalou of field artillery and (when necessary) units of engineers and other arms and services. The combat commands of the armoured divisions, composed of tanks, infantry, artillers and other arms, were likewise small task forces. Their usefulness was most evident and dramatic following a penetration of the enemy's main line of resistance. Combat commands would then be assigned specific objectives deep in the enemy's rear. Working together for their mutual protection and advancement, each element of a command could supplement and offset the strength and weakness

of the other arms Infantly protected armour from close-up attacks of enemy minartry and anti-tank guns Tanks, in turn, attacked enemy machine-gun aests and protected infantry from armoured counterattack Engineers helped in the assault on fortified strong points and in bridging streams. Arthlley, following closely behind the units in contact with the enemy, performed its historic missions of neutraliargo or destroying targets dangerous to both the armour and the infantry and of extending the depth of the combat area

The task force concept was eventually extended down to the smallest combat units An infantry platoon leader, for example, might at times have under his temporary command a squad of engineers and a single tank. Larget task forces, exceeding division strength, were not uncommon for special operations, as in some

of the Pacific Island Invasions

Development of these combined arms teams gave armies greater flexibility without induly altering their traditional organizational forms. It permitted high commanders to apply forces in the strength and composition best suited to the needs of a particular situation. Thus all armies tended to become more efficient in their use of trained manpower and weapons.

Air-Borne Forces and the Concept of Vertical Envelopment—Long before human fight was a resitive, mittary thinkers had recognized the tactical results that would ensue if soldiers might fly over the enemy's lines and drop behind him. The first actual proposal for such an operation had been advanced in 1918 by U.S. Gen William Mitchell in France, but never got beyond early planning stages. The growth of the concept of air-borne forces logically contided with the development of improved aeroplanes. The theory of vertical envelopment received the earnest attention of most armles in the years before World War II.

The Germans were the first to use parachute and glider-borne troops in battle in the Netherlands and Belgium, they were also the first to use such forces on a major scale, in the successful invasion of Crete in May 1941. Crete was defended by 27,550 troops, mostly evacuees from the disastrous British campaign in Greece. They lacked sufficient weapons and equipment, particularly tanks and artillery The royal air force had evacuated the island, and the nearest air force bases in Africa were too distant for effective defensive air action. The Germans surprised the Crete garrison when they followed a heavy bombing attack with an invasion by parachute and glider troops. In the bitter fighting one German force was almost wiped out by the poorly armed defenders, but more German forces were flown in, and the several groups of British forces were surrounded and gradually decimated in piecemeal fashion. Throughout the battle the invaders received heavy air support, the bombing and strafing of aircraft providing an effective substitute for heavy artillery. Although German casualties were heavy, the success of their vertical envelopment of Crete stimulated Great Britain and the United States to further efforts in developing air-borne forces of their own. Strangely enough, an opposite reaction occurred in Germany. Hitler was appalled at what he considered the needlessly heavy losses. He concluded that the element of surprise was essential to successful vertical envelopment, and that such surprise would be almost impossible to achieve in the future This view caused Germany to neglect further air-borne efforts until after the Allied air-borne success in Sicily in 1943. In this operation, despite the fact that only a minority of the troops landed in the assigned drop zones, the air-borne forces contributed much to the establishment of the beachhead by destroying German and Italian strong points and especially by delaying a German armoured division's counterattack on the sea-borne forces.

In the Normandy landings of June 6, 1944, three air-borne divisions (two U.S., one British), flying in 3,93 sircraft and 867 gilders, landed before daylight at several points behind the beaches. The primary missions were to disorganize the German rear destablish defensive areas on the east and west side of the planned beachhead. The British division landed on its zone and accomplished its missions. The U.S. divisions performed effectively although they were hadyl dispersed in dropping and lost much of their equipment. The accidental dispersal of the U.S. forces accidents.

tually proved of tactical advantage to them. The German defense plan aganst vertual envelopment had not envisaged so much dispersal of the opposing forces, so that German defense units were unable to group and gight according to plan Instead, small unit supposes of adsponted on the plan fasted of the plan special control of the plan spe

Allied air-horne operations in the Netherlands in Sept. 1944, although partially failures, were of a scale and type indicative of possible future trends in this form of tactics The three air-borne divisions that had dropped in Normandy were joined by the Polish 1st brigade and British and US troop-carrier groups to form an air-borne army For the first time there existed in one organization air-borne forces and the means of transporting them. This important development gave the air-borne army commander control over the planes assigned to escort and support the operation. The unusual tactical plan demonstrated the flexibility possible in aerial envelopment. The three air-borne divisions and the brigade were to be dropped along a single axis of communication from south to north. The two southernmost divisions were to seize bridges over intervening streams and provide a corridor for the rapid advance of the British and army The third division and the Polish brigade were to seize the bridge over the lower Rhine at Arnhem and await relief by the 2nd army Firm German resistance, however, delayed the ground advance, and the air-borne forces at Arnhem were all but destroyed by German armoured counterattacks This confirmed what had been feared, that airborne forces as then equipped could not hold indefinitely against armoured forces beyond the time set for the link-up with friendly ground forces

In the crossing of the Rhine north of Wesel by the British and army on March 23-24, 1945, two air-borne divisions (one British, one U.S.) supported the attack with a close-in daylight landing. The two divisions were flown in a single flight, 1,572 aerojions and 1,365 gliders carrying 17,122 officers and men, 0.44 peaps, 266 artillery pieces and mortans and hundreds of tons of suppless. Cover over the drop zones was provided by 900 fighter aircraft, while 1,253 fighters provided a screen east of the Rhine. So complete was air superiority that the few aircraft losses resulted entirely from anti-aircraft defenses.

Amphibious Operations—The crossing of even a lightly defined water barrer has always been considered among the most hazardous of tactical operations. Until World War II, the hisstory of amphibious operations had not been one to inspire confidence in their feasibility. Among the failures of note were the attempted invasion of England by the Spanish Armada in 1504, San and the costly and ill-fated Dardanelles campaign of the Allies in 1915. But in World War II, the total number of overwater assaults, successful and otherwise, exceeded those of all earlier wars combined.

There were two reasons for this. The first was the nature of the war itself. Especially in the Pacific, where the seizure of island bases became a major factor in the advance, many amphibious operations took place. In Europe such operations ranged from the one at Narvik in 1940 to the mammoth invasions of the channel and Mediterranean coasts in June and Aug. 1944. The latter operations were strategic in scope, being essential to the gaining of an Allied toe hold in western Europe in order to meet and destroy the German armies. A number of amphibious operations off the coasts of Europe were primarily tactical in nature. Examples include the two small flanking operations on the north coast of Sicily during the Allied campaign for that island in 1943, and the attempt to outflank the Germans in Italy by establishing the Anzio-Nettuno beachhead in 1944. Although Allied forces retained the Anzio beachhead at great cost, this operation failed to achieve its projected aim of forcing the Germans to evacuate their strong positions and retreat to the north of Rome.

748B TACTICS

The second reason for the many amphibious operations was that they had become feasible because of the development of special techniques and machines for overwater assault. The early amphibious successes of the Japanese against the Philippines, Malaya, the East Indies and the Aleutians were accomplished without many of these refinements. The Japanese had developed an assault boat mounted with a machine gun and other improvised equipment, but these were primitive compared with the sweet types of landing craft developed by the United States and Great stamplishous tanks, weapons and personnel carriers, small craft that fired batteries of rockets toward shore, specialized craft as amphibious tanks, weapons and personnel carriers, small craft that fired batteries of rockets toward shore, specialized communication equipment for the direction of navial firepower and tactical air power operating from accraft carriers.

The special British anophibous forces known as commando units staged a number of raids on the European coast during the years that Hitler ruled western Europe, the most notable of these being the Dieppe raid in the summer of 1942. No other nation followed the British method of forming these units with soldiers, sailois and airmen on a permanent basis. U.S. practice was to form a joint command for a specific operation, assigning army, marrine, navy

and air force units as needed

Despite the vast technical developments, amphibious assults against a defended coast continued to be costly and hazardous. Overwhelming strength in men and firepower, placed at decisive points, was essential for success. Such concentrations contributed to the canadities when attacking beavily defended beaches. In the Pacific, heavy U.S. losses in amphibious operations could be laid in part to fanatic Japanese opposition, and in pait to the smallness of the islands. The latter factor, by instituting operations could force for tactical movement, usually worked against the landing forces.

The time limit imposed on the navy command was another critical factor in these operations. It alose from the need to protect the invasion fleet against counterattacks by enemy submarines, surface ships and carrier-based or other hostile aircraft.

Amphibous assaults are featured by the concentration of forces in a relatively small area. Manoeuve is impossible until the beachbad is secured and the assaulting forces consolidated. Even with supporting aerial bombardment, naval gonfre and rocket fire from small craft, the first mnutes or even hours on the beach-head constitute the critical stage during which the valour and skill of men armed with rifles and machine guns determines the outcome.

Two theories of tactical defense against amphibious assault were favoured at various times. One is that the assaulters should be met on the beach with fire and prevented from landing. The other theory is to permit the landing and then to launch a strong counterattack before the invading forces can regroup and consolidate. Neither theory proved superior during World War II. In at least one instance a disagreement on this point became a boon to the invaders In 1944 the German command was divided on the question of defensive tactics to be used against the expected invasion of France Field Marshal Karl von Rundstedt, commander in chief of German forces in the west, favoured light resistance to the actual landing, with the main strength being reserved for counterattack. Field Marshal Erwin Rommel, commander of German forces in France, believed that the landing should be contested from the first landing on the beaches This led to a compromise. German infantry was on the beaches at Normandy but the armoured units were located well inland. This lessened the defensive effectiveness of both elements.

The invasion of Leyte Island in the Philippines in 1944 by U.S. forces under Gen. Douglas MacArthur featured deception and surprise; the Japanese expected the blow at another point. Consequently the beachbead was established with little opposition; the heavy fighting occurred inland a short time later. In the invasion of Okiasaw the U.S. roth army was permitted to land unepoposed, after which 'the Japanese attacked the beachbead. Neither of these tatckila methodsp. prevented the landings and subsequent advances from the beachbead. Superior U.S. firepower and teamwork of the combined earns operations both types of defense by the

Tapanes

By the end of World War II the tactics of amphibitous assault and been developed to a degree never before attained A seusof successful operations had proved that trained, intelligently led forces of any nation whose industrial potential could produce the necessary quantities of complex and costly modern arms and equipment could successfully assault any costs having tenan suited to the establishment of a beachhead and eventual manocurvabulity inland Ironically, the amphibitous assault renched this high degree of usefulness at the same time that a new weapon was born, one effect of which was to make the concentration of forces in numbers for such an assault extremely dangeous An atomic bomb, employed at the time of greatest concentration, could almost certainly disperse, if not completely destroy, the largest amphibition force

Conditions of Terrain and Climate.—Terrain and climate impose definite limits on tactical methods. In theory, these factors cause adaptation of standard tactics rather than tar-reaching changes. It is seldom that the adaptation is so unconventional as

to become something altogether different

Special units trained for operations under specific conditions were used frequently in World War II The US langers were élite troops, trained for all types of operations The British commandos were trained almost solely for amphibious operations The US marine corps raider battalions were essentially strong scouting and patrolling units, trained to operate behind enemy lines in all conditions of terrain. In Burma the British developed long-range penetration groups which, supported and supplied by air power, operated far behind enemy lines, establishing road blocks, attacking enemy headquarters and supply dumps U.S -Canadian special service force, organized and trained for arctic duty, eventually did its fighting in the mountains of Italy, Although several U S divisions in training were first designated as light and mountain divisions, all but one were eventually trained and equipped as standard infantry divisions before being committed to combat

Except in the deseats of Africa, where the tactics of armoured units came to full flower, unusual terain conditions encountered in World Wai II usually precluded the use of machines and large forces. In the jungles of the southwest Pacific and Burma, small forces generally manoeuvred along trails and streams, with the dense jungle providing a measure of security on the flanks. The objective usually was to secure bases and artifields for future operations to deny their use to the enemy. A frequent sectral aim was to cut on the flanks of the control of the

In all battles fought in mountains, infantry proved to be the arm of decision Armour and artillery supported infantry in the mountains of Italy whenever possible However, infantry's most useful support office was provided by its own accompanying weapons, especially mortass which could be carried to spots inaccessible to field gains. On Attu, in the Astunan, filemen shattled snow, can defrexing temperature at the strength of th

Japanese Tacties.—National characteristics and traductors often influenced Japanese tactics. The Japanese conquest of Malaya in the spring of roas combined amphibious and jungle was fare in a model of tactical skill and efficiency. The biltr of Malaya and the capture of Singapore were accomplished with very little armous and artillery support with the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the state of the Malayan peninsula, dragging small two-whele clark loaded with supplies, machine guns,

mortars and ammunition

When the Japanese began to meet equal or superior forces capable of fighting them with then you take tool inflution and isolation, they siftered a succession of defeats, and it was then that their national characteristics and truditions began to appear in Japanese takes. Mental inflexibility was owdent in their insistence upon following set plans even when the stutution had rendered the original orders entirely unfeasable. Japanese commanders of all echolons displayed; a marked lack of multiture, a fact that made their tactor; rigid and, in time.

TAD 749

easily discernible to Allied commanders. The Japanese banzar attack was simply the culimination of this characteristic obtuseness. The banzai can haidly be called a tactic, since it served no military purpose except to destroy a few of the enemy in a suicide attack. It was

Influence of Technical Developments.—In Europe World War II seemed to end as it had begun, with mechanized forces and air power sweeping across Europe But if we consider the full import of five years of technical developments and then influence on tactics, the

similarity between 1940 and 1945 is seen to be superficial

By 1945 the attack seemed to be as superior to the defense as it had been in the spring of 1940 But the British and French in 1940 were not equipped to stand up against the Panzer-Stuka teams, just as in 1945 the Germans lacked the new weapons needed to match the offensive power of the Alhed mechanized forces and the Red army infantly Germany probably would have had such weapons had not Hitler wasted the German scientific and technological effort on guided missiles which, designed for the destruction of London, were not developed until Lon-

don had ceased to be a military target

By 1945 an effective defense system required thousands and even
millions of land mines, artillery firing shells equipped with the new minions of and mines, actuacy fring stems equipped with the new poximity fuze, and rocket-firing weapons employing the principle of the hollow charge. These weapons, used intelligently and in sufficient numbers, could almost certainly stop any infantry-tank attack. Radar and the proximity-tuzed shell in anti-artial artillery guns might have and the proximity-tured shell in anti-attent artillery guns might have effectively protected the German anims from Albiel lettical an power effectively protected the German anims from Albiel and the Albiel Setter land mines were devised faster than were deviced faster than were deviced factering and exploding them Proximity-fued attillery was much more effective than the conventional type—perhaps ten times more, according to Vannevar Bush, wattrue durects of US scientific re-

search and development search and development

The appearance of recoilless rifles, firing shells of light artillery calible but light enough to be carried by one or two infantrymen, greatly added to the firepower of this arm. The use of radar to spot ground targets was another important development.

The Atomic Bomb and Postwar Tactics,-The atomic bombs employed at Hiroshima and Nagasaki were at first interpreted as the end of conventional military and naval forces. Later and more sober judgments based on study of the results in Japan tended to be less judgments based on study of the results in Japan tenden to be less settleme. Such factors as high cost and scarcity were said to militate against the use of atomic bombs against an army of fleet properly deployed for defense against them. Great concentrations of troops are as those which massed for the major amphibious landings in World War. II would be particularly vulnerable, but even then the defending nation would probably weigh the cost of attempting to destroy the invaders with atomic bombs against the cost of meeting the threat with its conventional forces-its army, navy and air force, equipped with modern weapons and machines.

Scientific and technological advances of the kind discussed above had, in the opinion of most military thinkers, given the defense an advantage over the attacker, in the air, on land and at sea acvaniage over the attacker, in the air, on iand and at sea. While the ascendancy of defense over offense, or vice veias, had always been short-lived throughout the history of war, the situation following World War II suggested certain conclusions regarding tactical trends

Tanks, for example, had lost much of their terro; for infantiymen

med with improved tocket-firing weapons of tecoilless rifles defender heavily mined his strong points, used modern anti-aircraft guns against agrial attack and had other weapons equal to those of the

attacker, the advantage would rest on his side

on the other hand, the attacker had new methods of destroying a haden enemy protected by several feet of reinforced concrete and steel Radia could spot the defender's strong point, which could then be attacked by rocket-ning tactical suicraft, heavy artillery and ground combat troops armed with hollow-charge weapons.

One fact seemed certain: to protect themselves from the increased firepower of new weapons, both attacket and defender would have to deploy over wider areas The mitiative and responsibility of the small unit leader would be greater than ever before; he would command a

greater variety of weapons and would need greater tactical skill in em-

ploying them

With large amphibious operations less feasible, interest in the trans-With large amphibious operations less feasible, interest in the trans-portation of armies by air moreased. But here too the defensive portation of armies by air moreased but here too the defensive combat would involve some of the same problems of concentration combat would involve some of the same problems of concentration and mass faced by large amphibious forces. Nevertheless, air-boine transport of ground combat units held considerable promise following world Wer II. Agreal envelopment as a surprise and shock action had reast strategic and tactical possibilities; whether it would be suited to operations on a larger scale than were attempted in World War II depended partly on developments in aircraft and in methods of landing. The parachutist armed only with his individual weapon seemed headed are paracturust armed only with ins individual weapon seemen headed for obsolescence, except as the spearhead of a greater force following him. Transport planes that could land and take off from unprepared an strips, and planes that could carry tanks, artillery and vehicles were some of the more pressing needs in this field. Most of the world's armies at mid-20th century appeared to be stressing air transportability in

1050 were, in numbers of forces involved and in scope of military actions, compatable to several decayer campaigns of World Wai II What new developments Korea produced, however, were not in the field of tactical docturies or techniques but rather in the fields of weapons and logistics

and logistics. Viewed factically, much of the Kotean fighting can be compared with that which took place in Italy at various times between 1943 and 1945. The ternam and chimate of Korea, in fact, were probably more influential that those of Italy in determining offensive and defensive deployments. For example, even more than in Italy troops and vehicles were a the contraction. fined to a few roads, which meant movements in long columns and the induction of opportunities for surprise and deception in the attack The defender generally was at an advantage over the attacker for this

The United Nations forces in Korea developed important new logistical techniques, such as the evacuation of wounded by helicopter as well as the use of these versatile arrusaft in the short-haul transport of personnel and supplies. This development was closely ideated to the personnel and supplies. or personner and supplies. This development was closely infante to active because it represented a solution to the unusually difficult condi-tions of terrain which otherwise might have stalled all progress in some phases of the fighting New types of weapons (such as the 35-in tocket launcher), first used in Korea, improved the effectiveness of troops but did not cause any marked changes in tactical formations or in fundamental tactical doctrines

inches hunter of that uses in more designs in technal formations or indimental actival doctrines.

Billiography—General Henit Jomin, Summary of the Art of the (1852), H M Johnstone, A Hirtory of Tackic (1966), O Gibbert, War (1871), O L Spaulding, Helitron of Tackic (1966), O Gibbert, War (1971), O L Spaulding, Helfman Nickesson and Wright, Warger (1937). Classical cycle M Carrinon-Nisse, Evoi sur Philipper effective de Fort ministers (1832), T A Dodge, Alexander (1860), Rivers (1937). Classical cycle M Carrinon-Nisse, Evoi sur Philipper effective de Fort ministers (1832), T A Dodge, Alexander (1860), Rivers (1987). Classical cycle M Carrinon-Nisse, Evoi sur Philipper effective de Fort ministers (1832), T A Dodge, Alexander (1860), Rivers (1987), A Republic (1987), R Philipper, Rote is O Strategy (1960). Cavalty cycle G T Demison, A History of Cavalty (1871), T R Philipper, Rote is O Strategy (1962). Cavalty cycle G T Demison, A History of Cavalty (1871), T R Philipper, Rote is O Strategy (1962). T R Philipper (1962), Rote of North Modelling the French Amery (1983), M de Saxe, Plan for New Modelling the French Amy (1983), I Regues Gulbert, Exan de tactique (1962), the History of Industry (1963), B H. Lädedl Hart, A Scacce of Industry (1963), B H. Lädedl Hart, A Scacce of Industry (1963), Annua, The Influsiona of Forte-min Upon Tactics (1964), Regues of 1969-11 (1964), North Steep of the Hist (1964), Hell (1964), Regues of 1969-11 (1964), North Steep of the Hist (1964), Regues of 1969-11 (1964), North Steep of the Hist (1964), Regues of 1969-11 (1964), Regues of Processing (1964), Regues of North Steep of the Hist (1964), Regues of 1969-11 (1964), North Steep of the Hist (1964), Regues of 1969-11 (1964), North Steep of the Hist (1964), Regues of 1969-11 (1964), North Steep of the Hist (1964), Regues of 1969-11 (1964), Regues of 1969-11 (1964), Regues of 1969-11 (1964), Regues of 1969-11 (1964), Regues of 1969-11 (1964), Regues of 1969-11 (1964), Regues of 1969-11 (1964), Regues of 1969-11 (1964), Regues of 1969-

TAD, the pen name of Thomas Aloysius Dorgan (1877-1929), US journalist, boxing authority and cartoonist, who was

born in San Francisco, Calif., on April 29, 1877.

At an early age he joined the art department of the San Francisco Bulletin, where he worked as a cartoonist and comic

In 1902 he was employed by William Randolph Hearst, becoming a political cartoonist of the New York Journal. When Hearst, a candidate for the office of mayor of New York, ran against George B. McClellan in the election of 1905, Dorgan produced effective cartoons saturizing Hearst's opponent

Dorgan did not continue as a political cartoonist, however, concentrating his interests instead on sports, particularly boxing Not only did he publish sketches of fighters and commentaries, which were widely syndicated throughout the country, his pen name Tad (the mitials of his name) becoming well known, but he also served as an unofficial boxing referee and was recognized as an authority on the sport.

Tad also developed comic-strip characters, such as "Silk Hat Harry" and "Judge Rummy" which he used in his daily amusing

cartoons based on social satire

Tad was responsible for the wide currency of many slang expressions. Among them were "The first hundred years are the hardtheir technical and training efforts

siohs. Among them were "The first hundred years are the hardThe Korean War.—The Korean campaigns which began in June
est"; the simile "As busy as a one-armed paper hanger with the hives"; "23, skidoo"; and "Yes, we have no bananas." He died at Great Neck, L I, on May 2, 1929

TAEL. The tael (Chinese, hang), a Chinese unit of weight, when applied to silver was long used as a currency unit There have been many taels of varying weight, generally in the neighbourhood of 14 oz.

The cut rency tael was seldom musted in the form of a coin, but served as a standard money of account, actual transactions being completed with ingots of silver, with bank notes or checks expressed in taels, or with silver coins, especially the Spanish and Mexican dollars which flowed into China in great volume in the 18th and right entures. Be a silver imported into China was remelted and cast in ingots weighing about 50 taels, of a special shape called "shose" (from the Dutch word scharty meaning boat) of syces (literally, fine silk, hence, fine silver). Each shoe was marked by the public assaying office with its weight and fineness, from which data its value in currency taels was computed. Sycee formed a large part of bank reserves down to 153.

The most important currency tael was the Shanghai tael, adopted in 1857 to espace the Spannsh dollar which was becoming scarce. The fine-silver equivalent was 518 512 grams. Since China was not a silver standard while the rest of the world was on a gold standard, the exchange value of the Shanghai tael fluctuated with the price of silver in London and New York, ranging from around 6s or \$1 50 before 1893 to as low as 15. 2d or 38 conts in 1931. If was the bass for wholesale trade and for-eign exchange transactions in China's most important commercial city.

Of the numerous other taels used as moneys of account at various times and places, two deserve mention. The k'uping or treasury tael was used under the Manchu dynasty for the payment of taxes, 100 k'uping taels equalled 100 fo Shanghai taels. The Haukwon or customs tael was adopted in 1858 for the valuation of imports and exports and for the fixing of duties, 100 Haukwan taels equalled 111 a OSnanghai taels.

From ancient times the money of the masses for small transactions was the said, (x) but from the latter part of the roth century retail trade gradually began to be conducted with Mexican and, later, Chinese silver dollars, fractional silver cons, and to-cash copper pieces Finally, in April 10,33, the tale was officially abolished and replaced by the new Chinese standard dollar or yuan at a fixed rate of Shanghai tels y; so equal 100 yuan The new coin weighed at y grains, oSh nea, and its exchange value, of course, fluctuated with the world price of silver, See Cattrax: Production, Commerce and Communications;

**TAENIA**, in architecture, the uppermost member of the architerave  $(\eta, v)$  of one of the classic orders. (See Orders.) In the Tusean and Doric orders it is a projecting filled from which, in the Doric order, hang the regulae (q, v), and guttae (q, v). In the Long, Corinhian and Composite orders it is moulded with an ovelo or cyma reverse as the main form and usually carved.

TAFARI MAKONNEN, RAS: see Makonnen, Ras

TAFFANEL, CLAUDE PAUL (1844-1908), French flutist and conductor, was born in Bordeaux, Fr., on Sept 16, 1844, and studied at the Paris conservatory.

From 1864 until 1890 he played first flute of the Paris Opéra orchestra and from 1867, at the Société des Concerts du Conservatoire Appointed a professor at the Paris conservatory in 1893, he served as conductor of both orchestras from 1890 until 1903.

Taffanel died in Paris on Nov. 22, 1998

TAFFETA, a term structly denoting a light, thin and plain texture of silk possessing a high sheen or gloss and finished in a manner that imparts to it the "rattle" or "scroop" peculiar to certain types of closely woven, plain silk textures produced from spun silk yara. The warp and weft may be of corresponding deigher or counts, approximately, while the number of warp threads and picks per inch may also correspond.

Taffeta is sometimes embellished with a very small brocade or "float" figuring of warn or wett, and may either be woven from skein-dyed yarn, or else piece-dyed after weaving. Some qualities of taffeta fabrics are artificially, "loaded", i.e., weighted, with me-

talic salts, and are therefore more liable to split or crack when creased or folded It is used chiefly for dress, millinery and similar numbers

The word "taffeta," however, is now applied as a description of many other varieties of fabrics produced from silk, wool, cotton and combinations of these materials

Chifion taffeta so of a softer texture and finish than that of ordinary taffeta. One variety of taffeta is produced from a slik warp and Botany wool weft, another variety, described as "wool taffeta." is woven entirely of fine wool yarm both for warp and weft, which makes a fine and close texture of light weight, with a smooth sur-

Some varieties of taffeta are produced from a cotton warp and fine Botany weft, while others are woven entirely with twofold cotton yarn of fine counts, and finished with a stiff "finish" to

simulate the "scroop" peculiar to silk fabrics
TAFF VALE CASE. A number of employees of the British
Taff Vale Railway company had a dispute with the firm in Aug.
1900 and walked out on strake Led by two officers of the Amajamated Society of Railway Servants, the employees attempted to negotiate with the company, which held, however, that it would confer with only its own employees.

During the strike, which was settled about two weeks later after the board of trade intervened, the company petitioned the court of chancery for a witl of injunction against the union officers, forbidding the watching and besetting of certain railway property. The company based its request on the provisions of the Conspiracy and Protection of Property act of 1875 declaring such action illegal.

The union, on the other hand, held that it was not liable for damages caused by its agents during a strike since it was neither a corporation nor an individual, the injunction, therefore, should not be granted.

Justice Sir George Farwell (1845-1915) decided, however, that the union was a corporate body although it was neither a corporation nor a partnership and hence hable for payment of such dam-

His decision was strongly contested by labour, since, it was argued, it was a direct threat to labour's right to strike. The court of appeal reversed Farwell's decision, granting the union costs. On appeal to the house of lords, however, the court of appeal sustained Farwell's opinion, holding that the union, a legal entity, could be sued.

The effect of that decision was nullified by the Trade Disputes act of 1006.

(See also Trade [Labour] Unions: Great Britain: Later Legal History)

TAFILALT or TARILET (i.e., "The Country of the Fidia," as its nahalitants are called, because descended from the Antana tribe of Hillid, settled there in the 11th century), unportant casas of the Moroccoan Sahara, ten days journey south of Fez, across the Atlas. It is celebrated for its dates, to the successful cultivation of which, soon after the arrival of an ancestor of the religning dynasty of Morocco (hence called the Filidi Sharifs, 1e, descendants of Mohammed): a Da 12so, the dynasty owed its rise.

Tafilalt is a succession of ksurs (fortified villages) and palm groves which correspond to the zone irrigated by the Wad Ziz, and stretch over a length of about 50 km. The largest centre is

Bu-Am, an important market.

The sedentary natives, who were exploited by the Ati-Atta nonads, live in poverty on their palm groves. The midustry is the tanning of goatsians to obtain fidal: leather, which has a great reputation. The takeaut (Z'marra articulata) yields gall for tanning. After 1648 it was the custom of Moorish sultans to dispatch superfluous soons and daughters to Tafiliki. In fili, the central portion, formerly existed the town of Siglimasa, founded by Miknikas Berbers in 757 s.C. I was on the direct caravan route from the Niger to Tangier, and attained a considerable degree of prosperity.

The first European to visit Tafilalit was Rene Caillie (1828), the next Gerhard Rohlfs (1864) A later visit to the oasis by W. B. Harris is described in his book Tafilet (London, 1895).

TAFT 750A

TAFT, ALPHONSO (1810-1801). US lawyer and public official, was born in Townshead, Vt, on Now 5, 1810. Intermittently teaching school to finance his education, he studied at Amberst academy and Yale college. He was graduated from Yale and served as a tutor there while he studied law. In 1838 he was admitted to the bar

Taft settled in Cincinnati, O, where he established a successful law practice He served on the bench of the superior count of Cincinnati, resigning on Jan 1, 1872

Under Pies Ulysses S Grant he served for short periods as secretary of war and later attorney general, 1876-77

Taft was unsuccessful in his attempts to win the Ohio Republican gubernatorial nomination in 1875 and 1879 He later held diplomatic posts in Austria-Hungary and Russia

Charles Phelps Taft (q v) was a son by his first wife, Fanny Phelps, whom he married in 1841

William Howard Taft (q v.), a son by his second wife, Louisa Torrey, whom he married in 1853, became the 27th president of the United States

Taft died in California on May 21, 1891.

TAFT, CHARLES PHELPS (1843-1929), US editor and lawer, born at Cincinnali, O, on Dec 2t, 1843, was the halfbrother of William Howard Taft (qv), whom he aided in his successful campaign for the presidency of the United States

The son of Alphonso Taft  $(q \, v)$  and Fanny (Phelps) Taft, his first wric, Charles Taft attended public schools in Cuncinant, Phillips academy, Andover, Mass, and Yale university, New Haven, Conn, where he was graduated with a bachelor of arts degree in 1864 and a master of arts degree three years later H had also studied law at Columbia university, and in 1866 was awarded a degree in law and admitted to the bar.

He studied further at Heidelberg and also in Berlin and at the Sorbonne, Paris Returning to the United States, Taft, who had practised law for a short period before going to Europe, again

began to follow that profession in 1869.

That served as joint editor of The Ceneumant Superior Court Reporter, 1870-73, and also prepared a codification of the Ohio school laws. He became a member of the Ohio house of representatives in 1871 and in the following year was defeated as a candidate for the U.S lower house In 1894, however, he was elected to the US house of representatives, serving in the 54th congress from 1800 to 1807.

In 1879 Taft purchased, with his father-in-law, David Sinton, a controlling interest in the Cincinnati Times Taft consolidated the Times with the Star in 1880, the new paper being named the Times-Star, and became editor and later the only owner. The

paper prospered under his management.

He played an important part in the election of William Howard Taft in 1908, advang the presidential candidate and providing financial aid. In the following year Charles Taft, who had been nommated to run for the U.S. senate, withdrew as a candidate. He continued to support the Republican party, and served as a presidential elector at large from Ohio in 1904 and as president of the Ohio electronic college in Jan. 1905.

In addition to his newspaper business, Charles Taft had interests in real estate, state utility companies and major league baseball clubs. His philanthropic acts included an endowment of \$1,000,000 given, with his wife, to the Cincinnati Symphony orchestra

and contributions to the Cincinnati law school.

Taff died on Dec. 31, 1929.

TAFT, HELEN HERRON (1861-1943), was born in Cincinnati, O, on June 2, 1867, the fourth of eight children, and lived there until 1900. She met William Howard Taft (q.v.) after he had begun to practice law and they were married in 1886.

Most remarkable of her achievements during her early matried life was the organization of the Clincinnati Symphony orchestra, for which she raised considerable sums of money. When her huse band was appointed head of the cruil commission which organized the government of the Philippine Islands in 1900, she and her three children (Robert Alphonos, Helen, Charles Phelips) accompanied lum to Manila. She was of much assistance to her husband in his relations with the Filipinos; her receptions at Malacatian palace

after Taft became governor were an important means of bringing Americans and Filipinos together. She was also instrumental in saving the mediaeval walls of the old city of Manila, which were threatened with demolition in the interests of efficiency.

After her return to Washington, DC, in 1904, when Governor Taft became secretary of war, Mrs Taft was influential in persuading Pres Theodore Roosevelt that her husband should be a candidate for the presidency rather than accept an appointment to the US supreme court Shortly after the inauguration in 1909 she was taken seriously ill and never entirely recovered her health During the last two years in the White House, however, she took her full part in all official functions and interested herself especially in the development of Potomac park Japanese cherry trees had been sent to her as a personal gift by the mayor of Tokyo and she supervised their planting around the basin which later became the site of the Jefterson memorial After a period of eight years away from official life, most of which was spent in New Haven, Conn , Mrs Taft returned to Washington, D C , in 1921, when the ex-president was appointed thief justice, and lived there untıl her death on May 22, 1943

Bibliography —Mrs Tait's reminiscences, Recollections of Full Fears (1914), Henry F. Pringle, The Life and Times of William Howard Taft (New York, Toronto, 1939) is based in part on Mrs Tait's correspondence with her husband (H T Mc)

TAFT, LORADO (1860-1936), US sculptor, was born at Elmwood, Ill, on April 29, 1860 He graduated from the University of Illinois, where he first worked in sculpture, in 1879 and then studied at the École des Beaux-Arts in Paris until 1883, remaining in that city with but brief interruption until 1885 It was on the modern French school that his style was formed. Establishing himself in Chicago in 1886, he taught sculpture at the Art institute and began his long career of public lecturer. He was elected to the National academy in 1911. He participated actively in the formation of plans for public education in art, and served (1914-17) as director of the American Federation of Arts Aside from many portraits, included among his works are "Sleep of the Flowers and "Awakening of the Flowers" for the Columbian exposition (1893), "Despair" (1898); "Solitude of the Soul" (1900), the colossal "Black Hawk" at Oregon, Ill. (1912), Thatcher Memorial Fountain, Denver, Colo. (1918), and the "Fountain of Time" (1920) intended as part of a monumental complex of sculpture to be erected in Chicago

In 1903 he published The History of American Sculpture, the first comprehensive work on the subject, revised in 1924, his Some Modern Tendencies in Sculpture was published in 1920.

(JCT)

TAFT, ROBERT ALPHONSO (1889—1953), United States senator from Ohio and son of Wilham Howard Taft, 27th president of the United States, was born in Cincinnati, 0, on Sept. 8, 1889, the attended the public schools of Cincinnati and the Taft school at Watertown, Conn; was graduated from Yale university with a B.A. degree in 1910 where he stood first in his class, graduated from Harvard university with an LLB, degree in 1913 where he was first in his class and editor in chef of the Harvard Law Review. In 1913 he passed the Ohio bar examination with highest honours in the state. In 1914, he married Martha W, Bower

After practising law in Cincinnati, Taft served during World War I, 1517–16, as assistant counsel for the United States Food administration. In 1919 he was counsel for the Amenican Relief administration in Europe From 1920 through 1938 he practised law in Cincinnati, establishing a reputation as one of the ablest lawyers in Ohio. During this period, 1921–26, he was a member of the Ohio house of representatives where he became Republican floor leader and speaker of the house. He served in the Ohio senate in 1931 and 1932.

Shortly after his election to the United States senate in 1938, Taft became a natuonal political figure. He was re-elected to the senate in 1944 and re-elected again in 1950 by a majority of 4,337, coc votes, one of the largest ever given a candidate for U.S. senator from Ohio. With each U.S. senator being responsible only to one of 48 constituencies, leadership in the senate is often more tutlar than real. Taft, however, excelled in the essential political tutlar than real. Taft, however, excelled in the essential political

750B TAFT

capacity for work gave him a mastery of legislative facts far beyoud the narrow range of committee specialization. His honesty, integrity and patriotism were never responsibly questioned. His Republican colleagues in the senate selected him in 1047 as chairman of the senate Republican policy committee, a position he held until his election as senate majority leader in Ian 1953. It is difficult for anyone outside the congress to evaluate precisely the worth of one of its members. Much of the actual work is done in closed committee meetings and in informal conferences. The congress itself is the only point at which all the myriad facts and pressures coalesce Perhaps the most meaningful tribute to Senator Taft's stature is that he was regarded by his colleagues, Democrats as well as Republicans, with unprecedented respect and esteem

Taft lacked many of the traits commonly associated with a good politician in the United States He was thought by many to be cold and austere. His genial personality and gentle humour were reserved for friends and for direct personal contacts. He had no trace of demagoguery. His appeal was to logic, rarely to emotion. He championed unpopular causes. He disdained the use of wit, eloquent speech and brilliant metaphor He spoke bluntly. armed only with facts and simple statements of his principles His willingness to make an unequivocal statement on any controversial issue frequently embarrassed his political managers. Typical was his forthright condemnation of the Nucemberg trials as vengeance by the victors decked out in the trappings of justice Whether or not enemy leaders were tried under ex-post facto laws was not an issue that would ever come before the senate. His bold expression of his convictions contrary to prevailing public opinion flouted all conventional norms of good politics.

Taft was generally regarded as a conservative in American politics. In recognition of his leadership of the more conservative political party, he was nicknamed "Mr Republican" by the Ameucan press But even in the field of social-welfare legislation, he was not inflexibly wedded either to the status quo or to his former position. He was an original sponsor of legislation providing for public housing for low-income groups He sponsored legislation authorizing federal aid to state governments for the improvement of medical care and education and of the living standards of the

On the other hand, Taft was an uncompromising opponent of legislative measures which, in his judgment, undermined personal incentives for economic betterment or demanded excessive government intervention in the lives of its citizens. He consistently opposed compulsory health insurance on the ground that government control of the medical profession made the promised benefits illusory He opposed peacetime price and wage controls His political philosophy was perhaps best stated in 1948 when he described the "one great issue in the world today" in these words. "It is that of government operated by a free people on the basis of freedom and justice for every individual, on the one hand, against the totalitarian state on the other-the kind of state which concentrates in a central government power to direct the lives of all its people, its agriculture, its commerce and its industry" Taft often defined the basic domestic issue in American life as one of "liberty versus socialism '

It was in the field of labour law that Taft won his greatest legislative fame In the nation-wide transportation strike of 1946, Pres. Harry S. Truman made a personal appeal to the congress for legislation authorizing him to draft striking workers into the army "on such terms as he might impose." The house of representatives passed the bill immediately, and the senate seemed likely to follow suit. Notwithstanding the intense pressure for drastic action, Taft blocked it in the senate by utilizing its rule of unlimited debate,

When the Republican party won control of congress in the elections of 1946, Taft had the choice of becoming chairman of either the senate finance committee or the senate labour committee. Typically, he chose the more politically explosive assignment. As chairman of the labour committee he guided to passage over a presidential veto the Labor-Management Relations act of 1947, popularly known as the Taft-Hartley law. He defended it as imposing on labour unions obligations comparable to those imposed

art of compromise His exceptional intellect and almost legendary on management Labour union leaders, almost without exception, denounced it as a "slave labout" law. They mobilized their forces to defeat him in 1950. No senatorial campaign in U.S. history attracted so much nation-wide interest. Taft's overwhelming viitory was interpreted by his followers as proof that no economic group in America is cohesive enough to decide the outcome of an election through bloc voting on isolated issues

Prior to United States participation in World War II, Taft opposed measures calculated to increase the chances of involvement For that stand, he was trequently criticized as an "isolationist After the war he recognized the United States' new position of world leadership. He urged ratification of the United Nations charter Because of Soviet Russia's intransigence, however, Taft had little faith in the UN as a shield against aggression. In opposition to the Truman administration and many Republicans as well, he advocated reduced foreign aid expenditures, greater emphasis on retaliatory air power and less on ground defense forces in western Europe, increased attention to far eastern problems, and congressional approval of executive decisions to send American troops abroad

Taft was three times an unsuccessful candidate for the Republican nomination for president. In the Republican national convention of 1940, he lost the nomination to Wendell Willkie, in 1948 to Thomas E Dewey, and in 1052 to Dwight D Eisenhower Despite the bitterness of the prenomination struggle in 1952, Tait and his followers united wholeheartedly behind Eisenhower It was widely predicted that the differences between Eisenhower and Taft, particularly on foreign policy issues, would make close cooperation between the White House and the Capitol impossible Taft, however, was determined to make the first Republican administration in 20 years an unqualified success Most observers agreed that he was emmently successful in bridging the constitutional gap dividing executive and legislative authority which is so essential in the American ideal of freedom and yet so often productive of discord and maction

Taft died of cancer in New York city on July 31, 1953 His body lay in state in the rotunda of the Capitol-an honour accorded to only 12 others. He was buried near his home in Cincinnati in the cemetery of the Indian Hill church

BIBLIOGRAPHY.—See indexes for the Congressional Record, vol 84-99, under heading "Tafs, Robert A (a Senator from Ohio)", Robert A Taft, A Foreign Policy for Americans (New York, 1951) (J W Ba)

TAFT, WILLIAM HOWARD (1857-1930), the 27th president and tenth chief justice of the United States, was born in Cincinnati, O, on Sept. 15, 1857 His father, Alphonso Taft, was attorney general in Pres U. S Grant's cabinet (1876-1877) and minister to Austria (1882-84) and to Russia (1884-85) William Howard Taft graduated second (salutatorian) in his class at Yale college in 1878, and at the law school of Cincinnati college, in 1880, dividing the first prize for scholarship. In the same year he was admitted to the Ohio bai. In 1881 he was appointed assistant prosecuting attorney of Hamilton county (in which Cincinnati is situated), but resigned in 1882 on being appointed U.S. collector of internal revenue for the first district of Ohio.

In 1883 he returned to the law. From 1885 to 1887 he served as assistant solicitor of Hamilton county, and in the latter year was appointed judge of the superior court of Ohio, to fill a vacancy, being elected in the next year. In 1890, he was appointed solicitor-general of the United States by Pies Benjamin Harrison. In 1802 he was appointed U.S. circuit judge for the sixth circuit.

From 1806-1000 Taft also served as professor and dean of the law department of the University of Cincinnati

Governor of Philippines .- In 1900 he was appointed by Pres William McKinley to the presidency of the Philippine commission. He served as such from March 13, 1900, to Feb. 1, 1904, becoming governor ex officio on the establishment of civil government, on July 4, 1901 (see PHILIPPINE ISLANDS). The delicate matter of confiscated church lands was arranged by Taft in a personal interview with Pope Leo XIII, in the summer of 1902. The pope sent a special delegate to appraise the

TAFT 751

lands, and the sum of \$7,239,000 was paid for them in Dec 1003 Secretary of War .- In Feb 1904, Taft returned to the United States to become secretary of war In Sept 1906, on the downfall of the Cuban Government and the intervention of the Limited States he took temporary charge of affairs in that island (Sept-Oct ) In the next year (March-April) he inspected the Panama canal and also visited Cuba and Porto Rico. He again visited the Philippines to open the first legislative assembly (Out 16, 1907) On this tout he visited Japan, and on Oct 2, at Tokyo, made a speech which had an important effect in quieting the apprehensions of the Japanese on the score of the treatment of their people on the Pacific coast. While secretary of war. Taft entirely reorganized the work of carrying on the construction of the Panama canal, and selected Col George W Goethals, whom President Roosevelt put in entire charge of the work From that moment the enterprise assumed a new vigour, the work was completed and was opened to traffic in 1913

President .- In 1908 Taft was favoured by President Roosevelt as his successor, and in the November election, was vic-torious over William Jennings Bryan, the Democratic nominee. by a popular majority of 1,269,900 votes (Taft, 7,679,006 Bryan, 6,409,106) and by a majority of 159 votes in the electoral college. In accordance with his pre-election pledge, he called the Congress to meet in extra session on Maich 15, 1909, to revise the tariff. The final bill known as the Payne-Aldrich Act was approved by the president on Aug 5, 1909, although in many respects it was not the measure he desired. The income of the Government under the Dingley tauff had proved inadequate to meet its current expenses, the estimated deficit for the fiscal year ending July 1, 1909, being \$100,000,000 He therefore recommended to the Congress the adoption of resolutions to amend the Constitution by expressly granting Congress power to levy an income tax without apportionment among the several States For the purpose of meeting the immediately anticipated deficiency in the revenues, he recommended the adoption of a provision in the Tariff Bill imposing an annual special excise tax upon corporations organized for profit, measured by a percentage on their net incomes Pursuant to these recommendations a proposed amendment to the Constitution was passed by both Houses of Congress, afterwards ratified by the requisite number of the States, and became the 16th amendment, and there was included in the Payne-Aldrich Act a provision imposing the proposed annual special excise tax upon corporations, measured by 1% of their net incomes

Payne-Aldrich Tariff Act.—While the Psyne-Aldrich Act was much citized, because it failed to reduce duties on imports to the extent expected, yet it marked a distinct step towards a lower scale of import duties, and opened the door to the free exchange of commerce with the Philippones. By the enactment of the maximum and minimum tariff provisions, it placed a powerful weapon in the hands of the Amencan Government for the protection of American commerce against unduly discriminatory practices by foreign Governments. It also, for the first time in American history, provided for the establishment of a tariff board to study the questions which lie at the foundation of the protective system.

While Congress was considering the Tariff Bill, the president called upon the heads of the departments of Government to prepare, in advance of the usual time, their estimates for the fiscal year ending June 30, 1911, admonishing them to reduce expesses wherever it could be done. These estimates were then considered by the president and cabinet, and for the first time in American history, a comprehensive budget was prepared. As a result of these efforts, a cut was made of about \$5,500.000 in the estimates for the fiscal years 1910 and 1911. In June 1910, the Congress granted the president's request for an appropriation to enable him to employ competent persons to study the methods of transacting the public buseness of the executive departments and other Government establishments, and to recommend such legislation as might be necessary to carry into effect changes found to be desirable that could not be accomplished by executive action alone. President Taft caused a commission to be

organized, and as a result of its studies, sent to Congress four special messages transmitting the reports of the commission, dealing with particular subjects, pointing out defects in the organization and conduct of the business and changes that might be made advantageously

Federal Budget Urged .- In his message of Jan 17, 1912. the president called attention to the fact that the United States was the only great nation whose Government was operated without a budget, and recommended the adoption of an annual budget Nothing was done by Congress in these matters, but many, if not most, of the improvements in the organization and conduct of the administrative branch of the Government which have been adopted in more recent years were first formulated and recommended by President Taft He also recommended to Congress the enactment of amendments to the interstate commerce law, the establishment of a postal savings bank system, the enactment of laws giving the interstate commerce commission the power to determine upon the uniform construction of appliances used by railway trainmen in the operation of trains and to intervene and investigate the reasonableness of a proposed increase in railway rates before they became effective. of amendments making the Employer's Liability Act more easy to enforce; of laws carrying out with intelligent discrimination the principle of conserving the national resources, the estabhishment of a national health bureau, requiring publicity of campaign contributions, regulating the procedure of Federal courts concerning the issue of injunctions, and readjusting the regulations concerning postage of second class mail matter. Most of these recommendations were embodied in laws passed by the Congress By executive order, the President placed the positions of secretaries in the diplomatic service in much the same position as those in the consular service, and introduced into both the principle of appointment for reasons of ascertained fitness and promotion by merit

Arbitration Treaties .- In 1910 and 1911, President Taft negotiated with the Governments of France and Great Britain identical treaties, signed on Aug 3, 1913, intended to be models for a series of treaties providing firstly, for the arbitration of all differences which might arise between the parties which it was not possible to adjust by diplomacy, and which were justiciable in their nature, and secondly, for the creation of a joint high commission of inquiry, to which should be referred for impartial investigation, any justiciable controversy between the parties before submission to arbitration, and also any other controversy, even if the parties were not agreed that it fell within the scope of the first article, the report of such commission not to be regarded as a decision on the questions submitted. The first of these provisions embodied in effect the agreement reached in the treaty between the United States and France of Feb 6, 1928 The second furnished a model for the treaties negotiated by Secretary Bryan in 1914, known as the Bryan Conciliation Treaties. Together, they represented a greater advance in provisions for the peaceful settlement of international controversy than any the world had known The U.S Senate qualified its approval by such extensive reservations, that the president withdrew the treaties from further consideration. In 1010, President. Taft initiated negotiations with the British Government for the establishment of a reciprocal trade agreement between the United States and the Dominion of Canada, Instead of embodying the desired tariff changes in the formal shape of a treaty, it was agreed that the Governments of the two countries should use their utmost efforts to bring about such changes by concurrent legislation at Washington and Ottawa It was further agreed that a considerable list of articles produced in both countries should be reciprocally free. As to another group, common rates of duties upon importation from either country into the other were fixed The proposed legislation was, however, defeated in the dominion parliament, and the effort failed

As the construction of the Panama canal approached completion, a bill was introduced in Congress to provide for its operation and for the government of the Canal Zone Taft was of the opinion that as the United States had built the canal at its own expense, it was entitled to permit the use of the canal by American merchant ships without payment of tolls Great Britain claimed that this would be a violation of the Hay-Pauncefote Treaty While not admitting the contention, the president expressed his willingness to arbitrate the question. The bill, as passed, embodied the president's views, but the next Congress modified the act by removing the discrimination

Other Events in Administration .- President Taft's administration was characterized by a systematic and vigorous en-forcement of the antitrust laws. The decisions by the U.S. Supreme Court in 1911, of the prosecutions which had been initiated by Pres Theodore Roosevelt against the Standard Oil trust and the American Tobacco combination, and which were argued in the Supreme Court by Atty Gen. George Wickersham, gave an authoritative interpretation to the act, which was at once put into effect by the Department of Justice, and for the first time after the enactment of the law in 1890, a careful, systematic effort was made by the Government to enforce its provisions. Both the oil trust and the tobacco combination were dissolved in such manner as to restore healthy competition in those industries without destruction of the value of their securities held by innocent parties A large number of combinations in restraint of trade were either put an end to by judicial process, or voluntarily desisted from a continuance of the practices which had been adjudged to be illegal

During Taft's administration, many vacancies occurred in the Federal judiciary. He was called upon to appoint six justices of the Supreme Court, including a chief justice On the death of Chief Justice Fuller, in 1910, President Taft nominated as his successor, Associate Justice Edward D. White, a Democrat. a former Confederate soldier, and a Roman Catholic-a nomination which was confirmed by the Senate at once

Conservation of the natural resources of the nation was one of the subjects which had greatly occupied the attention of the president and his administration. While Taft was in full sympathy with the objects of this policy, he did not approve of some of the means adopted by that administration. In making up his cabinet, he did not include James R. Garfield, secretary of the interior under President Roosevelt, and on Jan. 7, 1910, he dispensed with the services of Gifford Pinchot, the forester. These men, with a number of other adherents of Roosevelt, initiated a campaign against President Taft, based upon the representation that he was opposed to the conservation policy of Roosevelt. Their first attack upon his Administration was directed against Richard Ballinger, who had succeeded Garfield as secretary of the interior. A complaint by L R Glavis, an agent in the land office in the department of the interior, of Ballinger's action with regard to certain coal land entries in Alaska known as the Cunningham claims, which President Taft on investigation held to be unfounded, and which led to the dismissal of Glavis from the service, gave rise to a Congressional investigation into the conduct of the interior department by Ballinger. After prolonged hearings a report was made by the committee exonerating Ballinger, but failing to win the confidence of the public, he resigned in the spring of 1911.

In the regular Republican convention at Chicago, Ill., the total number of delegates summoned was 1,078, with 540 necessary to a choice. Taft had 561 votes on the first and only ballot and was declared the nominee. Roosevelt and his progressive supporters, claiming that part of his delegates had been stolen through the action of a hostile committee, refused to accept the results of the convention, organized one of their own, known as the "Bull Moose" convention, nominated Roosevelt for the presidency and carried on an aggresive campaign against Taft, which resulted in splitting the Republican vote in almost every State, and thus electing Woodrow Wilson, the Democratic nominee, as president. The electoral vote was: for Wilson, 435, Roosevelt, 88 and Taft, 8. The popular vote, however (Wilson, 6,285,214; Roosevelt, 4, r26,020; Taft, 3,483,922), showed a much closer contest. This Party schizm served in large measure to obscure the merits of President Taft's administration.

Subsequent Career. On retiring from the presidency in

1913, Taft became Kent professor of law at Yale, but devoted much time to lecture engagements. In the same year he was elected president of the American Bar association, and in 1914 first president of the American Institute of Jurisprudence, organized to improve law and its administration. Taft was an active promoter of the League to Enforce Peace, but after U.S entrance into World War I, he supported the Administration, taking the ground that victory was necessary to the attainment of lasting peace In 1918, he was appointed by President Wilson a member of the national war labour board for arbitrating labour disputes In 1919, he endorsed the peace treaty of Versailles, regarding its most important part to be the Covenant of the League of Nations He spoke throughout the country on behalf of the League uiging reservations if these would secure intification. On the death of Chief Justice Edward White, on June 30, 1921, he was appointed chief justice by Pres Warren G Harding He died in Washington on March 8, 1930

In 1886 he had married Helen Herron (1861-1943),

Int 1000 the aud marited treefin faction (1001—1943).

Talt is the author of Popular Government, its Essence, its Performance, and its Perils (1913). The Anti-Trust Act and the Supreme Court (1914). The United States and Pance (1914). Eliters in Service, Yale lectures (1915), Our Chef Magistrate and His Powers, College Head (1915), Our Chef Magistrate and His Powers, College Head (1915). Opportunities and its Limitations, lectures at the University of Virginia (1916) (G W W1)

TAGALOG, a tribe of central Luzon, Republic of the Philippines, formerly head-hunters, particularly on occasions of the deaths of prominent tribesmen, they made wood or stone figures to accommodate the souls of deceased persons (Relacion de las Islas Philipinas, anon., c. 1595) They are now Christians and make excellent soldiers, sailors, artisans, etc They cultivate rice on irrigated terraces. Women have equality with men They are the most cultured of the various peoples in the Philippine Islands

and have made rapid advance in recent years

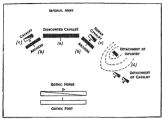
TAGANROG, a Russian seaport in the Rostov Oblast, R.S.F.S.R., in 47° 12' N , 38° 50' E , on the north shore of the Gulf of Taganrog, northeastern arm of the Sea of Azov. Pop (1939) 188,808 It is connected by rail with the north, and also with Rostov-on-Don to the east. It has three harbours and several grain warehouses. The anchorage is 5 to 6 ft. at the loading pier, but there is no regular port accommodation, and the usual anchorage ground, 18 to 20 ft deep, is 25 to 30 mi. from Taganrog. It is icebound for three or four months in winter, and the depth of water near the town may be diminished as much as 7 ft by a prolonged east wind Its imports include fruits (dried and fiesh), nuts, oil, wine, coffee, tobacco, woollen goods, cement and manufactured iron goods, and its exports are grains, macaroni. linseed, rape seed, caviare, wool, butter and oilcake Many of the exports are brought by lighters or local steamers from Rostov-on-Don. The town has a fishing industry and manufactures metal goods (especially instruments) and paper. A colony was founded on the site by Pısan merchants in the 13th century, but was destroyed by the Mongols Later it was occupied by the Turks Peter the Great attempted to gain possession of the promontory, but it was not annexed to Russia until 1769. Its commercial importance dates from the construction of the railway linking it with Kharkov. The Anglo-French fleet bombarded the town in 1855. War II. Taganrog was captured by the Germans during World

TAGES, a minor Etruscan deity, the grandson of Jupiter, and founder of the art of divination in Etruria According to the story, during the ploughing of a field near Tarquinii a being of boyish appearance sprang out of the furrow. The shouts of the ploughman (Tarchon) brought to the spot all the people of Etruria, whom the boy proceeded to instruct in the art of divination. Having done this, he suddenly disappeared. His instructions were for some time handed down orally, but were subsequently committed to writing and formed the twelve books of Tages, containing a complete system of Etruscan lore

BERLICORAFUE,—Cicero, De Div., ii, 23, Ovid, Metam, xv, 553; Mommsen, Hit., of Rome (Eng. tr.), bk i, ch 12.

TAGINAE, BATTLE OF (A.D. 552). The battle of Taginae was fought in July 552. It terminated the Gothic Wars of the Emperor Justinian, and was won over the Gothic King Baduila by the cunuch Naises, a general who in ability ivalled the great Relsarius, his contemporary Tagnene is situated below the Apenmes near modern Gubbio Narses had crossed the head of the valley of the Chassio when Baduila arrived and seized its main outlet The Goth ranged the whole of his horsemen in front, his infantry, mostly acthers, he drew up in second line His aim was to ride down the imperial army in one terrific charge

Belisarius had noted the weakness in the Gothic tactics, namely, that there was no co-operation between lance and bow Narses



BATTLE OF TAGINAE (JULY, A D. 552), WON BY NARSES, GENERAL OF THE EMPEROR JUSTINIAN, OVER BADUILA, KING OF THE GOTHS

now aimed at this co-operation, but in a novel form which closely resembles the combined tactics made use of by Edward III. at Crécy He dismounted his cavalry (\*Peederat\*) and formed a phalaim 8,000 strong, on the wings of which he drew up 8,000 arches with their outer flanks thrown forward In rear of these he posted his Roman cavalry to combine fire and shock His left flank he rested on a small hill, which he occupied by a force of infantry and at the foot of which he deployed a few squadrons of cavalry.

At noon Badulla, ignoring the archers, suddenly charged his enemy's centre, expecting to overwhelm it, for infantry be held in contempt. He was met by a tremendous converging fire of arrows which slow and dismounted hundreds of his knights. After several assaults he clinched with the mpenal centre—sts protective base of action—which held him firm whits his faints were piled with arrows. At length, exhausted, the Gothic horsemen broke back, when immediately Narses launched his mounted squadrons driving them in confusion on to their infantry which were ridden over The victory was complete.

Wester Student over \_\_ Interview years complete.

Bibliogramy—Processure, History of the Wars (Loeb edition);
Oman, The Art of War in the Middle Ages (1924); Cambridge Meddaction of History, vol. 1; Gibbon, Declare and Fall of the Roman Empire;
Finlay, Greece under the Romans.

(J. F. C. F.)

TAGLIACOZZO, a town of the Abruzsi, Italy, in the province of Aquita, 5 cm i. by rail E.N. E. of Rome and 10 mil. Wo of Avezano. Pop. (1936) 3,693, town; 10,320, commune. It lies 4,438 ft, above sea-level, at the mouth of the deep ravine of the Imele It contains several old churches, notably S. Franceso, with a fine rose window in the fiquel, and mediareal houses The palace, built at the end of the 14th century by the Orani, is fine, with interesting pathings in the interior. At the Orania is fine, with interesting pathings in the interior. At Industrial Safe 3 at the Cost place with the best the most of the contract of the cost place and the cost place of the cost place.

TAGORE, SIR RABINDRANATH (1861-1941). Indian poet and author, was born in Calcutta on May 6, 1861, the youngest son of Maharshi Devendranath and grandson of Prince Dwarkmanth Tagore. After a private education in India he was sent to England in 1871 to study law, but soon returned to India, and while still quite young commenced writing for Bengali periodicals. In 1001 he established the finous Santinitaten, a school at

Bolpur, 93 mi from Calcutta, which developed into an important educational institution conducted on unconventional lines In 1913 Tagore was awarded the Nobel prize for literature, and utilized the amount, £8,000, for the up-keep of his school He visited Europe on several occasions and travelled also in Japan and the United States He accepted a knighthood in 1915, but in 1919 resigned it as a protest against the methods adopted for the repression of disturbances in the Punjab In later years, however, he offered no objection to the use of this title Tagore was interested in politics only in so far as it concerned the deeper life of India, and he desired that the nationalist movement consider social reforms before political freedom By his abundant writings, which are permeated by a sense of the beauty of the universe, by a love of children and of simplicity, and by a consciousness of God, Tagore did much to interpret for the west the more serious reflections of the people of Bengal In 1929 he took up painting He died Aug 7, 1941

His most important works which have been translated into

His most impottant works which have been translated into English are Galanjul (1934), The Crascent Moon (1932), Chitra (1934), The Fost-Office (1934), The Gardenser (1934), One Hundred Poems of Kabr (1935), Fratl-Gathering (1936), Study Buds (1936), Nationalism (1937), My Reminiscences (1931), Red Oldender (1934), Broken Ties (1935), Letters to a Friend (1938), The Religion of Man (1931) See E. Thompson: R

Tagore, Poet and Diamatist (Oxford, 1926)

TAGUS, the second longest river of the Iberian peninsula Its length is 565 mi, of which 171 are on or within the frontier of Portugal, and the area of its basin is 30,500 sq mi. The basin is comparatively narrow, and the Tagus, like the other rivers of the Iberian tableland, generally flows in a rather confined valley, often at the bottom of a rocky gorge, as at Toledo and Alcántara, below the general level of the adjacent country. The river rises on the western slope of the Muela de San Juan (5,282 ft), a mountain which forms part of the Sierra de Albarracin, 88 mi. E of Madrid Thence the Tagus flows at first north-westwards, but, after receiving the Gallo on the right, it flows west, and then south-west or west-south-west, which is its general direction for the rest of its course Regular river navigation begins only at Abrantes, a few miles below which the Tagus is greatly widened by receiving on its right bank the impetuous Zezere from the Serra da Estrella Passing Santarem, the highest point to which the tide ascends, and the limit of navigation for large sailing vessels and steamers, the river divides below Salvaterra into two arms which enclose a deltaic formation, a low tract of marshy alluvium known as the Lezirias, traversed by several minor channels. Both branches terminate in a broad tidal lake immediately above Lisbon (q v.) The Tagus estuary, though partly blocked by a bar of sand, is one of the chief harbours of south-western Europe,

TAHITI, the largest and most important of the Society Islands (part of French Oceania) in the central South Pacific ocean The island lies in 17° 38' S latitude and 149° 25' W longitude It is 33 mi. long, northwest to southeast, and consists of the deeply dissected cones of two ancient volcanoes joined by a narrow isthmus of low land, the whole fringed by a coral barrier reef lying from I to 2 mi offshore. The northern cone is roughly circular in plan, about 20 mi. across, and rises to a height of 7,339 ft. Numerous secondary cones rise from its ravined sides and there is a narrow plain completely encircling the base. To the southeast and joined to the larger cone by an 1sthmus 1 mi. wide, the second cone rises to a height of 4,341 ft The oval-shaped peninsula thus formed has a northwest-southeast length of 14 mi and a breadth of 8 mi Tahiti has an area of about 402 sq mi. and a population (1941) of 23,133 The chief town and seat of the French administration is Papeete at the northwestern end of the island. Its population in 1941 was 11,614 of whom about one half were French. The island produces coco-nuts, bananas, sugar cane, and other tropical plants as well as phosphates. The chief exports included copra, phosphates, vanilla, mother-of-pearl, and rum

sent to England in 1877 to study law, but soon returned to India, History.—Though known to the Pacific explorers of the late and while still quite young commenced writing for Bengali period-roth, and early 17th centures, no attempt at colonization or posiicals. In 1901 he established the famous Santimitetun, a school at twe European control of Tahuti was made unity-4. Unsuccess.

ful colonial efforts were made by the Spanish in that year and by British missionaries in 1797. Inter-island wars were mainly responsible for the failures though the attempts were favoured by the support of the local rulers, Pomare I and Pomare II The latter fled with the missionaires of 1797, but returned with them in 1812, having renounced heathenism, and regained his power in 1815 For a time missionaries made good progress-a printing press was established (1817), and coffee, cotton and sugar were planted (1819), but soon there came a serious relapse Pomare II died of drink in 1824 His successor, Pomate III, died in 1827, and was succeeded by his half-sister Armata, "Queen Pomare (IV)" In 1836 French Catholics attempted to open a mission in Tahiti Queen Pomare, advised by the English missionary and consul, Pritchard, refused her consent, and removed by torce two priests who had landed surreptitiously. In 1838 a French frigate appeared under the command of Abel Dupetit-Thouars, and extorted from Pomare the right of settlement for Frenchmen Pritchard opposed this, and caused Pomare to apply for British protection, but this was a failure, and the native chiefs compelled the queen, against her will, to turn to France. A convention was signed in 1843, placing the islands under French protection, the authority of the queen and chiefs being expressly reserved Dupetit-Thouars now reappeared, and, alleging that the treaty had not been duly carried out, deposed the queen and took possession of the island. His high-handed action was not countenanced by the French government, but while, on formal protest being made from England, it professed not to sanction the annexation, it did not retrace the steps taken. Two years were spent in reducing the party opposed to French rule, and at length, by agreement with England, France promised to return to the plan of a protectorate

Queen Pomare died in 1877, and her son Ariane (Pomare V) abdicated in 1880. In the same year Tahiti was proclaimed a French colony In 1903 the whole of the French establishments in the Eastern Pacific were declared one colony, and the then existing elective general council was superseded by the present administration. After this federation trade increased

Tabiti, with the other Society islands, adhered to the "Free French" movement of Gen, Charles de Gaulle during the German occupation of France, 1940-44

occupation of France, 1946-44
Bunzonsaury — A Gonfi, "Tabuli," in La Prance coloniale (Paus, 1886), H. La Charten, Tabuli (Paus, 1887); Monchousy, La Nouvelli, 1886), H. La Charten, Tabuli (Paus, 1887); Monchousy, La Nouvelli (Paus, 1888), G. Collinuidge, Who Discovered Tabuli'll Jounn Polyweian Soc, vol. (1901), P. L. Nordmann, Tabuli (Paux, 1881); Filia Resemberg, The Pacific Occean (1994); Fartified Osbonn, ed., The Pacific World (1944) Among the natiative works may be emetioned Petic Loth, Le nounce de Lott (Paus, 1881), Dout Hort, Rasitea la sacide (Neuchâlel, 1901); G. Caldron, Tabuli (1901), Rasitea la sacide (Neuchâlel, 1901); G. Caldron, Tabuli (1901), Himalayan wild goat, characterized by its short, triangular and shauply keeled horns. Besides the tabu the genus includes the warriation or Nilsuu thes CH Medocrine). From soul Indias, and the

wariatu or Nilgin ibex (H hylocrius), from south India, and the smaller H jayakers, from south Arabia Tahr frequent the worst ground of all ruminants. (See Goat.)

TAILLE, the equivalent of the English tallage (q v), was in France the typical direct tax of the middle ages, just as the word tonlieu was the generic term for an indirect tax. Other words used in certain districts in the same sense as taille were queste (questa, quista), fouage (foragium), cote. The essence of the tax denoted by these names was that the amount was fixed en bloc for a whole group of persons, and afterwards divided among them in various ways. In ancient French law we find three forms of taille: the taille servile, taille seigneuriale and taille royale.

The taille servile can scarcely be termed a tax; it was rather a tax which had degenerated into a source of profit for certain individuals. Every lord who possessed serfs could levy the taille on them, and originally this was done arbitrarily (a volonté) both as to frequency and amount. It always remained a characteristic feature of serfdom, but was limited and fixed, either by contracts or concessions from the lord (taille abonnée), or by the customs.

The taille seigneuriale was a true tax, levied by a loid on all his subjects who were neither nobles nor ecclesiastics, but the writer

holds that, when fendalism was set up, the right to levy it did not belong to every lord, but only to the lord having the haute pustice But he levied it by right, without the necessity for any contract between him and those who paid it. He fixed the sum to be paid by each group of inhabitants, who then had to see that it was assessed, collected and paid to the lord, electing commissaries (breud hommes) from among themselves for this purpose The seignional taille, like the servile, had the character of a personal tax (taille personelle), a sudimentary tax on income, every man being taxed according to his wages or other income. The king originally had only the right of levying the taille in places where he had retained the exercise of the haute justice. At that time there was no royal taille, strictly speaking, it was only the seigniorial taille transferred to the Crown, but it was one of the first taxes his right to levy which upon all the inhabitants of the domain of the Crown, whether serfs or toturiers, was recognized. The general taille, for the benefit of the king, became more frequent, and tended to become permanen. This transformation was confirmed, rather than effected, by the ordonnance of 1439 Its immediate object was, not the regulation of the taille, but the organization of the compagnes d'ordonnance, ve, the heavy cavalry which the king from that time on maintained on a permanent footing Military expenses thus becoming permanent, it was natural that the taille, the tax which had long been devoted to meeting the expenses of the royal wars, should also become permanent This was contained implicitly in the ordonnance of 1433, which at the same time suppressed the seigniorial taille, as competing too closely with the royal taille by imposing a double burden on the taxpayer A kind of seigniorial taille continued to exist besides the servile taille, but this kind presupposed a title, a contract between the taxable rotusies and the lord, or else immemorial possession, which amounted to a title (See France Law and Institutions)

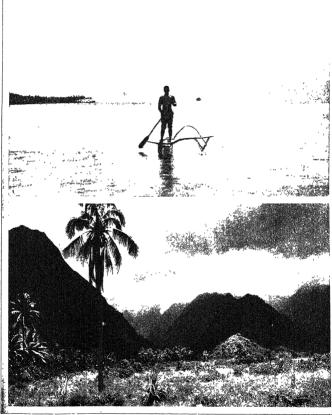
Throughout the pays d'élections the taille was almost universally personal (taille personnelle); ie, a tax on the whole income of the taxpayer, whatever its source. It was also a distributory tax (impôt de repartition), every year the king in his council fixed the total sum which the taille was to produce in the following year, he diew up and signed the brevet de la taille (warrant), and the contribution of the individual taxpayer was arrived at in the last analysis by a series of subdivisions

In certain districts the taille was real (taille reelle); i.e , a tax on real property It was not an equal tax falling on all landowners, but the question as to whether a certain estate was to be taxed or not was decided according to the quality of the property, and not that of the owner The biens nobles (fiefs) and the biens ecclesiastiques were exempt, tenures roturières however, by whomsoever held, were taxed A small part of the pays d'élections was also pays de taille réele But it was the chief form of tax in the pays d'états, and even there an attempt had generally been made to check the exemption of nobles' property It has been shown that in these districts the taille had originally been personal, having become real by a curious evolution In these districts there were cadastres, or compoin-terriers (land registers), which allowed of a non-arbitrary assessment; and at the end of the ancien régime merely needed revision.

In certain provinces where the royal taille was levied there were neither élections nor généralités, and the whole administration of the tax was in the hands of the intendants These were the provinces of the east and north, which were united to the Crown at a period when the power of the intendants was already fully developed; they were sometimes known as pays d'imposition.

See Franch Law and Institutions; Auger, Code des tailles (1788); Henri Sée, Les Classes rurales et le régime domantal en France ou (I. P. E.: X.) Moyen Age (1901).

TAILLEFER, the surname of a bard and warrior of the 11th century, whose exact name and place of birth are unknown. He accompanied the Norman army to England in 1066, and obtained permission from William to strike the first blow at the battle of Hastings, where he was killed. Mention of Taillefer is made by Guido, bishop of Amiens, in his Carmen de bello Hastingensi, v. 931-944 (in Mon. Hist Brit., 1848) and by Henry of Huntingdon in his Historia Anglorum (in Rer. Brit med. gevi script., p.



SCENES IN TAHITI

- Tabilita past diver in outriged cane. These native become very proficient in the art of managing their tiny creaft. A dictate sense of balance is one of their necessary coalification.
   Inland view of Tabili showing conical peaks, econout paims and luxuriant undergrowth characteristic of the Island's landcages

763, ed., Arnold, London, 1879); and his prowess is depicted on the Bayeux tapestry The statement of Wace in the Roman de Roy, 3rd part, v 8035-62, ed Andresen (Heilbronn, 1879), that Tailefer went before the Norman army singing of Charlemanne and of Roland and the vassals who died at Roncevaux has been considered important in demonstrating the existence of a comparatively early tradition and song of Roland

See W Spatz, Die Schlacht von Hastings (Berlin, 1896), Ficeman, History of the Norman Conquest

TAILOR, one who cuts out and makes clothes (Fr tailleur, from tailler, to cut, Lat talea, a thin 10d, a cutting for planting) Formerly the tailor, or cissor, made apparel for both men and women, and not merely outer garments, but also articles of linen and the padding and lining of armour -- whence the style ' Taylors and Linen Armourers" applied to the Merchant Taylors Comnany of the City of London in their earliest charters. But the word is now generally limited to those who make the outer (cloth) garments for men, and less frequently for women, though a phrase such as "shirt-tailor" is occasionally met with. In modern usage, too, it commonly has the implication that the gaiments are made to the order, and to the measure, of the individual purchaser, as opposed to ready-made clothing, which means articles of apparel manufactured in large quantities in a series of stock or standard sizes, such that any purchaser may expect to find among them one that will fit him with more or less accuracy. The clothing trade was originally confined to goods of the poorest grades, but it has come, both in Great Britain and in America. to include articles of good, though not of the first, quality It probably first came into existence at seaport towns, where, to meet the convenience of sailors returning from long voyages and requiring their wardiobes to be replenished at short notice, the "outfitters" kept stocks of ready-made garments on sale, but it made no considerable progress until after the middle of the roth century, when the introduction of the sewing-machine brought about the possibility of manufacturing in large quantities. Its development was attended with gradually increasing subdivision of labour and, to a large extent, with the disappearance of the tailor as a skilled craftsman

The first step was for a garment, such as a coat, to be completed by the toint efforts of a family Then followed the "task system. which in America was the result of the influx of Russian Iews that began about 1875. Under it a team of three men, with a "messer" and a girl to sew on the buttons, divided the work between them Payment was made by the "task," se, a specified number of garments, the money being divided between the memhers of the team in certain proportions. Often several teams would be run by a contractor, who naturally selected the cheapest workshops he could find and packed them as full of workers as possible, and when through stress of competition he had to accept lower prices the plan he adopted was to increase the number of garments to a task, leaving the pay unaltered. The result was the introduction of many of the worst features of the "sweating system." the workers having to work excessively long hours in order to finish the task, which in some cases meant as many as 20 coats a day. In the "factory" or "Boston" system the subdivision is still more minute, and as many as 100 persons may be concerned in the production of one coat The amount of tailoring skill required in a worker is even further reduced, but the premises come under the regulation of the factory laws. The factory system has also cheapened production in a legitimate way, because it has enabled mechanical power for driving sewing-machines, and also expensive labour-saving machinery, to be introduced to an extent not practicable in small shops. (See CLOTHIERS, WHOLESALE.)

TAIN, royal and small burgh, county of Ross and Cromarty, Scotland Pop. (1951) 1,602 Area, 36 sq mi. It is within I mi of Dornoch Firth, 25½ mi. N.E. of Dingwall by the L M.S.R. The name is from the Icelandic thing, "assembly" or "court." The industries include distilling and woollen manufactures, and the town is a market and distributing centre. In the centre of the town is a picturesque tower, once a gaol Duthac (locally called Duthus), a saint of the 11th century, is believed to have been a native, and the ruined chapel near the station is supposed to

have been his shime. To the collegiate church of St. Duthus, a Decorated building, founded by James III in 1471, James IV made several pilgimages in penance for his father's death. The building was used as the parish church till 1815, when it fell into disrepair, but it was restored between 1871 and 1876 It has monuments to Patrick Hamilton, the martyr, and Thomas Hog (1628-1692), the Scottish divine Three and a half miles SE. are the remains of the Early English abbey of Fearn, founded at Edderton in 1230 by Farquhar, 1st earl of Ross, and transferred hither in 1338 Patrick Hamilton became titulai abbot in 1517, and after his martyidom the abbey was added to the bishoping of

TAINE, HIPPOLYTE ADOLPHE (1828-1893), French critic and historian, the son of Jean Baptiste Taine, an attorney, was born at Vouziers on April 21, 1828 J B Taine died on Sept 8, 1840, leaving a moderate competence to his widow, his two daughters, and his son. Taine was educated at the Collège Bourbon, where he formed lifelong friendships with Prévost-Paradol, for many years his most intimate friend, Planat, the future "Marcelin" of the Vie Parisienne, and Cornélis de Witt, who introduced him to Guizot when the latter retuined from England in 1846 Taine passed from the Collège Bourbon to the Roole Normale, but in 1851 he was refused the fellowship in philosophy which was universally regarded as his due Nevertheless the minister of public instruction appointed him to a piofessorship at Toulon, which he exchanged for one at Nevers But he refused to express explicit approval of the coup d'état of Dec 27, 1851 Consequently he was removed to an inferior post, next year saw a further step downward, and he accordingly applied for, and received, indefinite leave of absence. In a few months his two dissertations, De personis Platonicis and the essay on La Fontaine's fables were finished, and May 30, 1853 he took his doctor's degree. This was the last act of his university career, his life as a man of letters was now to begin

No sooner had he deposited his dissertations at the Sorbonne than he began to write an essay on Livy for one of the comnetitions set by the Academy. Here again the moral tendency of his work excited lively opposition, and after much discussion the competition was postponed till 1855; Tame toned down some of the censured passages, and the work was crowned by the Academy in 1855. In the beginning of 1854 Taine, after six years of uninterrupted eifort, broke down and was obliged to rest The year 1854 was an important one in the life of Taine His enforced leisure, the necessity of mixing with his fellowmen, and of travelling, tore him from his cloistered existence and brought him into more direct contact with reality. He lived with his mother in the Isle Saint-Louis, and now he once more associated with his old friends, Planat, Prévost-Paradol and About He made the acquaintance of Renan, and through Renan that of Sainte-Beuve, and he renewed friendly relations with M. Havet, who for three months had been his teacher at the École Normale These years (1855-56) were Taine's periods of greatest activity and happiness in production. In 1855 he published seventeen articles in the Revue de l'Instruction publique, and twenty in 1856 on the most diverse subjects, ranging from Menandei to Macaulay From 1857 onwards he was a regular contributor to the Journal des Débats.

But he was seeking a larger field. In January 1856 his history of English literature was announced, and in 1855-56 he published in the Revue de l'Instruction publique a series of articles on the French philosophers of the 19th century, which appeared in a volume at the beginning of 1857 In this volume he energetically attacked the principles which underlie the philosophy of Victor Cousin and his school. The book closes with the sketch of a system in which the methods of the exact sciences are applied to psychological and metaphysical research. The work itself met with instantaneous success, and Taine became famous In 1858 appeared a volume of Essais de Critique et d'Histoire: in 1860 La Fontaine et ses Fables, and a second edition of the Philosophes Français.

In 1864 Taine succeeded Viollet-le-Duc as professor of the history of art and aesthetics at the École des Beaux Arts. Renan's 756 TAIT

appointment at the Collège de France and Taine's candidature for the Polytechnic School inda alarmed Mgr Dupanloup, who m 1863 issued an Avertssement à la Jeunesse et aux Pères de Feamlle, which consisted of a volent attack upon Taine, Renan and Litté. Renan was suspended, and Taine's appointment to Sant Cyr would have been cancelled but for the intervention of the Prancess Mathilde In December 1863 his Histone de la Littérature Anjañae was published, piefaced by an introduction in which Taine's determinist views were developed in the most uncompositioning fashion. In 1864, Taine sent this work to the Academy to compete for the Prix Bordin M de Falloux and Mgr Dupanloup attacked Taine with vollence, he was warnly defended by Guizot finally, after three days of discussion, it was decided that as the prize could not be awarded to Taine, it should not be awarded at all. After three attempts to secure admission to the Academy Taine was elected in November 1878.

The period from 1864 to 1870 was perhaps the happiest of Taine's life. He derived pleasure from his employment at the Beaux Arts and Saint Cyr, which left ample leisure for travel and research In 1865 appeared La Philosophie de l'Art, in 1867 L'Idéal dans l'Art, followed by essays on the philosophy of ait in the Netherlands (1868), in Greece (1869), all of which short works were republished later (in 1880) as a work on the philosophy of art In 1865 he published his Nouveaux Essais de Critique et d'Histoire; from 1863 to 1865 appeared in La Vie Parisienne the notes he had taken for the past two years on Paris and on French society under the sub-title of "Vie et Opinions de Thomas Frédéric Graindorge," published in a volume in 1867, the most personal of his books, and an epitome of his ideas. In 1867 appeared a supplementary volume to his history of English literature, and in January 1870 his Théorie de l'Intelligence. In 1868 he married Mademoiselle Denuelle, the daughter of a distinguished architect. He had made a long stay in England in 1858, and had brought back copious notes, which, after a second journey in 1871, he published in 1872 under the title of Notes sur l'Angleterre.

Tame, deeply shaken by the events of 1870, now felt that it was the duty of every Frenchman to work solely in the interest of France On Oct 9, 1870 he published an article on "L'Opmon en Allemagne et les Condutions de la Paix," and in 1871 a paraphlet on Le Suffrage Universel, and his intention of writing on the French Revolution returned in a new and definite shape. He determined to trace in the Revolution of 1789 the reason of the political matshulty from which modern France was suffering From the autumn of 1871 to the end of his life his great work, Les Origines de la France Contemporane, occupied all has time, and in 1834 he gave up his professorahup in order to devote himself wholly to his task; but he succumbed before it was finished.

dying in Paris on March 9, 1893.

Les Orienes de la France Contemboraine. Taine's monumental achievement, stands apart from the rest of his work. The problem which Taine set himself was to inquire why the centralization of modern France is so great that all individual initiative is practically non-existent, and why the central power, whether it be in the hands of a man or of an assembly, is the sole and only power; also to expose the error underlying two prevalent ideas:—(1) That the Revolution destroyed absolutism and set up liberty; the Revolution, he points out, merely caused absolutism to change hands. (2) That the Revolution destroyed liberty instead of establishing it; that France was less centralized before 1780 than after 1800. This also he shows to be untrue. France was already a centralized country before 1789, and grew rapidly more and more so from the time of Louis XIV. onwards. The Revolution merely gave it a new form The Origines differ from the rest of Taine's work in that, although he applies to a period of history the method which he had already applied to literature and to the arts, he is unable to approach his subject in the same spirit; he loses his philosophic calm; he cannot help writing as a man and a Frenchman, and he lets his feelings have play; but what the work loses thus in impartiality

it gains in life.

Taine was the philosopher of the epoch which succeeded the

appointment at the Collège de France and Taine's candidature era of romanticism (1820-50) in France The ideal of the newer for the Polytechnic School had alarmed Mgr Dupanloup, who generation was truth, their watchword liberty, to get as near as in 1859 issued on Avertisement à la Jenuese et aux Pères de possible to scientific truth became their object. Taine must ever Famille, which consisted of a volent attack upon Taine, Renan be regarded as one of the most authoritative spokesmen of this

Taine served science unfalteringly, without looking forward to any possible fruits or result. In his work we find neither enthusiasm nor bitterness, neither hope nor yet despair, merely a hopeless resignation. The study of mankind was Taine's incessant preoccupation, and he followed the method already described. He made a searching investigation into humanity and his verdict was one of unqualified condemnation In "Thomas Graindorge" we see him aghast at the spectacle of man's brutality and woman's folly In man he sees the primeval savage, the gorilla, the carnivorous and lascivious animal, or else the maniac with diseased body and disordered mind, to whom health, either of mind or body, is but an accident. Taine is appalled by the bête humaine, and in all his works we are conscious, as in the case of Voltaire, of the terror with which the possibilities of human folly inspire him It may be doubted whether Taine's system, to which he attached so much importance, is really the most lasting part of his work For Taine was an artist as well as a logician, an artist who saw and depicted what he saw in vital and glowing language. From the artist we get his essay on La Fontaine, his articles on Balzac and Racine, and the passages on Voltaire and Rousseau in the Ancien Régime Moreover, not only was Taine an artist who had not escaped from the influence of the romantic tradition, but he was by his very method and style a romanticist. His emotions were deep if not violent, his vision at times almost lurid He sees everything in startling relief and sometimes in exaggerated outline, as did Balzac and Victor Hugo Hence his predilection for exuberance, strength and sprendour; his love of Shakespeare, Titian and Rubens, his delight in bold, highly-coloured themes Tame's influence was great, and twofold. On his own generation

it was considerable; during the epoch in which he lived, while a wave of pessimism was sweeping over French literature, he was the high priest of the cult of misanthropy, in which even science was held to be but an idol, worthy of respect and devotional service, but not of faith In its turn came the reaction against positivism and pessimism, and an attempt at spiritual repascence Around a man so remarkable as Taine a school is certain to form itself; Taine's school, which was one of positivist doctrines, rigid systems and resigned hopelessness, was equally certain to produce at some time or another a school of determined opponents to its doctrines and system If, therefore, the tone which pervades the works of Zola, Bourget and Maupassant can be immediately attributed to the influence we call Taine's, it is also the influence of Taine which is one of the ultimate causes of the protest (M. Bc : X) embodied in the subsequent reaction.

embodied in the subsequent reaction.

(M. Bo; X.)

Binizionaswa-The official life, H Tolne, so vie et sa correspondence, was published in 3 vols. in 1900-00 (Eng. trans by Mrs. R. Devonabure, 1900-003) His rifend, M. E. Bouthy, published an R. Devonabure, 1900-003 (His rifend, M. E. Bouthy, published an Approximative study of Tame's philosophy in his Torne, Scherer, Laboulose (Paris, 1901). See also A Sociel, Nonveaux essus d'histore 4, 1904, 1904, 1906, 190

TAIT, ARCHIBALD CAMPBELL (1811-1839), English divine, archbishop of Canterbury, was born at Edinburgh on Dec. 21, 1811, of Presbyterian parents. He entered Balliol college in 1830 as a Snell exhibitioner from the University of Glasgow. He became fellow and tutor of Balliol and was also ordained deacon (1836) and priest (1838), and served the curacy of Baldon. He never symnathized with the principles of the Tractarian

movement, and on the appearance of Tract 90 in 1841 he drafted the famous protest of the "Four Tutors" against it, but this was his only important contribution to the dispute In 1842 he succeeded Arnold as headmaster of Rugby, and, after a serious illness in 1848, accepted a less strenuous appointment as dean of Carlisle in 1849 During his residence at Carlisle he served on the University Commission, restored his cathedral and did much excellent pastoral work There too he suffered the great sorrow of his life He had married Catharine Spooner at Rugby in 1843, in the spring of 1856, within five weeks, five of their children died of scarlet fever He was consecrated bishop of London on Nov 22, 1856 He became archbishop of Canterbury in 1868 His last years were interrupted by illness and saddened by the death in 1878 of his only son Craufurd, and of his wife

Tait was constant in his attendance in parliament, and pressed on many measures of practical utility. The modification of the terms of clerical subscription (1865), the new lectionary (1871) the Burials Act (1880) were largely owing to him; for all of them, and especially the last, he incurred much obloquy at the time The Royal Commissions on Ritual (1867) and on the Ecclesiastical Courts (1881) were due to him, and he took a large

part in the deliberations of both

Tast was less successful in dealing with matters which called for the higher gifts of a ruler, and especially in his relations with (a) the liberal trend in modern thought, and (b) the Catholic revival (1) His object in dealing with questions of faith, as in dealing with the ritual question, was primarily a practical one he wished to secure peace, and obedience to the law as he saw it Consequently, after his sympathies had led him to express himself favourably towards some movement, he frequently found himself compelled to draw back. He expressed a qualified sympathy with some of the writers of Essays and Reviews, and then joined in the censure of it by the bishops (1861) The same kind of apparent vacillation was found in his action in other cases, eg, in the Colenso case (1863), and in the controversy as to the use or disuse of the Athanasian symbol (1872) (#) Tait was concerned with the Catholic revival during the whole of his episcopate, and above all on the side of ritual. He had to deal with the St. George's-in-the-East riots in 1859, and the troubles at St Alban's, Holboin, in their earlier stages (1867), he took part as assessor in the Privy Council judgment in the Ridsdale case (1877); he was more closely concerned than any other bishop with the agitation against confession in 1858, and again in 1877. His method throughout was the same he endeavoured to obtain a compliance to the law as declared by the courts; failing this, he made the most earnest efforts to secure obedience to the ruling of the Ordinary for the sake of the peace of the Church; after this, he could do nothing In fact Tait could hardly realize anything but the connection between the English Church and the State From such a position there seemed to be no escape but in legislation for the deprivation of the recalcitrant clergy; and the Public Worship Regulation Act (1874) was the result. A widespread feeling of indignation spread not only among High Churchmen. but among many who cared little for the ritual practices involved. At length, when A. H. Mackonochie was on the point of being deprived of his benefice of St. Alban's, Holborn, for contumacy, the archbishop, then on his deathbed at Addington, took steps which resulted in the carrying out of an exchange of benefices (which had already been projected), which removed him from the iurisdiction of the court. This proved to be the turning-point; and the ritual difficulty was afterwards dealt with from a different' point of view, and the Public Worship Regulation Act became practically obsolete. The archbishop died on Dec. 3, 1882.

See R. T. Davidson and D. Benham, Life of Archbishop Tait, 2 vols. (1891); A. C. Tait, Catharine and Craufurd Tait (1880). TAIT, PETER GUTHRIE (1831-1901), Scottish physicist, was born at Dalkeith on April 28, 1831. After attending the Academy at Edinburgh and spending a session at the University, he went up to Peterhouse, Cambridge. As a fellow and lecturer of his college he remained in Cambridge until 1854, and then left to take up the professorship of mathematics at Queen's college, Belfast. There he joined Thomas Andrews (q.v.) in re-

searches on the density of ozone and the action of the electric discharge on oxygen and other gases From 1860 to 1901 he was professor of natural philosophy at Edinburgh, where he died on July 4, 1901.

His earliest work dealt mainly with mathematical subjects, and especially with quaternions (q v), of which he may be regarded as the leading exponent after their originator, Hamilton With the help of Hamilton and Philip Kelland (1808-1879), he wrote two text books, Elementary Treatise on Quatermons (1867), and Introduction to Quaternions (1873). He also produced original work in mathematical and experimental physics In 1864 he published a short paper on thermodynamics, and from that time his contributions to that and kindred departments of science became frequent and important. He worked on thermoelectricity and thermal conductivity, its variation with temperature and its relation to the electrical conductivity of the same material, (See HEAT)

From 1879 to 1888 he was engaged on difficult experimental investigations, which began with an inquiry into the corrections required, owing to the great pressures to which the instruments had been subjected, in the readings of the thermometers employed by the "Challenger" expedition (q v) for observing deepsea temperatures, and which were extended to include the compressibility of water, glass and mercury. Between 1886 and 1892 he published a series of papers on the foundations of the kmetic theory of gases; and about the same time he carried out investigations into impact and its duration

A selection only from his papers, published by the Cambridge University Press, fills three large volumes With Lord Kelvin he collaborated in writing the well-known Treaties on Natural Philosophy. "Thomson and Tait," as it is familiarly called, but only the first part

of it was ever completed.

Tait collaborated with Balfour Stewart in the Unseen Universe which was followed by Paradoxical Philosophy

TAI-YUAN (Yangku), capital of the province of Shansi, China, first noticed about A D. 450, but greatly developed after the expulsion of the Mongols by the building of a great wall in 1377. Its exposure to attack from Mongolia was the reason for this. It is situated on the Fen-ho river, in a well-peopled plain with many good villages, and is at an altitude of about 2,560 ft. above sea level The valleys of the plain nearly all have coal mines Tai-yuan's normal population was estimated between 80,000 and 220,000 By 1911 Tai-yuan was connected by rail with Chengting on the Peiping-Hankow line. Before 1935 a railway along the Fen river south to Yungtsi and north to Yuanping was completed which was later extended south to Fengling and north to Tatung on the Peiping-Suiyuan railway. Meteorological observations kept there show a rainfall of 11.6 in per annum, mainly from May to August, more than half the total falling in July, the month of highest average temperature (766°). The January average temperature is as low as 18.0°, and the January average minimum is 45°. The Japanese took Tai-yuan in 1937.

TAJIK, a subject race of Afghanistan, but the original Persian possessors of the soil, who still speak their mother tongue. The word as now used properly means Arab and was applied to those communities where Arabs settled at the time of the first Arab conquest They are agriculturalists, organized in village communities, sometimes tenants of Afghan overlords, with headmen in their own villages They are Sunnites. See Tribes and Castes of the Punjab and N.W. Frontier Province, vol. iv (1914).

TAJIK REPUBLIC, a state member of the U.S.S R., so constituted in 1929, having been created in 1924 an A.S.S.R. of the Russian S.F.S.R. It is bounded north by the Kirghiz S.S.R., south by Afghanistan, west by the Uzbek S.S.R., and east by Chinese Turkestan, It consists of mountain and plateau of the

Pamir-Alai system, west of the Sarikol range,

Geography and Climate.-The boundary between Russia and Afghanistan, as laid down by the Pamir Boundary commission in 1895, goes along the Lake Victoria Yashil-Kul affluent of the Oxus and eastwards along the Nicholas range, dividing the Great and Little Pamirs, so that all the head of the Little Pamir and the Wakhan valley lie in Afghanistan. The Alichur, Rang Kul, Kargosh (Kara Kul) and Sarez Pamirs are in the Tadzhik republic; a

penur (Persian par-mur or foot of the mountum peak), as a valley stretching urward on a long slope to the mountum peak, and these high level valleys (Lake Virtena Yashi-Kul hav an altitude of 13,400 ft). are mainly of glacual formation. The chief ridges crossing the republic are the Turkestan, Zarashan, Hissar, Trans-Alia, Peter the Gleat and Darvas Mt Leinn (formerly Mt Kaufmann) (23,386 ft.) together with Mt Stalin (24,590 ft) are the highest peaks in the US St.

The eastern part of the republic is characterized by broad flatbottomed valleys, with a series of lakes and low watersheds, and by a severe and dry climate, with an average January temperature as low as that of Novaya Zemlya. The range between day and might temperature is the greatest in the woild, and in mine years only 2 3 m of ram were recorded, this region is bleak and deserted. Of the lakes, Karak-ull (q\*v) is the Jargest, others are Shor-kul, Rang-kul, Yashi-kul, Zor-kul and Sarea. The last was formed in 1917, from the Murged (Battang) river after an earthquake m consequence of which the stream was dammed up by a huge avalanche, Lake Yashi-kul was formed in a similar way

The Amu-Daia or Osus is the chief waterway, and under the name of Pandhy, serves as a boundary between Tadhukstan and Afghanistan, it rises in the Hindu Kush as the Vakhan-darya Most of the glacer-fed streams in the republic are thibutares of the Amu Daia and flow in a southwesterly direction. Along the right bank of this stream and in the lower course of its ributantes, the Kadimugan and Vaksha, is a desert, with a hot dry summer,

which receives less than 10 in, of rainfall per annum

Fauna and Flora.—The valleys on the west are deeper than those on the east and are divided by high, snowy ridges. The northwestern lower slopes are well clad with forest, since they receive more moisture and are less parched in summer. The southwestern slopes are less favourable to vegetation, and a southeastern slope, which means great heat in summer, accompanied by dry winds from Mongolia, is least favourable. Thus in accordance with altitude, slope and type of soil many varieties of vegetation are represented, saxual scrub, jungle grass, especially in the valleys of the Surkhan, Vaksha and Kyayi-Su, where the tiger and deer are to be found, decidious and coniferous forest, and alpine and sub-plape pasture.

Along the northwest runs the upper course of the Zarafshan, with its tributary, the Fan, but the Zarafshan valley there is infertile and difficult to irrigate because of the irregularity of the surface. The most fertile regions are the valleys in which Diu-

shambe and Kurgan-Tyube are situated.

Population and Industry—The types of dwelling are as varied as the climate and vegetation, e.g., fell tents for the nomasi, loses brick walls with a thatch of reeds for the primitive cultivator, the houses are always low, whatever that irve, because of the frequent earthquakes. The chief occupation is slock raising of semi-monadic type, e.e., restricted to certain summer and winter pastures, true nomadism is fast dying out. The disturbances following the 1921 revolution muted diminished the herds. The numbers of assess and mules, so essential for transport in this difficult region, soon regained their former level; cattle, sheep and goats slowly increased, but the numbers of camels and horses long remained below rorq; level, Irrigation cultivation of cotton, rice, olives, wines and fruits in the more favoured valleys is making a steady progress Wheat and blardy as the cheef grain crops.

There are valuable minerals, including coal in the Un-Tyube district and the Zanfahn hasin, fron in the latter district and in the valley of the Vanch, where manganese also occurs. These minerals and gold are worked in a primitive way in some localities. Lead, sulphur, asbeatos and salt are reported, and there are hot springs, especially at Stalmabad. The natural wealth is, however, unsurveyed and there is little prospect of great exploitation in the present absence of means of transport, though some of the towns have enterprises to develop products from agricultural raw inaterials. There are small peasant weaving, carpentry, leather and million industries to supply local needs only.

The link with Uzbekistan is a winding road from Derbent to Stalinabad, which can be used by motors from April to October only. A railway to link Stalinabad via Termez with the trans-

Caspian line was constructed about 1932
The population consists of Tadzhiks, 746%, and Uzbeks, 212%, the rest being Kirghiz, Kazaks, Turkmens, Arabs and Jews It numbeted (1939) 1,485,691 (rural 1,233,209, urbar 25,1882), having been much dimmished in the post-1977 disturb-

ances, when many fugitives took refuge in Afghanistan Area, 55,545 sq mi

The literacy rate is low throughout the republic and in the Badakshan area it is probably less than 2% Education is difficult in this wild country and not more than 12% of the children of school age are provided for, medical help is almost entirely lacking The Tadzhiks are Mohammedans, but not of a strict type, and in the remoter areas much primiture nature worship survives Stalinabad (we DIUSHAMME) (pop in 1939, 82,540) is the administrative centre

The Mountain Badalshan Autonomous Area was created within Tadahistan in 1975, with Khorog (pop 1933, 1,200) as its centre; it has an area of 33,591 sq mi. If consists of the mountain thot in the southeast, of winch 75% is stony and sandy high desort. The climate is severe, average Janusity temperature  $-4^5$  F, average July  $+50^5$  F. on the east, and  $+14^5$  F, +71 6° F. on the east, and  $+14^5$  F, +71 6° F. on the west. The population in 1933 was 55,700 and consisted 588% Tadahists and 11 4% Kara-Kirghia. In the east are nomad herdismen raising hoises, mules, asses, camels, sheep and goats, while in the west scanty crops of rye and wheat supplement herding Hunting and trapping of marten, fox and otter are additional sources of income and gold is extracted in a primitive way

Billiousaphy —In English, S. G. Littledale, Across the Panin from North to South (1892), W. R. Rickmers, The Duado of Turbestan (1921). In Russan, P. S. Nararov, Trueds in the Panin; (1890), Y. D. Golovini, To the Panins (1902); A. I. Dimitra-Mamonov, Ordon and Computer (1903). A. R. Boburnish, Monstain Tribes of the Pani (1908).

TAJ MAHAL, the tomb built at Agra, India, by Shah Jahan for his wife, Mumtaz Mahal, where he is also buried. It was begun in 1632 (in which year the Shah ordered the stopping of all other Hindoo temple-building), and was completed by 1650 The Taj Mahal is the most perfect example of the Mogul style and is by some considered the most beautiful building in the world The tomb proper consists of a domed, square, white marble building, raised on a terrace from the corners of which rise four slim, white minarets. The whole is set in an exquisite garden surrounded by a red sandstone wall; a gate and a mosque are subsidiary elements in the composition. The tomb building itself is 186 ft square, with a dome 58 ft in internal diameter rising to a total height of 210 feet. The building is said to have cost over £3,000,000 It was probably designed by an architect named Ustad Isa, traditionally supposed to have been either Turkish or Persian For a complete description see Agra See also Indian Architecture.

TAKIN, a hollow-horned uminant (Budoreas taxcolor), which inhabits the southeast corner of Thete, while a second form is found farther east, in the Moupin district. The taken is clumisly built, with yellowish-brown or gray hair and currously curved horns, which recall those of the gnu. Its nearest relatives appear to be the myskore (av n. CSe BOUDLE.)

to be the musicozen (gw.). (See Bovubae.)

TAKIA, MAKAN, a desert area in Central Asia. This unit is the major division of that portion of the Tarim basin what stretches westwards from the lower course of the Tarim river to the Parmirs. Its borders on the west, north and east are formed by the Timaft, Yarkand and Tarim never sepsectively

Speaking generally, the Takla Makan is a region of bare drift sand and moving sand dunes, a waterless area, except for the Khotan and Kerlya rivers, which carry water northwards into the desert from the Kunlun. This sand dune desert is absolutely munhabitable, except for a few scattered settlements along the banks of these rivers. These sandy wastes are found all the way down the right bank of the Tarim river to its confluence with Lake Kara-Buran, and then continue up the Charchan Darya and almost as far west as Keriya. The sand dunes proper of the Takla Makan occupy chiefly the south and southwest of the tregion, where the full force of the northeast wand is felt.

Between the lower Tarm river and the Chaichan Darya, the surface conformation is different from that of the rest of the Takla Makan. Here the sand dunes are interrupted by tracts of periectly level soil entirely destitute of sand. In the southernmost part of this area there are patches of reeds and tamarisks.

and wells are to be found in this locality

In the west, stretching from Yangi Hissar to the left bank of the Yarkand river, there is the region of moving sands known as Ordam Padshah In the east, beyond the left bank of the Tarım river, there is a zone of high and barren sand ridges, extending beyond the river and filling the area between the foot of the Kuruk Tagh hills and the belt of wind-eroded desert along the western side of the ancient salt-encrusted Lop lake hed. In this region the sands are much less frequent than in the Takia Makan itself Here the soil is of loose saline clay, bare in some places, overgrown in others with tamarisk bushes. The plants bind the soil with their roots into a solid mass, the intervals between the masses of plants being subject to the full erosive force of the winds. The drift-sand accumulates around the bushes and gradually a billock of sand and tamarisks is formed These hillocks are between 7 and 14 ft high, and cover large tracts in this eastward extension of the sandy desert In the sand dune desert proper of the Takla Makan, there are two systems of dunes; one system, of the high chains, stretches from east to west, while the transverse dunes run from north to south, or north-east to south-west. The steeper faces of the dunes are, for the most part, turned towards the south, the south-west and the west, that is, away from the direction of the prevailing winds, but in some regions face east

Vegetation and animal life are extremely scarce. The former is practically confined to various steppe plants, kanish (teeds), tamarisks, almost invariably growing on root mounds, and poplars. The animals are hares, rats, and one of two other rodents, foxes,

and, in a few places, the wild camel,

The climate is one of extremes In the Charchan desert a temperature of -22° Fab seen observed in the depth of winter, and snow sometimes falls heavily there. During the sandstorns as much as 10° or 12° F below zero. On the other hand, a temperature as high as 86° Fab seen recorded at the end of April This desert can only be crossed safely in the winter, when it is possible to transport ice on the backs of camels. Sometimes, or days together, the desert is enveloped in an impenetrable dust huze, which tokes and smothers every living creature

In the second half of the 13th century, Maico Polo left a vivid description of this desert and related legends associated

with it. (See also SINKIANG, TARIM.)

TAKORADI, a port on the Gold Coast, Brutish West Africa, in 4° go N, 13° 45 W. The main breakwater, 1½ mi long, is built on a reef which extends a to 3 mi from the rocky foreshore. The lee breakwater is ½ mi long. the enclosed area is 270 sc. and mit shape up to 40 ft. draught can lie Shaps 400 ft long and 20 ft draught can lie alongsed the wharves. The port is excellently equipped and can handle 5,000 tons of cargo daily It is the terminus of the western railway to Kumasa, is the chief port of the Gold Coast, and the only deep water harbour between Sierra Leone and Nigeria, 1e., on 1,300 mi, of coast On high ground overlooking the harbour is a model towaship, built to accommodate 150,000 inhabitants. The port was opened to general traffic in 1928 Pop (1948) 44,150 including Sckodin in 1928 Pop (1948) 44,150 including Sckodin in 1928 Pop (1948) 44,150 including Sckodin in 1928 Pop (1948) 44,150 including Sckodin in 1928 Pop (1948) 44,150 including Sckodin in 1928 Pop (1948) 44,150 including Sckodin in 1928 Pop (1948) 44,150 including Sckodin in 1928 Pop (1948) 44,150 including Sckodin in 1928 Pop (1948) 44,150 including Sckodin in 1928 Pop (1948) 44,150 including Sckodin in 1928 Pop (1948) 44,150 including Sckodin in 1928 Pop (1948) 44,150 including Sckodin in 1928 Pop (1948) 44,150 including Sckodin in 1928 Pop (1948) 44,150 including Sckodin in 1928 Pop (1948) 44,150 including Sckodin includ

TALAING, a name given to the Mon people of Pegu in Burma, now largely absorbed into and indistinguishable from the Burmas nation. The Mon are a remnant of the oldest known coultastion of southeast Asia (see article Asia), speaking a Ianguage which connects with scattered survivals from the Mundas, in Chhota Nagpur and the Khasis of Assam to Cumbodia, and probably also to Yunnan and the Malay archipelago. The Mon, however, got their culture, their religion, now Buddhist but originally Hindu, and their literature from the Tellingana cost of South India; and from the Tellingas, whose culture they took and whose foreign blood they absorbed into their own stock, came the name Talaing. This culture was again passed on to the Burnese conquerors of Pegu, and Burnese is written in the Talaing alpha-

bet Burmese law is largely derived from Talaing monastic writ ings, and Burmese historical tradition is full of Indian nomenclature and Indian legend (See G. E. Harvey, History of Burma (J. H. H.) TALANA HILL, ACTION OF, Oct. 20, 1895; see Sourin

AFRICAN WAR, 1899-1902

TALAR, the throne of the Persian monarchs which is carved on the rock-cut tomb of Danus at Nakst-i-Rustan, near Persepols

TALAYERA DE LA REINA, a town of central Spain, mhe perome of Toledo, on the right bank of the river Tagus, and on the Madrid-Cacers railway. Pop (1940), 16,500 (mus. 1854); Talavera is of great antiquity, the Caesobrag of the Romans Portions of the triple wall which surrounded it remainstanding, and the Anco de San Pedro is one of its Roman gates testored Among the ancient buildings are the Torres Albarrans, built by the Moors in the 10th entury, and the Gothic collegate church. The bridge of thuty-five arches across the Tagus dates from the 15th century.

Talayera, Battle of, 1809 .- For the operations which culminated in the famous battle of Talavera, between the English and the French, and those which followed that engagement, see PENINSULAR WAR Sir Arthur Wellesley (afterwards Duke of Wellington), the British commander, acting in co-operation with Lieutenant-General Cuesta's Spanish army, took position on July 27, 1809, on the Upper Tagus, protected by his advanced guard His line, facing due east, ran north from the right bank of the river to a ridge running parallel to the Tagus, beyond which ridge, also parallel to the river, lay the Sierra de Montalban Cuesta's men with their right flank resting on the river held Talavera itself and the close country to the northward of it, Wellesley's right connected with Cuesta's left, and his line stretched away northwards to the ridge already mentioned. The Sierra was not, on the first day, occupied, and even on the inner ridge itself the division of General Hill was, from a misunderstanding, very late in taking up its position. The whole front was covered by a rivulet running from the ridge to the Tagus The battle was begun by the attack of two French divisions on the British advanced guard, which retired into the main position with severe loss and in some disorder Marshal Victor's forces followed them up sharply, and soon came upon Wellesley's line of battle For some time the retention of the ridge (owing to the delay of Hill's Division) was in doubt, but m the end the arrival of Hill's troops secured this all-important point for the Allied left. Meanwhile the Spaniards (though there was at first a temporary panic amongst them) and the right divisions of the British repulsed an attack in the plain, and the day closed with the armies facing each other along the rivulet and on the ridge The losses had been heavy on both sides Early on the 28th the battle was renewed by a furious attack on Hill's troops, whose left was now prolonged to the Sierra by the Allied cavalry and a division borrowed from Cuesta. King Joseph Bonaparte and Jourdan his chief of staff, who were present, were averse to fighting on this present ground, wishing to wait for Soult, whom they expected to come in on Wellesley's rear, and it was only after long discussion that the king gave a reluctant assent to Victor's plan of attack. That commander's divisions once more tried to oust Hill from the ridge, and once more failed before the steady volleys of the British line and the charge of the cavalry posted in this quarter (though, owing perhaps to defective ground-scouting, this nearly ended in disaster). At the same time Sebastiani's IV. corps, after a heavy bombardment, assaulted the Allied centre in the plain. Here the British and Spanish battalions held their own firmly, and a counter attack by Mackenzie's division hurled back the French in disorder. Yet another attack followed these failures, and came very near to achieving a great success This time Lapisse's division of Victor's corps attacked the Allies' left centre, composed of the British Guards. The French columns were again checked by the British line, but here the counterstroke, unlike Mackenzie's, was carried too far, and the troops in the ardour of incautious pursuit were very severely handled and pushed back to the position by the French reserves; but Wellesley decided the day by a counter attack with the 48th regiment, made with great intrepidity and

steadiness. The Guards, with splended discipline, resumed their positions, and eventually the French fell back. Failure all along the line and heavy losses left King Joseph no alternative but to retire towards Madrid The French lost, 7,685 men out of 46,138 present, the British 5,365 out of 26,641; the Spanish lossess were officially returned at 1,200 rout of 300ms 26,000 present

TALBOT (FAMILY). This is one of the few families in the English aristocracy which traces alike its descent and its surname from the Norman conquerors of England The name of Richard Talbot occurs in Domesday Book as the holder of nine hides of land in Bedfordshire under Walter Giffard. There is no evidence that he came over to England with the Conqueror himself; and, as he did not hold of the king in capite, it is clear that he was not a leader. Talbot being a personal nickname and not derived from a place, those who bore it were not of necessity connected, and the early pedigree is obscure. But a Geoffrey Talbot took part with the empress Maud against King Stephen, and a Hugh Talbot held the castle of Plessis against Henry I for Hugh de Gournay, and afterwards became a monk at Beaubec in Normandy. RICHARD TALBOT, with whom the proved pedigree begins, obtained from Henry II, on his accession the lordship of Linton in Herefordshire, and from Richard I the custody of Ludlow Castle His descendants for some generations appear to have been wardens of various castles on the borders of Wales, and intermarried with the great families of this region Under Edward II. a Gilbert Talbot was head of the house, and invaded Scotland in the king's company, but afterwards took part with Thomas of Lancaster against the king. He, however, was pardoned, and obtained from Edward III a confirmation of the grant of the manor of Linton and other lands, being also summoned to parliament as a baron (1331).

His son RICHARD, who married a daughter and co-heiress of John Comyn of Badenoch, laid claim to lands in Scotland in her right, and, when restrained from entering that country by land (Edward III having then made an alliance with King David), he joined in an expedition which invaded it by sea in the interests of Edward Baliol. Three years later he was taken prisoner, and redeemed for 2,000 marks, after which the king made him governor of Berwick He took part also in Edward's wars against France, as did likewise his son Gilbert, who succeeded him. His wife brought him Goodrich Castle on the Wye, and at this time the family possessed lands in the counties of Oxford, Gloucester, Hereford and Kent Gilbert's son Richard added to this inheritance by marrying the heiress of Lord Strange of Blackmere, and himself became under Richard II one of the heirs of the earl of Pembroke, thus adding to his estates, lands in Berkshire, Wilts, Salop and Essex. Another Gilbert Talbot, grandson of the last, claimed to carry the great spurs at the coronation of Henry V., and had a commission to receive the submission of Owen Glendower and his adherents. He also distinguished himself in the invasion of Normandy. He left no male issue, and was succeeded by his brother John.

Hutherto the head of the house had borne the name of Lord Talbot; but this John, after obtaining by marriage the title of Lord Furnival, was for his services created earl of Shrewsbury. (See Shrewsbury, John Talbot, 157 Barl Op.)

Jours, the second earl of Shrewsbury, was the 1st earl's son by his first wife He had been knighted at Leicester (1446) along with the unfant king Henry VI, had served in the wars of France, and been made chancellor of Ireland during his father's lifetime, when he was only Lord Talbot, Afterwards he was made lord high treasurer of England, and in 14,59 was rewarded for his services to the house of Lancaster with a grant of roo marks a year out of the lordship of Wakefield, forfeited by Richard, duke of York, But next year he and his brother Christopher were skin at the battle of Northampton, fighting in the cause of Henry VI. His son John succeeded him, and then his grandson George, who fought for Henry VI. at Stoke, and whom King Henry VIII. sput as his licutenant against the rebels in the Pillerfinging of Grace.

FRANCIS, the 5th earl, took part in the invasions of Scotland under Henry VIII, and Edward VI., and was one of the two peers

who alone opposed the bill for abolishing the pope's juusdiction under Ehzabeth His son George, who succeeded, was the earl to whom the custody of Mary Stuart was committed, his task being rendered the more difficult by the intrigues of his second write, Bess of Hardwick, the builder of Chatsworth, who was thrice marned before her unon with him Two sons of this last earl succeeded one another, and the title then devolved on the lineal descendants of Sir Gilbert Talbot of Grafton in Worcestershire, third son of John, the 2nd earl.

Charles, the 12th earl, was raised by William III to the dignity of a duke, but as he left no son this title died along with him in 1718, and the earldom of Shrewsbury devolved on his

cousin Gilbert, a Roman Catholic priest

From this time the direct line of Sir Gilbert Talbot of Grafton began to fail A nephew three times succeeded to an uncle, and then the title devolved upon a cousin, who died unmarried in 1856 On the death of this cousin the descent of the title was for a short time in dispute, and the lands were claimed for Lord Edmund Howard (now Talbot), an infant son of the duke of Norfolk, under the will of the last earl, but the courts decided that, under a private act obtained by the duke of Shrewsbury shortly before his death, the title and bulk of the estates must go together, and the true successor to the earldom was found in Earl Talbot, the head of another line of the descendants of Sir Gilbert Talbot of Grafton, sprung from a second marriage of Sir Gilbert's son, Sir John Talbot of Albrighton. The head of this family in the beginning of the 18th century was a divine of some mark. William Talbot, who died bishop of Durham in 1730 His son Charles, who filled the office of lord chancellor, was created Bason Talbot of Hensol in Glamorganshire in 1733, and his son William was advanced to the dignity of Earl Talbot in 1761, to which was added Ingestre, the barony of Dyneyor, with special remainder to his daughter, Lady Cecil Rice, in 1780 Then succeeded a nephew, who was created Viscount and Earl Talbot, and assumed by royal licence the surname of Chetwynd before Talbot, from his mother

All the titles just mentioned have been united in the line of the Earl Tallot who successfully claimed the Shrewsbury title as the 78th earl, the earldom of Shrewsbury (1442) being now the oldest existing that is not merged in a higher title The family seasts (Alton Towers and Ingestre Hall) and the chief estates are in Staffordshire. The old badge of the family was a "tialbot" or running hound

running hound (J. Gar; J. H. R.)

TALBOT, MARY ANNE (1778–1808), the "British Amazon," was born in London on Feb. 2, 1778. She believed herself to be the illegitimate child of the 1st Earl Talbot Early in her career she eloped, in the disguise of a boy, with a captain In 1792 she was a drummer in Flanders. In the capture of Valenciennes her love, was killed, and Mary Anne deserted and became cabin boy on a French lugger, which she asserted was captured by the British, who transferred her to the "Brunswick," where she served as a powder monkey, being wounded in Lord Howe's victory of June 1, 1794 For this she later received a small pension When the wound healed she again went to sea, was captured by the French, and imprisoned for a year and a half. Her sex was not discovered until shortly afterwards she was seized by a pressgang She finally became a household servant to Robert Kirby, a London publisher, who included an account of her adventures in his Wonderful Museum (1804) and in Life and Surprising Adventures of Mary Anne Talbot (1809). She

died on Feb. 4, 1308.

TALBOT, WILLIAM HENRY FOX (1800-1877), Eng-lish discoverer in photography, was born at Lacock abbey, Wils, on Feb 11, 1800, and died there on Sept. 17, 1877. He was educated at Harrow and at Trinity college, Cambridge. Before L J. M. Daguerre exhibited in 1839 pictures taken by the sun, Talbot had obtained similar success, and as soon as Daguerre's discoveries became known he communicated the results of his experiments to the Royal Society In 1847 he made known his discovery of the calcippe or Talbotype process, and after the discovery of the collodion process by Frederick Scott Archer in 1851 he devised a method of instantaneous photography. With Rawlinson

inscriptions from Nineveh His works include Pencil of Nature (1844), Hermes or Classical and Antiquarian Researches (1838-39), Illustrations of the Antiquity of the Book of Genesis (1839), English Etymologies (1846)

TALBOT OF HENSOL, CHARLES TALBOT, IST BARON (1685-1737), lord chancellor of England, the eldest son of William Talbot, bishop of Durham, a descendant of the 1st earl of Shrewsbury, was educated at Eton and Oriel college, Oxford, and became a fellow of All Souls college in 1704 He was called to the bar in 1711, and in 1717 was appointed solicitorgeneral to the prince of Wales. Having been elected a member of the House of Commons in 1720, he became solicitor-general in 1726, and in 1733 he was made lord chancellor and raised to the peerage with the title of Baron Talbot of Hensol He died on Feb 14, 1737 Talbot enjoyed the reputation of a wit, he was a patron of the poet Thomson, and Butler dedicated his Analogy to the lord chancellor

See Lord Campbell, Laves of the Lord Chancellors and Keepers of the Great Seal (8 vols London, 1845-69), Edward Foss, The Judges of England (London, 1848-64), Lord Hervey, Memoirs of the Reign of George II (London, 1848), G. E. C., Complete Peerage, vol vii. (London, 1896)

TALC, a mineral which in its compact forms is known as steatite, or soapstone It was probably the μαγνήτις λίθος of Theophrastus, described as a stone of silvery lustre, easily cut The name word comes indirectly from the Arabic talq, and is not connected with Swed talja, to cut It was confused with mica by the older writers, and even now mica is sometimes known in trade as tale, while the term was formerly applied to foliated gypsum

Talc is occasionally found in small hexagonal and rhombic plates with perfect basal cleavage, which are supposed to be monoclinic, and often occurs in foliated masses, sometimes with a curved surface, readily separating into thin, very flexible, non-clastic laminae The plates give a six-rayed percussion-figure Talc has a hardness of only about 1, and a specific gravity of from 26 to 28 Its extreme softness and its greasy feel are characteristic The lustre on the cleavage face is pearly, or sometimes silvery, and one of the old names of the mineral was stella terrae, while German writers sometimes called it Katzen-

silber The colour is white, grey, yellow or frequently green Talc is a magnesium silicate, H<sub>2</sub>Mg<sub>2</sub>S1<sub>4</sub>O<sub>12</sub>. It is generally regarded as a hydrous silicate, but the water is expelled only at a very strong heat, and may therefore be regarded as basic. By the action of heat the hardness of the mineral is greatly increased. Pseudomorphs are known after actinolite, pyroxene, etc, and the mineral has probably been generally formed by the alteration of ferro-magnesian silicates. Talc occurs chiefly in crystalline schists, usually associated with chlorite, serpentine and dolomite Fine examples of apple-green colour are found at Mt Gremer, in the Zillerthal, Tirol. Talc-schist is a foliated rock composed chiefly of tale, generally associated with quartz and felspar; but all soapy schists are not necessarily talcose.

The steatites of Pliny was a stone resembling fat, but otherwise undescribed Being easily cut, steatite has always been a favourite material with the carver: it was used for Egyptian scarabs and other amulets, which were usually coated with a blue vitreous glaze; it was employed for Assyrian cylinder-scals and for other ancient signets, and ancient steatite carvings are found among the ruins of Rhodesia. By the Chinese steatite is largely used for ornamental carvings; but many of their "soapstone" figures are wrought in a compact pyrophyllite (q.v), which is essentially different from talc. The name agalmatolite is often applied to the material of these figures, and was suggested by M. H. Klaproth from the Greek ἄγαλμα, an image. Pagodite is an old name for Chinese figure-stone

Steatite is usually a white, grey, greenish or brown substance, occurring in veins or nodular masses or in lenticular bedded deposits Pseudomorphs after quartz and dolomite occur near Wunsiedel in Bavaria. In some cases it is a product of the alteration of pyroxenic rocks, and the commercial mineral may be very impure. The ease with which steatite may be worked, coupled

and Hincks he was one of the earliest to decipher the cuneiform with its power of resisting heat, has led to its employment for vessels for household use, whence it is called "potstone"-the lapis ollaris of old writers; it is also used, especially in America, for sinks, stoves, firebricks, foot-warmers, tips for gas-burners and electric switchboards, and, when ground, as a filler for paper, for leather-dressing, for covering steam-pipes, as an ingredient in soap, for toilet-powder, for certain paints and as a lubricant A fine granular variety, known as "French chalk" or "Spanish chalk," is used by tailors for marking cloth; slate pencils are made of steatite and pyrophyllite, and in Burma steatite pencils are used for writing on black paper. In the oxyhydrogen flame, steatite has been fused and drawn out into threads, like quartz-

Steatite- and talc-schists are widely distributed and have occasionally been used as building stones. When first raised the stone is soft, but hardens on exposure Soapstone from Gudbrandsdal is used in the cathedral of Trondhjem, Norway Veins of steatite occur in the serpentine of the Lizard district, Cornwall, and the mineral was used under the name of soap rock in the manufacture of the old Worcester porcelain. In North America its distribution is very extensive

A fibrous steatite from New York State, used in the manufacture of paper, is known as agalite Rensselaerite is a wax-like 'talcose substance, passing into serpentine, from St Lawrence county, N Y, named by E Emmons in 1837 after S. Van Rensselaer, of Albany, N Y Beacounte is an asbestiform talc from Michigan, named by L W Hubbard. The term pyrallolite was given by Nils G Nordenskiold to a mineral from Finland, which appears to be talc pseudomorphous after pyroxene Talcoid was K F Naumann's name for a white lamellar mineral from near Pressnitz in Bohemia A blue earthy mineral from Silver City, New Mexico, known locally as "native ultramarme," is a magnesum silicate

nesum suicate
See "Tale and Sogastone" in vol 1 of Mineral Resources of the
See "Tale and J H. Pratt, "Genome Papers," No 3, of Gool
Sow 100 Ceroline (1900); C H. Smyth, Jr., "The Fibrous Tale
Industry of St Lawrence Co, N.Y." in Mercal Industry, vol 1 (1900); G P. Merrill, Non-metallic Mineral (1904), and R. H.
Ladoo, "Tale and Sogastone," US Bur of Mines, Bull. No. 213

TALCA, a province of Chile, bounded on the north by Curicó, east by Argentina, south by Linares and Maule and west
by the Pacific The area, since being separated from the province of Cuncó, 18 3,722 sq.mi; pop (1951) 174,047 In the east the Andean slopes cover a considerable part of its territory, and in the west another large area is covered by the coast range Between these is the central valley of Chile in which the population and industries of the province are chiefly concentrated. The lower mountainous parts are well wooded. The intermediate plain is fertile and devoted to wheat, grapes and stock. The capital of the province is Talca (pop 1944, 50,464), on the Rio Claro, 156 mi. by rail south of Santiago The city, founded in 1692 and revived in 1742, has a variable climate.

TALCAHUANO, a seaport of the province of Concepción, Chile, on the bay of Talcahuano, 8 mi. NW of the city of Concepción, Pop (1944) 35,774. It has the best harbour on the Pacific coast of South America and is one of the most important ports of southern Chile. The Chilean government established its chief naval base there.

TALE, a general term, in the usual acceptance of the word, for fictitious narratives, long or short, ancient or modern (O.Eng. talu, number, account, story; the word is common to many Teutonic languages; cf. Ger. Zahl, number, Erzählung, narrative, Du taal, speech, language). In this article "tale" is used in a stricter sense, as equivalent to the German "Volks-marchen" or the French "conte populaire." Thus understood, popular tales mean the stories handed down by oral tradition from an unknown antiquity So understood, popular tales are a subject in mythology. The Homeric epics, especially that of the Odyssey, contain adventures (those, for example, of the Cyclops and the husband who returns in disguise) which are manifestly parts of the general human stock of popular narrative. Other examples are found in the Rigueda, and in the myths which were handled by the Greek dramatists The Thousand and One Nights (a v) is full of popular tales, and popular tales are the staple of the mediaeval Gesta Romanorum, and of the collections of G Straparola and other Italian storytellers In all these the story, long circulated among the people, is handled with conscious ait. In Histoires ou contes du temps passé of C Perrault (Elzevir, 1697), we have one of the earliest collections of tales which were taken down as they were told by nurses to children The success of Perrault's tales brought the genre into fashion, and the Comtesse d'Aulnoy invented, or in some cases adapted, "contes," which retain popularity But the precise and scientific collection of tales from the hps of the people is not much earlier than the 19th century The chief impulse to the study was given by the brothers Jacob and Wilhelm Grimm The first edition of their Kinderund Haus-Marchen was published in 1812 The English reader will find a considerable bibliography of popular tales, as known to the Gumms, in Mis Alfred Hunt's translation, Grimm's Household Tales, with Notes (1884) In addition to the marchen of Indo-European peoples, the Grimms became acquainted with some Malay stories, some narratives of Bechuanas, Negroes, American Indians and Finnish, Estonian and Magyar stories

See the bibliography in the translation of Grimm already referred to, the Massonneuve collection, Lev Littératures populaires, Sir James Frazer's The Golden Bough See also Novel (A L, X)

TALENT, the name of an ancient Greek unit of weight, the heaviest in use both for monetary purposes and for commodities (see Measures and Weights, Ancient) (Lat talentum, adaptation of Gr τάλαντον, balance, weight, from root ταλ-, to lift, as in τλήναι, to bear, τάλας, enduring, cf Lat tollere, to lift, Skt tule, balance) The weight itself was originally Babyloman, and Egyptian kerker and the Syrian and Palestinian kikkai were denved from it. The Attic talent was divided into 60 mines at 100 drams each. The weight of the Attic talent was approximately 57 75 lb

In mediaeval Latin and also in many Romanic languages the word was used figuratively of will, inclination or desire, derived from the sense of balance, but the general figurative use for natural endowments or gifts, faculty, capacity or ability is derived from the parable of the talents in Matt. xxv

TALFOURD, SIR THOMAS NOON (1795-1854) English judge and author, the son of a brewer, was born at Reading on May 26, 1795. He was educated at Hendon, and at Reading grammas school. At the age of 18 he was sent to London to study law under Joseph Chitty, the special pleader. Early in 1821 he joined the Oxford circuit, having been called to the bar at the Middle Temple in the same year. He became a sergeantat-law in 1835, and a judge of the common pleas in 1849 He was MP for Reading, and carried an international copyright bill against stormy opposition in 1842 Charles Dickens dedicated the Pickwick Papers to him On the literary side, he contributed to various magazines, and his legal writings on literary subjects included "On the Principle of Advocacy in the Practice of the Bai" (Law Magazine, Jan. 1846), and his famous Speech for the Defendant in the Prosecution, the Queen v Moxon, for the Publication of Shellev's Poetical Works (1841).

But Talfourd cannot be said to have gained any position among men of letters until the production of his tragedy Ion, which was privately printed in 1835, and produced in the following year at Covent Garden theatre. Other less successful plays followed Talfourd died in court during the performance of his judicial duties, at Stafford, on March 13, 1854 Talfourd was also the author of The Letters of Charles Lamb, with a Sketch of his Life (1837); Recollections of a First Visit to the Alps (1841) Vacation Ramblas and Thoughts, comprising recollections of three continental tours in the vacations of 1841, 1842 and 1843 (2 vol., 1844); and Final Memorials of Charles Lamb (1849-50).

TALGARTH, a small town and civil parish in Breconshire, Wales, situated on the Ennig near its junction with the Llynfi (a tributary of the Wye), in the N.W. section of the Black mountains. It is served by the Western Region railway route. Pop

S E of Talgath, and commands the pass to Crickhowell and the eastern part of the vale of Usk The region shows evidences of Norman and English penetration and an early distinction between the lowland (English Talgarth) and the upland (Welsh Talgarth) in which the Welsh laws of property, etc., prevailed until the end of the middle ages The region has associations with early nonconformity and there is a Congregational church at Tredwestan founded in 1662 Howel Harris, one of the founders of Welsh Methodism, was born in 1713 at Trevecca, 1 mi SW, and there in 1752 he established a religious "family." Trevecca college is now a Welsh Methodist preparatory school

TALIENWAN, an open bay or roadstead on the east side of the Liaotung peninsula, Manchuna It was leased to Russia by China in 1898 with the naval fortress of Port Arthur, from which it is 40 mi distant, the lease being transferred to Japan m 1905 The Russian town of Dalny (now Dairen) was built upon the west side of the bay, which is known as Port Victoria Talienwan is in railway connection with Niuchwang and Peking and is also connected with Europe by way of the Siberian railway It was the rendezvous of the British fleet during the Anglo-China War of 1860, whence the names Port Arthur and Port Victoria See DAIREN

TALIESSIN, a late 6th-century British bard, to whom is attributed the collection of poems known as the Book of Taliessin. See Welsh Language and Literature.

TALLADEGA, a city of Alabama, US, the county seat of Talladega county, 57 mi E of Birmingham, in the foothills of the Blue Ridge, at an altitude of 554 ft. It is served by the Southern, the Louisville and Nashville and the Atlantic Coast Line railroads, and is on federal highway 241 Pop (1950) 13,186 It is in a fertile agricultural and dairying region, with marble and limestone quarries and iron mines The chief industrial products are cotton textiles, cottonseed oil, machine paits, pipe fittings, soil pipe, lumber, woollen worsted fabric and yarn The Alabama School for the Deaf and Blind and Talladega college (Negro coeducational, 1867, Congregational) are located there Near by are Cheaha State park, Talladega National forest (largest in the state) caverns and mineral springs The name Talladega, also applied to mountains south and east of the town, is Indian for "border town" as its site was on the edge of the Cieck Indians' land Andrew Jackson defeated a large force of Red Stick Indians there in 1813

TALLAGE was a tax which in England could be imposed by a feudal lord upon his unfree tenants The king could tallage the towns and his demesne manors. A lesser lord could tallage his demesne manors The royal tallage of the boroughs to some extent took the place of Danegeld under Henry II, the latter tax having ceased to be profitable Growing prosperity made tallages justifiable. Moreover Henry had a better machinery for the assessment and collection of tallage than any king before him. His judges, financial as well as legal experts, were going round the shires more frequently than any previous royal ministers They could assess the tallages, and the exchequer (q v) could see that they were paid The tax might be arranged by the judges in one of two ways; they might bargain with the town or manor to provide a definite sum for the king, or they might tallage the individual burgesses. The former practice was more usually followed. In the 13th century the custom of summoning representatives from the boroughs to meet the king and his magnates in parliament grew more frequent and the practice of taking tallages from the towns began to fall out of use, since grants were made to the king in the parliament. Nevertheless he kept his right of tallaging the boroughs. Edward I took a tallage in 1304, his son in 1312. His grandson tried to take one in 1332, but because of opposition took a grant from parliament instead. In the 12th century the lord seems to have been able to tallage his men at will. his exactions were bounded only by the custom of the manor, which might either limit his right narrowly or allow him considerable latitude in the matter. Beginning with the inquest of sheriffs in 1170 the kings took more and more interest in the relations between lord and man, and in time the right of the lord to tallage (1931) 1,882. A fortified station (Dinas) occupies a hill 2½ mi. his men was closely restricted. He had to obtain a heence from

the king before he could take a tallage. The right of towns, too, to tax individual burgesses was very narrowly limited. The king would allow a tallage to be taken for a necessary public work, or for the payment of sums due to him, but he kept a careful watch on the taking nowers of the borough madistrates. DM S)

TALLAHASSEE, the capital city of Flouda, ÜS, and the county seat of Leon county, in the nothern part of the state, on federal highway 90, midway between Jacksonville and Pensacola, and 20 m N of the Gulf of Mexoc. It has a municipal aniport, and is served by the Georgia, Flouda and Alabama and the Scahoural Au Libic railways Population was 27,237 in 1950 by the federal census and 16,240 m 1940. It has a fine location, being stutated on a full 216 ft above sea level, in a region of rolling hills, numerous lakes and streams, giant magnolia trees and majestic oaks which are hung with Spanish

The streets are wide and well-shaded. The state capitol, the supreme court and library building, the governor's mansion and other public buildings are displicad and pleasing.

other public buildings are dignified and pleasing
Tallahassee is the seat of the Florida State university and the
Florida Agricultural and Mechanical college for Negroes It has

a commission-manager form of government
Tradition says that the Spaniards, about 1638, fortified a hill
near the present site of Tallahassee, during a war with the Apalachee Indians About 1818 most of the Indians were diven out
of this region and a settlement was made by the whites, and in
1844 Tallahassee was chosen by the US government to be the
cential of the territory of Elorida.

From 1821 it was the home of Charles Louis Napoleon Achille Murat (1807-47, the eldest son of Joachim Murat), who became an American citizen and matried a grandniece of George Washington. Floiida's oithnance of secession was adopted by a state convention meeting in Tallahassee on Jan 10, 1867

# TALLBOY: see HIGHBOY.

TALLEMANT, GÉDÉON, SIEUR DES RÉAUX (1619-1692), French author, was born at La Rochelle on Oct 2, 1610 He belonged to a wealthy middle-class family of Huguenot persuasion, the name Des Réaux he derived from a small family property in Bourbonnais Tallemant married his cousin Elisabeth de Rambouillet His half-brother had married a d'Angennes, and this connection secured for Tallemant an introduction to the Hôtel de Rambouillet Madame de Rambouillet was no admirer of Louis XIII, and she gratified Tallemant's curiosity with stories of the reigns of Henry IV and Louis XIII But the society of the Hôtel de Rambouillet itself opened a field for his acute and somewhat malicious observation. In the Historiettes he gives finished portraits of Vincent Voiture, Jean-Louis Guez de Balzac, Francois de Malherbe, Jean Chapelain, Valentin Conrart and many others, Blaise Pascal and Jean de la Fontaine appear in his pages; and he chronicles the scandals of which Ninon de l'Enclos and Angélique Paulet were centres They are invaluable for the literary history of the time He died in Paris on Nov 10, 1692.

Des Réuux was a poet of some meut and contributed to the Guinale de Julie, but it is by his Historetete that he se remembered The work remained in manuscript until it was edited in 1831–35 by MM. de Châteaugnon, Jules Taschereau and L. J. N. de Monmerque. Several editions were published later, including one by G Mongréden (8 vol. 1933–34). Tallemant spoke frequently of witing Mémoires pour la régence d'Anne d'Autre, but no manuscript has been found and there is no proof that he ever began writing them. See also E Magne, La joyeuse jeunesse de Tallemont des Réaux (1921), La fin troublée de Tallemont des Réaux (1921), La fin troublée de Tallemont des Réaux (1921).

TALLEYRAND-PĒRIGORD, CHARLES MAURICE DE (1754-1858). Fench diplomatist and statesman, was born at Paris on Feb. 12 or 13, 1754, the son of licutenant general Charles Daniel de Talleyrand-Perigord His parents, descended from ancient and powerful families, were in constant attendance at the court of Louis XV. In his third or fourth year, while under the care of a nurse in Paras, he fell from a chest of drawers and injured his foot for life. This accident darkened his prospects; for though by the death of his delder brother he should have represented the family and entered the army, yet he forfeited the rights to primogeniture, and the profession of arms was thence-

forth closed to him. At the age of 8 he was sent to the Collège d'Harcourt at Paris, and, at 13 to 81. Sulpice, where he conceived a dishie of the doctines and discipline thrust upon him After a visit to his uncle, the archbishop of Reims, he returned to \$1 sulpice to finish his pielminary training for the church, but in his spare time he read the works of Montesqueu, Voltaire and other writers who were beginning to underrime the authority of the enceir rêgime, both in church and state. As subdeacon he winessed the coronation of Louis XVI at Reims, but he did not take pinest's orders until four years later. While rejecting the authority of the church in the sphere of dogma and intellect, he observed the proprieties of life, and respected the outward observances of reliation.

During his life at Pauls he frequented the salon of Madame de Genlis, and there formed his ideas in favour of political and collections, and there formed his ideas in favour of political and social reform. After taking his heentate in theology in March 1778, he gave hittle more attention to theological studies. Nevertheless his ability and his social position gained for him in the year 1780 the position of agent-general of the clergy of France The growing claims of the state on the exchequer of the clergy made his duties re-possible. At the extraordinary assembly of the clergy in 1782 he made proposals, by one of which he sought, though in vain, to redress the most glaring grevances of the underpaid curé. Though the excellence of his work as agent-general in the years 1780–86 was fully acknowledged, yet he did not gain a bishoptic until the beginning of the year 1789, probably because the king disliked him as a freethinker. He now became hishop of Autun, and was installed on March 13

The Revolution.—The first important act of the new bishop was to draw up a program of the reforms which he desired to see carned out by the states-general of France. It comprised the following items: the formation of a constitution which would strengthen the monarchy by calling to it the support of the whole nation, the drafting of a scheme of local self-government on democratic lines, the reform of the administration of justice and of the criminal law and the abolition of the most burdensome of reducid and class privileges. This program was adopted by the clergy of his diocese as their cahrer, or book of instructions to their representative at the states-general, namely Talleyrand

His influence in the estate of the clergy, however, was cast against the union of the three estates in a single assembly, and he voted in the minority of his order which in the middle of June opposed the merging of the clergy in the national assembly The folly of the court, and the weakness of Louis XVI at that crisis, probably convinced him that the cause of moderate reform and the framing of a bicameral constitution on the model of that of England were hopeless Thereafter he inclined more and more to the democratic side, though for the present he concerned himself mainly with financial questions. In the middle of July he was chosen as one of the committee to prepare a draft of a constitution, and in the session of the assembly which the comite de Mirabeau termed the orgse of the abolition of privileges (Aug 4) he intervened in favour of discrimination and justice. On Oct. 10, four days after the insurrection of women and the transference of the king and court to Paris, he proposed to the assembly the confiscation of church lands to the service of the nation, but on terms rather less rigorous than those in which Mirabeau (q v.) carried the proposal into effect on Nov 2. He identified himself in general with the left of the assembly, and supported the proposed departmental system which replaced the old provincial system early in 1790. At the federation festival of July 14, 1790 (Feast of Pikes) he officiated at the altar reared in the middle of the Champ de Mars. This was his last public celebration of mass For a brilliantly saturical but not wholly fair reference to the part then played by Talleyrand, the reader should consult Thomas Carlyle's French Revolution, vol ii, bk. i, ch. 12 The course of events harmonized with the anticlerical views of Talleyrand, and he gradually loosened the ties that bound him to the church He took little part in, though he probably sympathized with, the debates on the measure known as the Civil Constitution of the Clergy, whereby the state enforced its authority over the church to the detriment of its allegiance to the pope. obedience to the new decree. Talleyrand and three other bishops complied out of the thirty who had seats in the Assembly. The others, followed by the greater number of the clergy throughout France, refused, and thenceforth looked on Talleyrand as a schismatic He did not long continue to officiate, as many of the so-called "constitutional" clergy did, for, on Jan 21, 1791, he resigned the see of Autun, and in the month of March was placed under the ban of the church by the pope.

Just before his resignation he had been elected, with Mirabeau and Sievès, a member of the department of Paris, and for some eighteen months he supported the cause of order in the turbulent capital Though he was often on strained terms with Mirabeau. their views generally coincided Talleyrand's reputation for immorality, however, was as marked as that of Mirabeau While excelling Mirabeau in suppleness and dexterity, Talleyrand lacked the force of character possessed by the great "tribune of the people", and his influence was gradually eclipsed by the Girondins and the Jacobins

Debarred from election to the second National Assembly (known as the Legislative) by the self-denying ordinance passed by the "constituents," Talleyrand, at the close of 1791, sought to enter the sphere of diplomacy for which he was well equipped by his mental qualities and his clerical training. The condition of affairs on the continent seemed to French enthusiasts to presage an attack by the other Powers on France. In reality those Powers were far more occupied with the Polish and Eastern questions than with the affairs of France; and the declaration of Pilnitz. drawn up by the sovereigns of Austria and Prussia, which appeared to threaten France with intervention, was recognized by all well-informed persons to be "a loud-sounding nothing" The French foreign minister, Delessart, believed that he would checkmate all the efforts of the émigrés at the continental courts provided that he could confirm Pitt in his intention of keeping England neutral For that purpose Delessart sent Talleyrand, well known for his Anglophil tendencies, to London, but in the unofficial or semi-official capacity which was rendered necessary by the decree of the Constituent Assembly referred to above rand arrived in London on Jan. 24, 1792, and found public opinion so far friendly that he wrote off to Paris, "Believe me, a rapprochement with England is no chimeia" Pitt received him cordially; and to Grenville the envoy stated his hope that the two free nations would enter into close and friendly relations. each guaranteeing the other in the possession of its existing territories, India and Ireland being included on the side of Britam. The British government returned no definite answer to this proposal, but Tallevrand was convinced that Great Britain would not intervene against France unless the latter attacked the Dutch Netherlands.

He returned to Paris on March 10, to persuade the foreign minister (Dumouriez now held that post) of the need of having a fully accredited ambassador at London. The ex-Marquis Chanvelin was appointed, with Talleyrand as adviser. But the overthrow of the monarchy on Aug, 10 and the September massacres rendered hopeless all attempts at an entente cordiale between the two peoples; and the provocative actions of Chauvelin undid all the good accomplished by the tact and moderation of Talleyrand. The latter now sought to escape from France, where events were becoming intolerable; he succeeded in obtaining a passport to leave Paris on Sept. 14, and landed in England on the 23rd, avowedly on private business, but still animated by the hope of averting a rupture between the two governments In this he failed. The provocative actions of the French Convention, especially their setting aside of the rights of the Dutch over the estuary of the Scheldt, had brought the two nations to the brink of war, when the execution of Louis XVI. (21st of Jan. 1793) made it inevitable. Talleyrand was expelled from British soil and made his way to the United States. There he spent thirty months in a state of growing uneasiness and discontent with his sur-

roundings
The Directory.—The course of events after the Thermidorian reaction of July 1794 favoured his return to France. Thanks to

When the Assembly sought to impose on its members an oath of the efforts of Daunou and others his name was removed from the list of émigrés, and he set sail for Europe in November 1795. Landing at Hamburg in the January following, he spent some time there in the company of his friends Madame de Genlis and Reinhard, and when party rancour continued to abate at Paris, he returned thither in September After a time he was recommended by Madame de Stael to the Director Barras for the post of minister of foreign affairs. He gained the post of foreign minister, entering on his duties in July 1797

Talleyrand, despite the weakness of his own position (he was as yet little more than the chief clerk of his department), soon came to a good understanding with Bonaparte, and secretly expressed to him his satisfaction at the terms which the latter dictated at Campo Formio (Oct 17, 1797) The coup d'état of Fructidor (September 1797) had perpetuated the Directory and led to the exclusion of the two "moderate" members, Carnot and Bathélémy, but Talleyrand saw that power belonged really to the general who had brought about the coup d'etat in favour of

the Jacobinical Directors headed by Barras

With the renewal of war on the continent Talleyrand had little or no connection. His powers as minister were limited, and he regretted the extension of the area of war Moreover, in the autumn of 1797 his reputation for political morality (never very bright) was overclouded by irregular dealings with the envoys of the United States sent to arrange a peaceful settlement of certain disputes with France Talleyrand refused to clear himself of the charges made against him as his friends (especially Madame de Stael) urged him to do; and the incident probably told against his chances of admission into the Directory, which were discussed in the summer of 1708 A year later he resigned the portfolio for foreign affairs (July 20, 1799), probably because he foresaw the imminent collapse of the Directory If so, his premonitions were correct Their realization was assured by the return to France of the "Conqueror of the East" in October The general and the diplomatist soon came to an understanding, and Talleyrand tactfully brought about the alliance between Bonaparte and Sievès (q v) (then the most influential of the five Directors) which paved the way for the coup d'état of Brumaire (See FRENCH REVOLUTION and NAPOLEON I )

Talleyrand's share in the actual events of the 18th, 19th Brumaire (9th, 10th of November) 1799 was limited to certain dealings with Barras on the former of those days About midday he took to Barras a letter, penned by Roederer, requesting him to resign his post as Director. By what means Talleyrand brought him to do so, whether by persuasion, threats or bribes, is not known; but on that afternoon Barras left Paris under an escort of soldiers. With the more critical and exciting events of the 19th of Brumaire at St Cloud Talleyrand had no direct connection, but he had made all his preparations for flight in case the blow failed His reward for helping on the winning cause was the ministry for foreign affairs, which he held from the close of December 1700 on to the summer of 1807. In the great work of reconstruction of France now begun by the First Consul, Talleyrand played no unimportant part. His great aim was to bring about peace, both international and internal. He had a hand in the pacific overtures which Bonaparte, early in the year 1800, sent to the court of London; and, whatever may have been the motives of the First Consul in sending them, it is certain that Talleyrand regretted their failure. After the battle of Marengo an Austrian envoy had to come to Paris in response to a proposal of Bonaparte, and Talleyrand persuaded him to sign terms of peace. These were indignantly repudiated at Vienna, but peace was made between the two Powers at Lunéville on Feb 9, 1801.

As regards French affairs, Talleyrand used his influence to help on the repeal of the vexatious laws against émigrés, nonjuring priests, and the royalists of the west. He was also in full sympathy with the policy which led up to the signature of the Concordat of 1801-2 with the pope (see CONCORDAT); but it is probable that he had a hand in the questionable intrigues which accompanied the closing parts of that complex and difficult negotiation At the end of June 1802 the pope removed Talleyrand from the ban of excommunication and allowed him to revert to

the secular state On Sept 10, 1803, owing to pressure put on him by Bonaparte, he married Madame Grand, a dsvorcée with whom he had long been living

During the meeting of Italian notables at Lyons early in 1802 Talleyrand was serviceable in manipulating affairs in the way desired by Bonaparte, and it is known that the foreign minister suggested to them the desuability of appointing Bonaparte president of the Cisalpine Republic, which was thenceforth to be called the Italian Republic In the negotiations for peace with England which went on at Amiens during the winter of 1801-2 Talleyrand had no direct share, these (like those at Lunéville) being transacted by Napoleon's eldest brother, Joseph Bonaparte (q v ) On the other hand he helped the First Consul in assuring French supremacy in Switzerland, Italy and Germany In Germany the indemnification of the princes who lost all their lands west of the Rhine was found by secularizing and absorbing the ecclesiastical states of the empire This unscrupulous proceeding, known as the Secularizations (February 1803), was carried out largely on lines laid down by Bonaparte and Talleyrand, and the latter is known to have made large sums of money by trafficking with the claimants of church lands

While helping to establish French supremacy in neighbouring states and assisting Bonaparte in securing the title of First Consul for life, Talleyrand sought all means of securing the permanent welfare of France He worked hard to prevent the rupture of the peace of Amiens in May 1803, and he did what he could to prevent the sale of Louisiana to the United States earlier in the vear These events, as he saw, told against the best interests of France and endangered the gains which she had secured by war and diplomacy Thereafter he strove to moderate Napoleon's ambition and to preserve the European system as far as possible. The charges of duplicity or treachery made against the foreign minister by Napoleon's apologists are in nearly all cases unfounded This is especially so in the case of the execution of the duc d'Enghien (March 1804), which Talleyrand disapproved. The evidence against him rests on a document which is now known to have been forged On the assumption of the imperial title by Napoleon in May 1804, Talleyrand became grand chamberlam of the empire, and received close on 500,000 francs a

The Empire.-Talleyrand had rarely succeeded in bending the will of the First Consul He altogether failed to do so with the Emperor Napoleon. His efforts to induce his master to accord lement terms to Austria in November 1805 were futile, and he looked on helplessly while that Power was crushed, the Holy Roman Empire swept away, and the Confederation of the Rhine set up in central Europe In the bargainings which accompanied this last event Talleyrand is believed to have reaped a rich harvest from the German princes most nearly concerned On July 6, 1806, Napoleon conferred on his minister the title of prince of Benevento, a papal fief in the Neapolitan territory

In the negotiations with England which went on in the summer of 1806 Talleyrand had not a free hand, they came to nought, as did those with Russia which had led up to the signature of a Franco-Russian treaty at Paris by d'Oubril which was at once disavowed by the tsar. The war with Prussia and Russia was ended by the treaties of Tilsit (7th and 9th of July 1807) Talleyrand had a hand only in the later developments of these negotiations; and it has been shown that he cannot have been the means of revealing to the British government the secret arrangements made at Tilsit between France and Russia, though his private enemies, among them Fouché, have charged him with acting as traitor in this affair.

Talleyrand had long been weary of serving a master whose him in the council and took him with him to the interview with the Emperor Alexander I. at Erfurt (September 1808). Talleyrand disapproved of the Spanish policy of Napoleon which culminated at Bayonne in May 1808; and the stories to the contrary may in all probability be dismissed as idle rumours. On Talleyrand now fell the disagreeable task of entertaining at his new mansion at

Valençay, in Touraine, the Spanish princes virtually kidnapped at Bayonne by the emperor They remained there until March 1814 At the close of 1808, while Napoleon was in Spain, Talleyrand entered into certain relations with his former rival Fouché  $(q\,v\,)$ , which aroused the solicitude of the emperor and hastened his return to Paris He subjected Talleyrand to violent reproaches, which the ex-minister bore with his usual ironical calm

After the Danubian campaign of 1809 and the divorce of Josephine, Talleyrand used the influence which he still possessed in the imperial council on behalf of the choice of an Austrian consort for his master, for, like Metternich (who is said first to have mooted the proposal), he saw that this would safeguard the interests of the Habsburgs, whose influence he felt to be essential to the welfare of Europe He continued quietly to observe the course of events during the disastrous years 1812-13; and even at the beginning of the Moscow campaign he summed up the situation in the words, "It is the beginning of the end." Early in 1814 he saw Napoleon for the last time, the emperor upbraided him with the words: "You are a coward, a traitor, a thief You do not even believe in God You have betrayed and deceived everybody. You would sell even your own father" Talleyrand listened unmoved, but afterwards sent in his resignation of his seat on the council It was not accepted. He had no share in the negotiations of the congress of Châtillon in February-March 1814. On the surrender of Paris to the allies (Maich 30, 1814), the Emperor Alexander I. took up his abode at the hôtel Talleyrand, and there occurred the conference wherein the statesman persuaded the tsar that the return of the Bourbons was the only possible solution of the French problem, and that the principle of legitimacy alone would guarantee Europe against the aggrandizement of any one state or house As he phrased it in the Talleyrand Memoirs. "The house of Bourbon alone could cause France nobly to conform once more to the happy limits indicated by policy and by nature. With the house of Bourbon France ceased to be gigantic in order to be great' These arguments, reinforced by those of the royalist agent de Vitrolles, convinced the tsar, and Talleyrand, on April x, convened the French senate (only 64 members out of 140 attended), and that body pronounced that Napoleon had forfeited the crown Ten days later the emperor recognized the inevitable and signed the Act of Abdication at Fontamebleau. The next effort of Talleyrand was to screen France under the principle of legitimacy and to prevent the schemes of partition on which some of the German statesmen were bent. Thanks mainly to the support of the tsar and of England these schemes were foiled; and France emerged from her disasters with frontiers which were practically those of 1792.

The Restoration.-At the congress of Vienna (1814-15) for the settlement of European affairs, Talleyrand, as the representative of the restored house of Bourbon in France, managed adroitly to break up the league of the Powers (framed at Chaumont in February 1814) and assisted in forming a secret alliance between England, Austria and France in order to prevent the complete absorption of Poland by Russia and of Saxony by Prussia. The new triple alliance had the effect of lessening the demands of those Powers and of leading to the well-known territorial compromise of 1815. Everything was brought into a state of uncertainty once more by the escape of Napoleon from Elba; but the events of the Hundred Days, in which Talleyrand had no share-he remained at Vienna until June 10-brought in the Bourbons once more; and Talleyrand's plea for a magnanimous treatment of France under Louis XVIII. once more prevailed in all important matters. On July 9, 1815, he became foreign minister and president of the council under Louis XVIII., but diplomatic and other difficulties policy he more and more disapproved, and after the return from led him to resign his appointment on Sept. 23, 1815, Louis, how-Tilsit to Pans he resigned office Nevertheless Napoleon retained vever, naming him high chamberlain and according him an annulty of 100,000 francs. The rest of his life calls for little notice except that at the time of the July Revolution of 1830, which unseated the elder branch of the Bourbons, he urged Louis Philippe, duke of Orleans (q v.), to take the throne offered to him by popular acclaim. The new sovereign offered him the portfolio for foreign affairs; but Talleyrand signified his preference for the embassy in London In that capacity he took an important part in the aegotiations respecting the founding of the new kingdom of Belgium In April, 1834 he crowned his diplomatic career by signing the treaty which brought together as allies France. Great Britain. Spain and Portugal, and in the autumn of that year he resigned his embassy. During his last days he signed a paper signifying his reconciliation with the Roman Catholic Church and his regret for many of his early actions. The king visited his death-bed His death, on May 17, 1838, called forth widespread expressions of esteem for the statesman who had rendered such great and varied services to his country. He was buried at Valençay He had been separated from the former Madame Grand in 1815 and left no heir.

The Talleyland Mémoires were edited by the duc de Broglie in

The Telleyand Memorre were thetal by the due de Breghe in The Telleyand Memorre were that by the due de Breghe in The Telleyand Memorre were thanked in the English by A Hall, § vols (London, 1891-92) Of his letters and despatchs by A Hall, § vols (London, 1891-92) Of his letters and despatchs by A Hall, § vols (London, 1891-92) Of his letters and despatchs the following are the chief collections—G Pallain, La misson de Telleyand à Napolie, 1800-92 (Paris, 1889), and Le missische des did the the distributed of Telleyand à Napolie, 1800-92 (Paris, 1891), and Ambatsade de Telleyand à Londois (1870-54), a vols (Paris, 1891), and Ambatsade de Telleyand à Londois (1870-54), a vols (Paris, 1891), and Ambatsade de Telleyand à Londois (1870-54), a vols (Paris, 1891), and Charleyand, a vols (Paris, 1891), and Pichol, Hilly Sphinque et privale de Telleyand (Paris, 1883), a Pichol, Hilly Sphinque et privale de Telleyand (Paris, 1883), a Pichol, Hilly Sphinque et privale de Telleyand (Paris, 1883), a Pichol, Hilly Sphinque et privale de Telleyand (Paris, 1883), a Pichol, Hilly Sphinque et privale de Telleyand (Paris, 1883), a Pichol, Chenicare; 2 vel S (Candon, 1894) and that of Lord Broughain and Hilly Sphinque et privale (Paris, 1894). Telleyand, a Richardson by F Clarke, 2 vols London, 1894). Telleyand, a Richardson de Telleyand et al. (Paris, 1894). Telleyand, a Richardson de Telleyand et al. (Paris, 1894). Telleyand, a Richardson de Telleyand et al. (Paris, 1894). Telleyand, a Richardson de Telleyand et al. (Paris, 1894). Telleyand, a Richardson de Telleyand et al. (Paris, 1894). Telleyand, a Richardson de Telleyand et al. (Paris, 1894). Telleyand, a Richardson de Telleyand et al. (Paris, 1894). Telleyand, a Richardson de Telleyand et al. (Paris, 1894). Telleyand, a Richardson de Telleyand et al. (Paris, 1894). Telleyand, a Richardson de Telleyand et al. (Paris, 1894). Telleyand, a Richardson de Telleyand et al. (Paris, 1894). Telleyand et al. (Paris, 1894). Telleyand et al. (Paris, 1894). Telleyand et al. (Paris, 1894

TALLIEN, JEAN LAMBERT (1767-1820), French revolutionary, was born in Paris in 1767. He entered a printer's office, and by 1791 he had reached the position of overseer of the mining department of the Monitour While thus employed he conceived the idea of the journal-affiche, and after the arrest of the king at Varennes in June 1791 he placarded a large printed sheet on all the walls of Paris twice a week, under the title of the

Ami des Citoyens, journal fraternel

This enterprise, financed by the Jacobin Club, made him well known to the revolutionary leaders; and he made himself still more conspicuous in organizing the great "Fête de la Liberté" on April 15, 1792, in honour of the released soldiers of Château-Vieux, with Collot d'Herbois. He was active in the events of Aug to, and was made clerk to the Revolutionary Commune of Paris, At the close of September he resigned his post on being elected a deputy to the Convention by the department of Seine-et-Ose. He took his seat upon the Mountain, and was one of the most vigorous Jacobins, particularly in his defence of Marat, on Feb 26, 1793; he was elected a member of the Committee of General Security on Jan. 21, 1793. He took an active part in the coups d'état of May 31 and June 2, which resulted in the overthrow of the Girondists. On Sept. 23, 1793, he was sent with Claude Alexandre Ysabeau (1754–1831) to Bordeaux This was the month in which the Terror was organized under the superintendence of the Committees of Public Safety and General Se-

Tallien showed himself one of the most vigorous of the proconsuls sent over France to establish the Terror in the provinces and soon awed the great city. Among his prisoners was Thérèse, the divorced wife of the comte de Fontenay, and daughter of the Spanish banker, François Cabarrus, one of the most fascinating women of her time, and Tallien not only spared her life but fell in love with her. Suspected of "Moderatism" on account of this incident, Tallien increased, in appearance, his revolutionary zeal but from the lives Thérèse saved by her entreaties she received the name of "Our Lady of Thermidor," after the 9th of Thermidor. Tallien was even elected president of the Convention on must strike at his own colleagues in the committees if he was royal. He is known to have become organist at Waltham abbey.

to carry out his theories, but they determined to strike first, and on the great day of Thermidor Tallien opened the attack upon Robespierre and his friends were guillotined, and Tallien, as the leading Thermidonan, was elected to the Committee of Public Safety He suppressed the Revolutionary Tribunal and the Jacobin Club and fought bravely against the insurgents of Prairial. He was supported by Therèse, whom he mairied on Dec 26, 1791, and who became the leader of the social life of Paris His last political achievement was in July 1795, when he was present with Hoche at the destruction of the army of the émiei és at Ouiberon, and ordered the executions which followed

Tallien's political importance came to an end with the Convention for, though he sat in the Council of Five Hundred, the moderates attacked him as terrorist, and the extreme party as a renegade Madame Tallien also tited of him, and became the mistiess of the rich banker Ouvrard Bonaparte took him to Egypt in his great expedition of June 1798, and he edited the Décade Egyptienne in Cairo But General J F Menou sent him away from Egypt, and he was captured by an English cruiser and taken to London, where he had a good reception among the Whigs and was well received by Fox. On returning to France in 1802 he obtained a divorce from his wife (who in 1805 married the comte de Caraman, later prince de Chimay), and was for some time without employment. At last he was appointed consulat Alicante, and remained there until he lost the sight of one eve from vellow fever. On returning to Paris he lived on his halfpay, and his latter days were spent in poverty. He died in Paus on Nov 16, 1820.

on Nov 16, 1820.

Tallien left an interesting Discours sur les causes qui ont produit la Révolution française (1791) and in Mémoire sur l'administration de Révolution française. Revolution française franç

TALLINN, or (German) REVAL, primary scaport and capital of Estonia, in 59° 26' N., 24° 46' E, on a bay in the south coast of the Gulf of Finland. Est. pop (1939) 145,002. The port, frozen over about 45 days each winter, accommodates vessels drawing 30 ft. The chief exports are textiles, cereals, timber, paper and Portland cement, and the imports foodstuffs, cotton and coal The town has textile, paper, cement and timber industries The remains of the Toompea citadel (1539) and the ancient city wall with many of its towers make Tallinn picturesque. Many new buildings dominate the town, including a town hall. The Art Museum has a fine collection of modern Estonian painting and sculpture

A Danish settlement on the high Silurian crag known as the Domberg existed in 1003, and the Danish king, Valdemar II, built a castle in 1210. It was captured by the Livonian knights in 1228. but returned to the Danes in 1237. Merchants from Lubeck and Bremen settled here in the 13th century, and 1t became a port of the Hanseatic league. It was fortified early in the 14th century and in 1343 sustained a siege by the revolted Estonians. Valdemar III sold Estonia to the Teutonic knights in 1346, but on the dissolution of the order, in 1561, Estonia and Reval surrend-ered to the Swedish king, Erik XIV, A great conflagration in 1433, the pestilence of 1532, the bombardment by the Danes in 1560, and the Russo-Livonian War destroyed its trade. The Russians besieged Reval in 1570 and 1577 and in 1710 it was surrendered to Peter the Great, who erected a port for his Baltic fleet. His successors continued to fortify the access to Reval from the sea, especially in the early years of the 19th century. It passed from Russian to Estonian rule in 1918, but fell to Russia in 1940, and to Germany in 1941. In World War II the shipping sections were heavily bombed

TALLIS (TALLYS, TALYS OF TALLISIUS), THOMAS (c. 1515-1585), justly styled "the father of English cathedral music," was born probably before 1515 It has been conjectured that, after singing as a chorister at old Saint Paul's under Thomas March 24, 1794. Robespierre began to see, however, that he Mulliner, he obtained a place among the children of the chapel where, on the dissolution of the monstery in 1540, he received, in compensation for the loss of his preference, 200 in Sugardian and 200 for reward. In the library of the British Museum there is preserved a volume of imstreatises on music, once belonging to the abbey, on the last page of which appears his autograph. "Thomas Tallys"—the only specimen known. Not long after his dismissal from Waltham, Tallis was appointed a gentleman of the chanel royal.

One of the earliest compositions by Tallis to which an approximate date can be assigned is the well-known Service in the Dorian Mode, consisting of the Venite, Te Deum, Benedictus, Kyrie, Nicene Creed, Sanctus, Gloria in Excelsis, Magnificat and Nunc Dimittis, for four voices, together with the Preces, Responses, Paternoster and Litany, for five, all published for the first time, in the Rev John Barnard's First Book of Selected Church Music, in 1641, and reprinted, with the exception of the Venite and Paternoster, in Boyce's Cathedral Music in 1760 (Boyce's omission of the very beautiful Venite is hard to account for ) That this work was composed for the purpose of supplying a pressing need, after the publication of the second prayer-book of King Edward VI in 1552, there can be no doubt Written in the style known among Italian composers as lo stile famigliare, ie, in simple counterpoint of the first species, nota contra notam, with no attempt at learned complications of any kind, it adapts itself with equal dignity and clearness to the expression of the verbal text it is intended to illustrate. In self-restraint the Litany and Responses bear a close analogy to the Improperia and other sımılaı works of Palestrina

Tallis raised the English school to a height which it was to maintain until the death of its last representative. Orlando Gibbons, in 1625 Though this school is generally said to have been founded by Dr Tye, there can be no doubt that Tallis was its meatest master, and that it was indebted to him alone for the infusion of new life and vigour which prevented it from degenerating, as some of the earlier Flemish schools had done, into a mere vehicle for the display of fruitless erudition Like every other great musician of the period, he produced occasionally works confessedly intended for no more exalted purpose than the exhibition of his stupendous skill. In his canon Miserere nostri (given in Hawkins's History of Music) the intricacy of the contrapuntal devices seems little short of miraculous, yet the resulting harmony is smooth and normal, and only the irregular complexity of the thythm betrays the artificiality of its structure. The famous forty-part motet, Spem in alsum, written for eight five-part choirs, stands on a far higher plane, and the tow de force of handling freely and smoothly so many independent parts is the least remarkable of its qualities. It was edited by Dr A H Mann in 1888 (London, Weekes and Company) (In the sixth volume of Tudor Church Music [Oxford University Piess, 1928] all the forty parts are printed on one page ) The art with which the climaxes are built up shows that Tallis's object in writing for forty voices is indeed to produce an effect that could not be produced by thirty-nine But this illustrates one phase only of Tallis's many-sided genius, which shines with equal brightness in the eight psalm tunes (one in each of the first eight modes) and unpretending little Veni Creator, printed in 1567 at the end of Archbishop Parker's First Ouinquagene of Metrical Psalms

In 1575 Tallis and his pupil William Byrd—as great a contrapuntist as himself—obtaned from Queen Elizabeth royal letabeth royal canding music-paper for twenty-one years; and, in virtue of his privilege, they issued, in the same year, a joint work, entitled Cantiones gone do arguments Sacrae vocantin, quinque et exportism, containing sixteen motets by Tallis and eighteen by Byrd, all of the highest degree of excellence Some of these motets, adapted to English words, are now sung as anthems in the Anglican cathedral service But no such translations appear to have been made during Tallis's lifetime; and there is strong reason for belleving that, though both he and Byrd outwardly conformed to the new religion, and composed music expressly for its use, they meanined Catholics at heart.

Tallis's contributions to the Cantiones Sacrae were the last

of his compositions published during his lifetime. He died on November 23, 1585, and was burred in the parish church at Greenwish, where a quanti tryined epitaph, preserved by Strype, and repunted by Burrey at oyal during the heavings, recorded the fact that heavings for the property of the property o

TALLOW, the Substitution of the for running tannals, but commercially obtained by the Substitution of the Commercially obtained by the Substitution of the Commercially obtained by the Commercially obtained by the Commercial of t

Mutton tallow differs in several respects from that obtained from over 11 is whiter in colour and harder, and contains only jabout 39% of olem Newly rendered it has hittle taste or smallbut on exposure it quickly becomes ranced Sweet mutton tallow melts at 46° and solidnifes at 36° C, when old it does not melt under 49°, and becomes solid or reaching 44° or 45° C. It is sparingly soluble in cold ether and in boiling alcohol. (See Oils, FATS AND WAXES)

TALLOW TREE, the common name of a small tree, Sophumschlertom, stample Euphoblicacea, a nature of China, but cultivated in India and other warm countries. The seeds are thickly
coated with a white greasy substance—so-called vegetable tallow
—from which candles are made, and which is also used in soapmaking and dressing cloth. The butter tree or tallow tree of Senta
Leone is Pentudesma butty acca, family Guttiferne. The funt,
which is 4 to 5 in. long and about 3 in. in dimanter, has a thick
fleshy find abounding in a yellow greavy funce which is used as
butter

TALLY. The woodes tally used in reckoning comes from two primative notions, that of nothing (exering) a piece of wood for counting, as Robinson Crusoc did, and that of the boken six k shared between two parties to a bargain, the developed tally combines both. Use of this double tally, once prevalent all over Europe, is still frequent in the less advanced countries and not unknown in most. In England, though now nearly obsolets, it was exceedingly common mediaevally and its methods were highly developed; it endured long in certain connections; and its nomen-clature survives in many words; to score at cricket (in Pickwirle's day "ion notify) derives from the single tally, and the verb "to tally" comes obviously from the double one; and other derivatives are many, if not quite so direct.

In England, however, the chief interest of the tally centres in its public use This is earlier even than the very early "exchequer" organization (see EXCHEQUER); by a date not long after 1100 it was a settled system—a system, moreover, carefully differentiated from any private one and used for money only, and the tally continued to be the recognized form of receipt for payments into the Royal Treasury down to 1836 During this long period, though there were modifications of wording, it changed little outwardly save for a continually increasing length; the oliginal offine being extended in one extreme example which still surveys at the Bank of England to 816 inches. This, however, is due solely to the increased number of thousands (notches of the thickness of a man's hand) which the tally might be required to

show, and (apart from any difficulty due to the writing) a 13th century clerk could have interpreted it, the revolutionary changes lie, not in the tally's form, but in its employment

The Assignment System .- At a very early date anticipation of the royal revenue became habitual and in this practice the tally was invaluable, nothing was easier than to "levy" a tally for a sum due for payment later and to "assign" this as payment to a royal creditor Probably, at certain periods, creditors themselves had little objection to a practice which, in an age of difficult transport and clumsy currency, held many advantages At the same time it might obviously lead to the lowering of royal credit and to endless confusion in accounts Assignments were, in effect, payments, but tallies were essentially receipts, and as such, from the 13th century onwards, were all entered on "receipt rolls" and, later, figured in numerous supplementary series of records. Moreover an "assignment" tally frequently went wrong, and the mediaeval administrator could think of no better device than to substitute a fictitious "loan" on the roll, so as to square the account The roll of "receipts" might thus include actual payments of cash, sums credited long before they were paid or due, and entries which indicate no payment at all, but rather a debt to be cleared later The difficulties of the modern historian desiring to use these (exceedingly important) records, with none of the contemporary clerk's expert knowledge, needs no emphasis

The Last Tally, 1826 .- By Pepys' time tally-making at Westminster had become a ritual involving numerous officials, much delay and many fees, and from then onwards periodical attempts were made to destroy it But vested interest successfully withstood reform till the 18th century; and it was not till 1826 that the last tally was levied and a system of "indented cheque receipts" substituted A few years later (1834) reforming zeal celebrated its triumph by destroying (in the furnaces which heated the House of Lords) the whole accumulation of ancient tallies. with disastrous results; the old Houses of Parliament were burned and, incidentally (till the casual discovery in 1909, in the Chapel of the Pyx, of about 1,300 Exchequer tallies, practically all "stocks" of the 13th century), English historians were left without an essential clue to the understanding of some of the richest record series in the national collections

Bibliography.—See Hilary Jenkinson, "Tallies," Archaeologia, lxii (1911) and lxxiv. (1924). For tallies in a foreign country see M Gmur, Schweizerische Bauernmarken und Holzurkunden (Berne, 1017

TALMA, FRANÇOIS JOSEPH (1763-1826), French actor, was born in Paris on Jan. 15, 1763. His father, a dentist there, and afterwards in London, gave him a good English education, and he returned to Paris, where for a year and a half he practised dentistry. He made his début at the Comédie Française as Seide in Voltaire's Mahomet (Nov. 21, 1787). Talma was among the earliest advocates of realism in scenery and costume, being aided by his friend the painter David. His first essay in this direction took the form of appearing in the small rôle of Proculus in Voltaire's Brutus, with a toga and Roman headdress, much to the surprise of an audience accustomed to 18th century costume on the stage whatever the period represented might be. Talma possessed in perfection the physical gifts of a great tragedian. At first somewhat stilted and monotonous in his manner, he became by perfection of art a model of simplicity. Talma married Julie Carreau, in whose salon were the principal Girondists.

In 1808 the emperor had taken him to Erfort and made him play the Mort de César to a company of crowned heads. Five years later he took him also to Dresden. Talma was also a friend of Joseph Chénier, Danton, and Camille Desmoulins. In Chénier's anti-monarchical Charles IX, produced on Nov. 4, 1789, a prophetic couplet on the destruction of the Bastille made the house burst into a salvo of applause, led by Mirabeau. This play aroused political dissensions in the Comédie Française which led Talma to establish a new theatre known for a time as the Théâtre de la République, on the site of the present Théâtre Français. Here he won his greatest triumphs. He made his last appearance on June 11, 1826, as Charles VI, in Delaville's tragedy, and he died in Paris on Oct. 10, of that year,

Talma was the author of Mémoires de Lehain, précédés de réflewons sur cet acteur et sur l'art thédiral, contributed to the Collection des mémoires sur fair d'ensaitages, and published separately (1850) as Réflewons de Talma sur Lehain et l'art thédiral. See Mémoires de FJ Talma, écrit par lui-même, et recueills et em se no drès sur papers de sa famille, by Alex Dumas (1850), J. B. J. P. Regnault-Warm, Mémoires sur Talma (1950).

TALMAGE, THOMAS DE WITT (1832-1902), American Presbyterian preacher, was born near Bound Brook, N.J., on Jan. 7, 1832. He was educated at the present New York university and at the Reformed Dutch theological seminary at New Brunswick, New Jersey In 1856 he became pastor of a Reformed church at Belleville, N J, thereafter holding pastorates successively at Syracuse, Philadelphia, Brooklyn and Washington, District of Columbia During the last years of his life he devoted himself to editing, writing and lecturing He died in Washington on April 12, 1002

TALMUD, the great Rabbinical thesaurus which was reduced to writing during the second, fourth and sixth centuries of the Christian Era

Contents.-The Talmud (Hebrew "teaching, learning") consists of the Mishnah (Heb "[oral] repetition, teaching"), a systematic collection of religious-legal decisions developing the laws of the Old Testament, and the Gemārā (Aramaic "completion, decision," or perhaps also "teaching"), supplementary material, legal and otherwise. Mishnah stands in contrast to Migrā "reading, scripture", its Aram equivalent is Mathnīthā, from těnā, "to repeat," whence the appellation Tannā, "teacher These and the terms Gemara, Talmud, etc., are more fully explained in H L Strack's invaluable Einleitung in den Talmud (Leipzig, 1908), pp 2 sqq The whole was in two great recensions, Palestinian and Babylonian. Other material related to the Mishnah is preserved in the Tosephta (Aram. "addition") and the Midrashim, and since all these, together with the Targumin, represent the orthodox Rabbinical literature connecting the Old Testament with mediaeval and modern Judaism, the reader should also consult the articles Jews (parts it, and ni ); MIDRASH, TARGUM, and for more detailed and critical treatment the references given to the Jewish Encyclopedia

The Mishnah is a more or less careful arrangement of the extant Oral Law (see below). It forms the foundation of the Gemara, and is divided into six Sědārīm or Orders, each containing a number of Massektöth ("weavings," of the etymology of "text") or Tractates. These are subdivided into Peragim ("sections") or chapters, and these again into paragraphs or sentences (Mishnavoth) For a full list of these and of editions and translations, see Jew Ency

The Origin of the Mishnah .- A careful distinction was drawn between the Written Law, the Mosaic Torah and the rest of the Scriptures (apage min), and the Oral Law, or Töräh by Mouth (חף שְּבָשׁל מְּחִי). The latter has become codified in the Mishnah. The traditional view is well illustrated in the words ascribed to R Simeon Lakish, 3rd century A.D: "What is that which is written, 'I will give thee the tables of stone, and the Law and the Commandment, which I have written, that thou mayest teach them (Ex xxiv 12)?' 'Tables,' these are the Ten Words (the Decalogue); the 'Law' is the Scripture; 'and the commandment, that is the Mishnah: which I have written, these are the Prophets and Writings (ie, The Hagiographa), to teach them, that is the Gemara-thus instructing us that all these were given to Moses from Smai," Literary and historical criticism places the discussion on another basis when it treats the Mosaic Torah in its present form as a post-exilic compilation (about 5th century B C ) from sources differing in date, origin and history There is no a priori reason why other legal enactments should not have been current when the compilation was first made; the Pentateuchal legislation is incomplete, and covers only a small part of the affairs of life. Laws must be adjusted from time to time to meet changing needs, and new teaching must justify itself by a reinterpretation of the old writings. Just as the stern common law of the Semites was modified by the milder legislation of the Pentateuch, so, in process of time, further developments ensued Rabbinic law turned the Lex Talionis into monetary compensation. The

Pharisees were the liberalizing party and stood for the Spirit of the Scriptures, to the letter of which the conservative Sadducees clung (For an illuminating example see J Z Lauterbach in Heb. Umon College Annual, IV Cincinnati, 1927, pp. 173 seq ) It is probable that this process was largely an unconscious one, and even if conscious, the analogy of the conventional "legal fiction" and the usual anxiety to avoid the appearance of novelty is enough to show that it is not to be condemned. Contemporary custom or ideals could appear to have ancient precedents, or by means of an exegetical process they could be directly connected with old models In the Old Testament many laws in the Mosaic legislation are certainly post-Mosaic and the value of not a few narratives lies, not in their historical or biographical information, but in their treatment of law, ritual, custom, behef, etc. Thus, the problem of the origin or antiquity of the unwritten Oral Law, a living and fluid thing, lies outside the scope of criticism, of greater utility is the study of the particular forms the laws have taken in the written sources which from time to time embody the ever-changing legacy of the past

Growth of the Mishnah and Gemara.—According to the traditional view the canon of the Old Testament closed with the work of Ezra He was followed by the Sopherim, "scribes" (or the men of the great Synagogue), to the Maccabaean age, and these again by the "Pairs" (zūgōth, Gr ζυγόν) the reputed heads of the Sanhedrin, down to the Herodian age (150-30 BC) The last culminate in Hillel (q v) and Shammai, the founders of two great rival schools, and to this famous pair the work of collecting hălākōth ("legal decisions") has been ascribed. The ensuing period of the Tanna'im, "teachers" (about AD. 10-220), is that of the growth of the Mishnah (On the various teachers, especially the Haggadists, see W Bacher, Agada der Babylon Amoraer, pub. Strassburg, 1879, A d Tannasten, pub 1884, new edition begun in

1903, A. d Pal Amoraer, pub 1892)

Among the best known representatives of the schools are Rabban (a title given to Hillel's descendants) Gamaliel, the Phil-Hellene and teacher of the apostle Paul (Acts xxii, 3) and his son Simeon (Josephus, Life, § 38 seq, Wars, iv 3, 9), and Rabban Johanan b Zakkai, founder of the seat of learning at Jamnia (Jabneh) A little later (about AD. 90-130) are the famous Gamahel 11, Eliezer b Hyrqanos (at Lydda), and Ishmael b Elisha, the last of whom founded the school at Usha and is renowned for his development of the rules of exegesis framed by Hillel. With Rabbi Aqība (q v) and the synods of Jamma (about A.D 90 and 118) a definite epoch in Judaism begins. At Jamma, under the presidency of Gamaliel II. and Eleazar b. Azariah, a collection of traditional halakoth was formed in the tractate 'Edwyyoth (larger than and not to be identified with IV., 7). Here, likewise, was discussed the canonicity of the Song of Songs and of Ecclesiastes, and it is probable that here Aqība and his colleagues fixed the official text of the canonical books. Agība had an important share in the early development of the Mishnah (Strack, pp. 19, 89); and, in the collecting of material, he was followed notably by the school of Ishmael (about AD 130-160), which has left its mark upon the early halakic Midrashim The more interesting names include R. Meir, a well-known haggadist, R. Simeon b. Yohai, R. Jose b. Halaphta and R. Jehudah b. 'Ha'i. But, as collections of decisions were made by prominent teachers from time to time, confusion was caused by their differences as regards both contents and teaching (Sotah, 22a; Shabb. 138b). Consequently, towards the close of the second century a thoroughly comprehensive effort was made to reduce the halakoth to order.

Judah, grandson of Gamaliel II., known as the Prince or Patriarch (nāsī'), as Rabbēnū ("our teacher"), or simply as "Rabbi" par excellence, was the editor. He gathered together the material, using Meir's collection as a basis, and although he did not write the Mishnah as it now is, he brought it into essentially its present shape. His methods were not free from arbitrariness; he would attribute to "the wise" the opinion of a single authority which he regarded as correct; he would ignore conflicting opinions or those of scholars which they themselves had afterwards retracted, and he did not scruple to cite his own decisions.

The period of the 'Amorā'im, "speakers, interpreters" (about AD 220-500), witnessed the growth of the Gemara, when the now "canonical" Mishnah formed the basis for further amplification and for the collecting of old and new material which bore upon it In Palestine learning flourished at Caesarea, Sepphons, Tiberias and Usha, Babylonia had famous schools at Nehardea (from the 2nd century AD), Sura, Pumbeditha and elsewhere Of their teachers (who were called Rabbi and Rab respectively) several hundreds are known. R Hiyya was redactor of the Siphra on Leviticus, to him and to R Hoshaiah the compilation of the Tosephtā is also ascribed. Abbā Arīka or Rab, the nephew of the first mentioned, founded the school of Sura (AD 219) Rab and Shemuel (Samuel) "the astronomer" (died AD 254) were pupils of "Rabbi" (10, Judah, above), and were famed for their knowledge of law; so numerous were their points of difference that the Talmud will emphasize certain decisions by the statement that the two were agreed The Gemara is much indebted to this pair and to Johanan b Nappāhā (199-279) The latter, founder of the great school of Tiberics, has indeed been venerated, on the authority of Marmonides, as the editor of the Palestinian Talmud; but the presence of later material and of later names, e.g., Mani b Jona and Jose b Abin (Abin), refute this view The Babyloman Rabbah b Nahmani (died c 330) had a dialectical ability which won him the title "uprooter of mountains" His controversies with R Joseph b Hiyya (known for his learning as "Sinar"), and those between their disciples Abaye and Raba are responsible for many of the minute discussions in the Babylonian Gemara Meanwhile the persecutions of Constantine and Constantius brought about the decay of the Palestinian schools, and, probably in the 5th century, their recension of the Talmud was essentially complete In Babylonia, however, learning still flourished, and with Rab Ashi (352-427) the arranging of the present framework of the Gemara may have been taken in hand. Under Rabba Tosepha'a (died 470) and Rabina, ie, Rab Abina (died 499), heads of the academy of Sura, the Babylonian recension became practically complete

Finally, the Sabōrā'ē, "explainers, opiners" (about 500-540), made some additions of their own in the way of explanations

and new decisions

The Palestinian Recension of the Mishnah and Gemara is called "the Talmud of the Land of Israel," or "T of the West"; a popular but misleading name is "the Jerusalem Talmud" It is an extremely uneven compilation. "What was reduced to writing does not give us a work carried out after a preconcerted plan, but rather represents a series of jottings answering to the needs of the various individual writers, and largely intended to strengthen the memory" (Schechter) Political troubles and the unhappy condition of the Jews probably furnish the explanation; hence also the abundance of Palestinian haggadic literature in the Midrashim, whose "words of blessing and consolation" appealed more to their feelings than did the legal writings. The Pal. Talmud did not attain the eminence of the sister recension, and survives in a very incomplete form, although it was perhaps once fuller. It now extends only to Orders I.-IV, with the omission of IV. 7 and 9, and with the addition of part of VI. 7.

The Two Versions.-The Babylonian Talmud (or Tal. Babli) contains the Gemara to 361 tractates, but the material is relatively very full, and it is about three times as large as the Pal... although the Gernara there extends to 39 tractates. In the latter the Gemara follows each paragraph of the Mishnah; in the former, references are usually made to the leaves (the two pages of which are called a and b), the enumeration of the editio princeps being retained in subsequent editions. The Mishnah is written in a late literary form of Hebrew; but the Gemara is in Aramaic (except the Baraithas), that of the Bab. T. being an Eastern Aram, dialect (akin to Mandaitic), that of the Pal. T. being Western Aram. (akin to Biblical Aram, and the Targums). Greek was well understood in cultured Palestine; hence the latter recension uses many Greek terms which it does not explain; whereas in the Bab. T. they are much less common, and are sometimes punningly interpreted. The Pal. Tal. is the more concise, but it is remarkable for the numerous repetitions of the same passages; these are useful for the criticism of the text, and for the light they throw upon the incompleteness of the work of compilation. The Bab Tal, on the other hand, is diffuse and freer in its composition, and it is characterized by the exuberance of Halakah, which is usually rather subtle and far-fetched Both Talmuds offer a good field

Especially interesting are the Barasthas which are preserved in the Gemara in Hebrew, they are "external" decisions not included in the more authoritative Mishnah, but they differ from and are sometimes older than the Mishnic material, with which they sometimes conflict (so in particular as regards the rejected decisions of the school of Shammar). They usually begin. "our Masters taught," "it is taught," or "he taught," the verb tēnā (cf. Tannā'im, "teachers") being employed (see further Jew Ency. in. 513 seg ) Parallel to the Mishnah is the Tosephia, an independent compilation associated with R Nehemiah (a contemporary of Meir and Simeon b Yohai), Hiyva b Abba and others, it is arranged according to the Mishnic orders and tractates, but lacks IV 9 and V. 9-11. The halakoth are fuller and sometimes older than the corresponding decisions in the Mishnah, and the treatment is generally more haggadic. The method of making the discussions part of an interpretation of the Old Testament (halakic Midrash), as exemplified in the Tosephta, is apparently older than the abstract and independent decisions of the Mishnah-which presuppose an acquaintance with the Pentateuchal basis-and, like the employment of narrative or historical Midrash (eg, in the Pentateuch, Chronicles and Jubilees), was more suitable for popular exposition than for the academies

The Responses of the Geonim.—The Palestman Talmud, although used by the Qarastes in their controversies, fell into neglect, and the Bahylonian recension became, what it has since been, the authoritative guide. With the Geonim, the heads of Sura and Pumbeditha (about 589-1038), we enter upon another stage The "canonical" Mishnah and Gemara were now the objects of study, and the scattered Jews appealed to the central bodies of Judaism in Babylonia for information and guidance. The Geonim in their "Responses" or "Questions and Answers" supplied authoritative interpretations of the Old Testament or of the Talmud, and regulated the application of the teaching of the past to the changed conditions under which their brethren now lived. The legal, religious and other decisions formulated in the pontifical communications of one generation usually became the venerated teaching of the next, and a new class of literature thus sprang into existence (See Gaon.)

Meanwhile, as the Babylonian schools decayed, Talmudic learning was assiduously pursued outside its oriental home, and some Babylonian Talmudists apparently reached the West. However, the fortunes of the Talmud in a hostile world now become part of the history of the Jews, and the many interesting vicissitudes cannot be recapitulated here (See JEWS) To the use of the Pal. Talmud by the Qarastes in their controversies with the Rabbis we owe the preservation of this recension, incomplete though it is To the intolerance of Christians are no doubt due the rarity of old mss., and the impure state of the text of both Talmuds. At the same time, the polemics had useful results since the literary controversy in the 16th century (when Johann Reuchlin took the part of the Jews) led to the editio princeps of the Babylonian Talmud (Vienna, 1520-23). A change shows itself in the second edition (Basel, 1578-81), when the tractate Abodah Zārāh was omitted, and those passages which offended the Christians were cancelled or modified

Characteristics.—Owing to the nature of its contents the Talmud stood sorely in need of aids and guides, and a vast amount of labour (of varying value) has been devoted to it by Jewish scholars.

Neither the Mishnah nor the subsequent Gemara aimed at presenting a digested corpus of law. It is really a large collection of opinions and views, a remarkably heterogeneous mixture of contents, for which the history of its growth is no doubt largely responsible. It appalls the reader with its irregularity of treatment, its variations of style, and its abrupt transitions from the spiritual

sight. Like the Koran it is often concise to obscurity and cannot be translated literally, it presupposes a knowledge which made commentaries a necessity even, as we have seen, to the Jews themselves. The opening of Order II 6, for example, would be ununtelligible without a knowledge of the law in Levit xxiii 42 "A booth (the interior of which is) about 20 cubits high is disallowed R Judah allows it One which is not ten hands high, one which has not three walls, or which has more sun than shade is disallowed 'An old booth?' (marks of quotation and interrogation must be supplied) The school of Shammai disallows it; but the school of Hillel allows it," etc. In the Gemara, the decisions of the Mishnah are not only discussed, explained or developed, but all kinds of additional matter are suggested by them Thus, in the Bab Gem to III 5, the reference in the Mishnah to the Zealots (Σικάριοι) is the occasion for a long romantic account of the wars preceding the destruction of the Second Temple In IV 3 the incidental prohibition of the cutting up of a roll of Scripture leads to a most valuable discussion of the arrangement of the Canon of the Old Testament, and other details including some account of the character and date of Job There are numerous haggadic interpolations, some of considerable interest Prose mingles with poetry, wit with wisdom, the good with the bad, and as one thing goes on to suggest another, it makes the Talmud a somewhat rambling compilation. It is scarcely a law-book or a work of divinity, it is almost an encyclopaedia in its scope, a store-house reproducing the knowledge and the thought, both unconscious and speculative, of the first few centuries of the Christian era

Estimates,-Ordmary estimates of the Talmud are often influenced by the attitude of Christianity to Judaism and Jewish legalism, and by the preponderating interest which has been taken in the religious-legal side of the Rabbinical writings. The canonization of oral tradition in the Mishnah brought the advantages and the disadvantages of a legal religion, and controversialists have usually seen only one side. The excessive legalism which pervades the Talmud was the scholarship of the age, and the Talmud suffers to a certain extent because accepted opinions and isolated views are commingled. To those who have no patience with the minutiae of legislation, the prolix discussions are as irksome as the arguments appear arbitrary But the Talmudical discussions were often merely specialized and technical-they were academical and ecclesiastical debates which did not always touch every-day life; sometimes they were for the purpose of reconciling earlier conflicting views, or they even seem to be mere exhibitions of dialectic skill (cf., perhaps, Mk. xii 18-23) It may be supposed that this preddection for casuistry stimulated that spirit which impelled Jewish scholars of the middle ages to study or translate the learning of the Greeks. Once again it was-from a modern point of view-old-fashioned scholarship; yet one may now recognize that in the development of European science and philosophy it played a necessary part, and one can now realize that again the benefit was for common humanity rather than for the Jews alone. In any case, the Talmud must be judged, like other authoritative religious literature, by its place in history and by its

Results of Criticism .- The Talmud itself is still the authoritative and practical guide of the great mass of the Jews, and is too closely connected with contemporary and earlier Palestinian history to be neglected by Christians. With the progress of modern research the value of this and of the other old Rabbinical writings is being re-estimated, and criticism has forced a modification of many old views. Thus, an early reference to the title of a work does not prove that it is that which is now current; this applies, for example, to the tractate Edwyjoth (see Jew Ency vni 611), and to the Midrash Siphre, which frequently differs from that as known to the Talmud (sb, xi 331). It has been found that a tradition, however tenacious or circumstantial, is not necessarily genuine, and that, too, in spite of the chain of authorities by which its antiquity or genuineness appeared to be confirmed. Implicit reliance can no longer be necessarily placed upon the reputed authorship or editorship of a work; yet, although many of the to the crude and trivial, and from superstition to the purest inviews of mediaeval Jews in this respect prove to be erroneous

(eg, on the authorship of the Zöhar; see Kabbalah), they may sometimes preserve the recollection of a fact which only needs restatement (eg, R Johanan as the editor of the Pal Talmud). Finally, the Talmud comes at the end of a very lengthy develop-

rmany, the raimon comes at the end of a very lengthy development of Palestinian thought. It is in the direct line of descent from the Old Testament—intervening literature having been lost

-the essence of which it makes its own

Forced by events of history, this legacy of the past was subjected to successive processes and adapted to the needs of successive generations and of widely different historical and social conditions Legal compendiums and systems of philosophy served their age and gave place to later developments, and the elasticity of interpretation which characterizes it enabled it to outlive Karaites and Kabbahsts It also escaped the classicism of the Renaissance with its insistence upon the test-either fact or fiction. As an oriental work among an oriental people the moral and spiritual influence of the Talmud has rested upon its connection with a history which appealed to the imagination and the feelings, upon its heterogeneity of contents suitable for all moods and minds, and upon the unifying and regulative effects of its legalism. The relationship of Talmudism to the Old Testament has been likened to that of Christian theology to the Gospels; the comparison, whether fitting or not, may at least enable one to understand the varying attitudes of Jewish thinkers to their ancient sources With closer contact to the un-oriental West and with the inevitable tendencies of modern western scholarship the Talmud has entered upon a new period, one which, though it may be said to date from the time of Moses Mendelssohn (see Jews), has reached a more distinctive stage at the present day. In the weakening of that authority which had been ascribed almost unanimously to the Talmud, and invariably to the Old Testament, a new and greater strain has been laid upon Judaism to reinterpret its spuit once more to answer the diverse wants of its adherents. This is part of that larger and pressing psychological problem of adjusting the "authority" ascribed to past writings to that of the collective human experience, it does not confront Judaism alone, and it must suffice to refer to the writings of "Reformed Judaand a must sounce to refer to the writings of "Ketormed Judaism"; see, e.g., C. G. Montefiore, Liberal Judaism (1903); Truth in Religion (1906); I. Abhahams, Judaism (1907); Permanent Values (1924), and the essays of S. Schochter.

Values (1924), and the essays of S. Schochter.

BERLICORANY—E. Deutsch's article on the Tahmad in the Quarterly Review, Oct. 1867 (repunted in hu Listerry Remans), is noteworthy for the great interest it anoused. For other introductions, see J. Z. Lautenbach, "Mishnah," and W. Bacher, "Tahmud" in the Jew. Ewey, S. Schechter, "Allahud", in Lattings 'Dict. 1869, E.R. E', and all S. Funk, Eststehung der Tahmud" (Lapzig, 1910). More compression of the Calmud (New York, 1903), and especially H. I. Strack, Essethung in den Tahmud (New York, 1903), and especially H. I. Strack, Essethung in den Tahmud (Lepizig, 1908, every concise, but replies with bibliographical and may be supplemented from the critical Jewish plumais, e.g., the Jewish Montaschrift f. Gatch. at Wissenschoft des Judentowns (Breslau), the Peter Danby, The Mishnah (Eng. trans., 1933); Isidore Epstein (ed.), The Babylonian Tahmud (1938).

TAM. JACOB BEN MEÏR (1100-1171), a grandson of Rashi (q.v.), was the most famous French glossator (tosafist) on the text of the Talmud. In 1147 he was attacked and injured by a disorderly band who had attached themselves to the Crusaders. He escaped to the neighbouring Troyes, where about 1160 was held the first of the Jewish Synods, for which the Rhinelands became celebrated. At this meeting it was laid down that disputes between Jew and Jew were not to be carried to a Christian court, but were to be settled by fraternal arbitration. New conditions of life had arisen owing to the closer terms on which Jews and Christians lived, and Jacob Tam was foremost in settling the terms which were to govern the relations, from the Jewish side. His practical ordinances (Takkanoth), connected with marriage and divorce, trade and proselytism, as well as with synagogue ritual, bear the stamp of enlightened independence within the limits of recognized authoritative tradition and law. Of his legal work the most important was collected in his Sefer ha-yashar. He was also a poet and grammarian.

See Gross, Gallia Judaica (index); M. Schloessinger in Jewish Encyclopedia, vn 36-39.

TAMAI, BATTLE OF, March 13, 1884. This is memorable as the occasion on which the charge of the Sudanese tribesmen, followers of Osman Digna, broke the British "square," although eventually repulsed For an occount see Ecver AND SUBAY CAN-PRIONS (1883-1900)

TAMAQUA, an anthracite-mining borough of Schuylkill county, Pennsylvanna, USA, 15 mm NE of Pottsville, on the Tamaqua (Little Schuylkill) ruse, severed by the Central of New Jersey, the Lehigh and New England and the Reading railways Pop (1959) 11,563, 1940 federal census was 12,486 There are many collentes in the borough and its immediate environs, and vanious industres (including foundress and machine shops, powder mills, shut factories, tubing manufacture, baby bottle manufacture and knitting mills) Settlement dates from 1799 Anthracite was discovered in 1791 and the first coal company was organized the net year. In 1829 a town was laid out, which in 1833 was incorporated as a botough. The name is an Indian world meaning "tunning water."

TAMARIND, the name popularly applied to the pods of a legumnons tree, which are had externally, but within filled with an acid jucy pulp containing sugar and varieus acids, such as citric and fartaric, in combination with potash. The acid pulp is used as a lanature, the pods being largely imported both from the East and the West Indies. The tree is now widely distributed in tropical countries, but it is generally considered that native country is in eastern tropical Africa, from Abyssinas southward to the Zambea. The name (meaning in Arabic "Indian date") shows that it entered mediaeval commerce from India, where it is used, not only for its pulp, but for its seeds, which are astringent, its leaves, which furnish a yellow or a red dye, and stimber. The tree (Tamarindus sindica) attains a height of 70 to 80 ft., and bears elegant pinnate foliage and purplish or orange veined flowers arranged in terminal raceness

TAMARISK. The genus Tamarix gives its name to a small group of shrubs or low trees constituting the tamarisk family, Tamaricaceae. The species of tamarisk and of the very closely allied genus Myricaria giow in salt-deserts, by the sea-shore, or in other more or less sterile localities in warm temperate, subtropical, and tropical regions of the eastern hemisphere. long slender branches bear very numerous small appressed leaves, in which the transpiring surface is reduced to a minimum Tho flowers are minute and numerous, in long clusters at the ends of the branches or from the trunk. Each has 4-5 free senals. and as many petals springing with the 4-ro stamens from a fleshy disk. In Tamarix the stamens are free, while in Myricaria they are united into one parcel. The fruit is capsular, and contams numerous seeds, each usually with a long tuft of hairs at one end. The value of these shrubs or trees hes in their ability to withstand the effects of drought and a saline soil; they grow where little else can flourish. On this account the common tamarisk, T. gallica, the salt cedar, is planted on seaccasts, and affords shelter where none other could be provided. T. articulata, the Athel tree, native to western Asia, has been introduced as a windbreak in desert areas in southern California. Several species are cultivated as ornamentals. For tamarisk manna, see Manna.

TAMATAVE (known by the natives as Tōamāxina) (pop. 159371 ar.,455), the chief seaper of Madagascar, is nearly on the cartre of the eastern coast in 18° 10° S., 49° 32° E. It owes its importance to the eastern coast in 18° 10° S., 49° 32° E. It owes its majoratina to the eastern coast in 18° 10° S., 49° 32° E. It owes its considerable of the eastern coast in 18° 10° S., 49° 32° E. It owes its large of the eastern coast in 18° 10° S., 40° S. The town is built on a sandy peninsula on which are crowded numerous houses, with good shops and merchants' offices in the main thoroughfares. Tamatave is the seat of several foreign consuls, as well as of numerous French officials, and is the chief port for the capital and the interior. Imports consist principally of piece-goods, fart-accous foods, and from and stell goods, and exports of gold dust, raffa, hides, caoutchous and live animals. The town possesses several meat preserving factories. Communication with Europe is maintained by steamers of the Messageries Martitimes and the

Havraise companies, and also with Mauritius, and from thence to culture and general social conditions, see Voronezh, noting how-Ceylon, by the British Union-Castle line Of the whole foreign trade of Madagascar, 46 per cent is through Tamatave. The town is connected with the interior of the country by a network of roads and railways Since 1895 the native population has

settled in a new village to the northwest

TAMAULIPAS a northern Gulf-coast State of Mexico.
Area 30,726 sqmi. Pop. (1950) 716,029. The central and southern parts of the state are mountainous, but there are extensive fertile plains in the north sloping gently northeast toward the Rio Grande, and the coastal zone is sandy, much broken by lagoons, and sparsely inhabited Except in the north this coastal zone is only 5 to 7 mi, wide, but the footbills region back of this is usually well wooded and fertile, and the low alluvial river valleys penetrate deeply into the sierras. There are four important rivers in the state-the Rio Grande del Norte or Rio Bravo, which forms the boundary line with the United States, the Conchas or Presas, the Soto la Marina and the Tamesi Pánuco forms the southern boundary for a short distance A peculiar feature of the hydrography of Tamaulipas is the series of coastal lagoons formed by the formation of new beaches across the indentations of the coast. The climate is hot and humid on the coast, but is pleasant on the more elevated lands of the interior The rainfall is abundant, especially on the mountain slopes of the south The principal industry is agriculture. Sugar, cereals, tobacco, cotton and coffee are produced, and probably fruit may be raised successfully. Stock raising receives some attention, and hides and cattle are exported. The preparation of ixtle fibre for export is becoming an important industry Copper is mined and extensive deposits of petroleum and asphalt are being exploited. Railway communication is provided by the Mexican National, which crosses the northern end of the state east and west, and runs southeast from Monterrey to Tampico. The line from San Luis Potosi to Tampico crosses the state's southern tip

The capital of Tamaulipas is Ciudad Victoria (pop. 1950, 31,815), a small sterra town on the Monterrey and Tampico railway, about 120mi from Tampico. Among other towns may be mentioned Tampico (qv.) (1950, 94,342), Ciudad Madero (1950, 41,074), Nuevo Laredo (1950, 57,669), Matamoros (qv) (1950, 18,215) and

Reinosa (1950, 34,076), the latter three being on the U.S. horder.

TAMAYO Y BAUS, MANUEL (1829-1898), Spanish dramatist, came of a family connected with the theatre, his mother being the eminent actress, Joaquina Baus. The earliest of his printed pieces, Juana de Arco (1847), is an arrangement from Schiller, as also is Angela (1852), while Virginia (1853) is a dramatic essay in Alfieri's manner. La Locura de Amor (1855) established Tamayo's reputation as Spain's leading playwright Hija y Madre (1855) is a failure, and La Bola de Nieve (1856) is notable solely for its excellent workmanship. Tamayo's straitened means during the next few years forced him to put original work aside and to adapt pieces from Léon Laya, Jules Sandeau and Émile Augier. In this period he produced only one original piece, Lances de Honor (1863), which turned upon the immorality of duelling, and led to a warm discussion among the public.

TAMBOV, a region of the Russian S.F.S.R., surrounded by those of Voronezh, Ryazan, Penza, Saratov and Stalingrad. Area 13,745 sq mi. Pop. (1939) 1,882,139 (rural 1,601,115, urban 281,024). It is much smaller than the pre-1917 province of the same name, part of which is now in Ryazan region, and is included in the Black Earth area (Central) (q v.) It consists of an undulating plain (450-800 ft.), intersected by deep ravines and broad valleys; the Don and its tributaries, the Voronezh, Vorona and Khoper, drain it toward the south, and the Tsna links it with the Oka on the north. Cretaceous and Jurassic deposits, thickly covered with boulder clay and loess, conceal the underlying Devonian and Carboniferous strata. Phosphorite beds exist in the northeast and are used for the production of chemical manure; iron is mined in the Lipetsk district, which also has mineral springs, and limestone, clay and gypsum are worked. The soil is black earth, very fertile in the Borisoglyebsk district, but having a lower humus content toward the north, where wild cherry and almond abound. For climate, the difficulties of agri-

ever that Tambov has a smaller annual rainfall

The population is mainly Great Russian in origin, settlement beginning from the principality of Moscow at a very early date, but Tatar raids prevented active colonization until the end of the 17th century, when landowners who had received large grants of land from the tsars began to bring their serfs from central Russia There were some Finnish tribes in occupation, and the Mordva still form an independent group in the region. After the 1917-20 civil war, and the retreat of Denikin's army (1920), the region was infested by bandits, and recovered slowly from the devastation that followed. Prosperity began with establishment of railway construction works at Tambov

TAMBOV, chief town of the above region, situated on the Tsna river (non-navigable), and at a railway junction, in 52° 45' N, 41° 23' E Pop. (1939) 121,285 It has smelting works, a railway repair shop, steam flour mills, distilleries and brick works. The absence of a navigable river lessens its trading importance, though it has a grain elevator. The town was founded in 1636 as a fort against Tatar and Kalmuck raids, was a station for part of Peter the Great's army during his attack on Azov, and later was centre of Tambov province, created in 1796.

TAMERLANE: see TIMUR.

TAMILS, the Sanskrit generic appellation for the south Indian peoples and their languages, which passed through various stages-Dravida, Dramida, Dramila, Damila Bishop Caldwell fully explains this in his Comparative Grammar of the Dravidian Languages (2nd ed , 1875, p 10 seq ) The term Tamulic or Tamulian has occasionally been employed as the designation of the whole class of Dravidian peoples and languages The Tamils proper are smaller and of weaker build than Europeans, though graceful in shape. The hair is plentiful, and occasionally curly The skin varies from brown to black. Of medium stature, they are in general long headed with medium noses They are enterprising, and wherever money is to be earned there will Tamils be found, either as merchants or in the capacity of domestic servants and labourers. The tea and coffee districts of Cevlon are peopled by about 950,000; Tamils serve as coolies in the Mauritius and the West Indies; in Burma, the Straits, and Siam the so-called Klings are all Tamils. They have settlements in east and south Africa.

Language.—Tamil is still the principal language of the Madras Presidency; in Tanjore and Tinnevelly it is supreme. In Coimbatore it is dominant, is second in Chittoor and the Nilgiris (Census of India 1921, vol xiii). Tamil is a sister of Malayâļam, Telugu, Kanarese, Tulu; and, as the oldest, richest and most highly organized of the Dravidian languages, is typical of that family. The one nearest akin to it is Malavalam, originally a dialect of Tamil, but now differing from it in pronunciation and in idiom, in the retention of old Tamil forms obsolete in the modern language, and in having discarded all personal terminations in the verb, the person being always indicated by the pronoun. Also, the proportion of Sanskrit words in Tamil is less than in any other Dravidian tongue.

The modern Tamil characters originated "in a Brahmanical adaptation of the old Grantha letters corresponding to the socalled Vatteluttu," or round-hand, an alphabet once in vogue throughout the whole of the Pandyan kingdom, as well as in the South Malabar and Coimbatore districts, and still sparsely used for drawing up conveyances and other legal instruments It is also used by the Moplahs in Tellicherry, while in Malabar it continued in general use down to the end of the 17th century. The modern Tamil characters, which have changed but little for the last 500 years, differ from all the other modern Dravidian alphabets both in shape and in their phonetic value. Their angular form is said to be due to the widespread practice of writing with the style resting on the end of the left thumb-nail, while the other alphabets are written with the style resting on the left side of the thumb.

The Tamil alphabet is sufficiently well adapted for the expression of the twelve vowels of the language (a, â, i, î, u, û, e, ê, o, ô, ei, au), the occasional sounds of ö and ü, both short and TAMILS 773

long, being covered by the signs for e, ê, i, î, but it is utterly madequate for the proper expression of the consonants, masmuch as the one character k has to do duty also for kh, g, gh, and similarly each of the other surd consonants ch, t, t, p represents also the remaining three letters of its respective class. The letter k has, besides, occasionally the sound of h, and ch that of s Each of the five consonants k, ch, t, t, p has its own nasal In addition to the four semivowels, the Tamil possesses a cerebral r and l and has retained a liquid &, once peculiar to all the Dravidian languages, the sound of which varies in different districts. There is, lastly, a peculiar n, differing in function but not in pronunciation from the dental n. The three sibilants and h of Sanskrit have no place in the Tamil alphabet, but ch often does duty as a sibilant in writing foreign words, and the four corresponding letters as well as 1 and ksh of the Grantha alphabet are now frequently called to aid Many of the Sanskrit words imported into Tamil at various periods have therefore assumed disguises under which the original is scarcely recognizable examples are ulagu (loka), uruvam (rûpa), arukken (arka), arputam (adbhutam), natchattıram (nakshatram), ırudı (rıshı), tîrkam (dîrgha), arasen (râjan)

Tamil has borrowed from Hindustan, Arabic, and Persain a large number of revenue, political, and judicial terms, and more recently a good many English words have crept in, such as tratis, treaty, patiar, butler, åkt, act, hulbb, clib, kawarner, govenin, pinnalahådu, penal code, sikku, sick, mejastrættis, magistrate Of Tamil words which have found a permanent home in English may be mentioned curry (kari), mulligatawny (milagu, pepper, and tamifr, colo water), cheroic (surtist), pariah (paperyam).

The Older Literature.-The early existence, in southern India, of peoples, localities, animals and products the names of which, as mentioned in the Old Testament and in Greek and Roman writers, have been identified with corresponding Dravidian terms, goes far to prove the high antiquity, if not of the Tamil language, at least of some form of Dravidian speech (Caldwell, loc. cst., Introd, pp 81-106, Madras District Manual, i. Introd, pp 134 seq.) But practically the earliest extant records of the Tamil language do not ascend higher than the middle of the 8th century of the Christian era, the grant in possession of the Israelites at Cochin being assigned by the late Dr. Burnell to about A.D. 750, a period when Malayalam did not exist yet as a separate language. There is every probability that about the same time a number of Tamil works sprung up, which are mentioned by a writer in the 11th century as representing the old literature (Burnell, loc cit., p. 127, note) The earlier of these may have been Saiva books; the more prominent of the others were decidedly Jain. Though traces of a north Indian influence are palpable in all of them that have come down to us (see eg., F. W. Ellis's notes to the Kural), we can at the same time perceive, as we must certainly appreciate, the desire of the authors to oppose the influence of Brahmanical writings, and create a literature that should rival Sanskrit books and appeal to the sentiments of the people at large. But the refinement of the poetical language, as adapted to the genius of Tamil, has been carried to greater excess than in Sanskrit; and this artificial character of the so-called Sen-Tamil is evident from a comparison with the old inscriptions, which are a reflex of the language of the people, and clearly show that Tamil has not undergone any essential

change (Burnell, loc ett, p. 142).

The rules of Sen-Tamil appear to have been fixed at a very early date. The Folkshophyme, the oldest extant Tamil grammar, is assigned by Dr. Burnell (On the Aindra School of Sonskrit Grommarious, pp. 8, 55) to the 8th century (best edition by C. Y. Tämodaram, Pillei, Madras, 1885). The Virasidiyam, another grammar, is of the 11th century. Both have been superseded by the Normall, of the 15th century, which has exercised the skill of numerous commentators, and continues to be the leading native authority (English editions in Pope's Third Tamil Grammar) and an abridgment by Lazarus, 1884). The period of the prevalence of the Jains in the Päqdya kingdom, from the 9th or roth to the 13th century, is justly termed the Augustan age of Tamil literature. To its earlier days is assigned the Nidadsyyar, an ethical

poem on the three objects of existence, which is supposed to have preceded the Kural of Tiruvalluvan, the finest poetical production in the whole range of Tamil composition Tradition, in keeping with the spirit of antagonism to Brahmanical influence, says that its author was a pariah It consists of 1,330 stanzas on virtue, wealth and pleasure It has often been edited, translated and commented upon, see the introduction to the excellent edition published by the Rev Dr Pope, in which also a comprehensive account of the peculiarities of Sen-Tamil will be found To the Avvei, or Matron, a reputed sister of Tiruvalluvan, but probably of a later date, two shorter moral poems, called Attisuds and Konrewêyndan, are ascribed, which are still read in all Tamil schools Chintâmans, an epic of upwards of 3,000 stanzas, which celebrates the exploits of a king Jivakan, also belongs to that early Jain period, and so does the Divakaram, the oldest dictionary of classical Tamil The former is one of the finest poems in the language, but no more than the first and part of the third of its thirteen books have been edited and translated Kamban's Râmâyanam (about AD 1100) is the only other Tamil epic which comes up to the Chintâmani in poetical beauty

comes up to the Combandon in posecular deaductions which appeared in the period of the Saiva reevistal productions which appeared in the period of the Saiva reevistal productions with the production of Saiva reventions of Saiv

1875-76)

After a period of literary torpor, which lasted nearly two centuries, King Vallabha Deva, better known by his assumed name Ativîrarâma Pândyan (second half of the 16th century), endeavoured to revive the love of poetry by compositions of his own, the most celebrated of which are the Neidadam, a somewhat ex-travagant imitation of Sri Harsha's Sanskrit Naishadham, and the Verrivêrkei, a collection of sententious maxims. Though he had numerous followers, who made this revival the most pro-lific in the whole history of Tamil literature, none of the compositions of any kind, mainly translations and bombastic imitations of Sanskrit models, have attained to any fame. An exceptional place, however, is occupied by certain Tamil sectarians called sittar (1e, siddhas or sages), whose mystical poems, especially those contained in the Swavakyam, are said to be of singular beauty Two poems of high ment, composed at the end of the 17th century, also deserve favourable notice-the Nitinerivilakham, an ethical treatise by Kumaragurupara Desikan, and the Prabhulingalilei, a translation from the Kanarese of a famous text-book of the Vîra-Saiva sect. See the analysis in W. Taylor's

Catalogus, vol. il. pp. 83,7–47.

Catalogus, vol. il. pp. 83,7–47.

The Modern Period, which may be said to date from the beginning of the last century, is ushered in by two great poets, one native and the other foreign. \*Tōyumdnavam, a philosopher of the panthesite school, composed 1,453 starnas; \$\fotag{doi:10.10}\$ which have a high reputation for sublimity both of sentiment and style; and the Italian Jesuif Joseph Beschi (d. 1742), under the name Viraminumi, elaborated, on the model of the \$Chindmani, a redigious epic \*Tōmbūnari, which, though marred by Dlemishes of taste, is classed by native critics among the best productions of taste, is classed by native critics among the best productions of taste, is classed by native critics among the best productions of their literature. It treats of the history of St. Joseph, and has been printed at Pondicherry in three volumes, with a tull analysis. English influence has here, as in Bengal and elsewhere in India, greatly tended to create a healthier tone in literature both as to style and seatiment. As one of the best Tamili translations of English books in respect of diction and idiom may be mentioned the \$Bdioxydphrida, or "Little Merchants," published by the Vernacular Text Society. Madras. P. Percival's collection of Tamil Provents (3 and ed., 1875) should also be mentioned.

The copper-plate grants, commonly called fasanams, and stone

inscriptions in Tamil, many of which have been copied and translated (Archaeological Survey of Southern India; vo. iv.; R. Sewell, Lists of the Antiquarian Remans in the Presidency of Madra; vols 1, in), are the only authentic Instorical records. (See also Sir Walter Elliot's contribution to the International Numismato Orientiala, vol in pt. 2) As early as the time of the Chinese traveller Hsuan Tsang, books were written in southern india on talpot leaves, and Albiruil mentions this custom as quite prevalent in his time (1031). It has not died out even descriptions of the control of the Control of the National States is now the largest depository of Tsanil polin-leaf mas, which have been described in Wishor's Calalogue of the Matchanie Collection (Calcutta, 1282, a vols.), W Taylor's Catalogue (Madras, 1857, a vols.), and Condaswany Iyer's Catalogue (Vol. 1, 1861)

The art of printing, however, which was introduced in southern India at an early date, while it has tended to the preservation of many valuable productions of the ancient literature, has also been the means of perpetuating and circulating a deal of literary rubbish and lasciviousness which would much better have remained in the obscurity of manuscript. Dr. Burnell has a note in his Elements of South Indian Paleography (and ed , p 44), from which it appears that in 1578 Tamil types were cut by Father João de Faria, and that a hundred years later a Tamil and Portuguese dictionary was published at Ambalakkâdu. At present the number of Tamil books (inclusive of newspapers) printed annually far exceeds that of all the other Dravidian vernaculars put together The earliest Tamil version of the New Testament was commenced by the Dutch in Ceylon in r688; Fabricius's translation appeared at Tranquebar in 1715 Since then many new translations of the whole Bible have been printed, and some of them have passed through several editions

The German missionary B Ziegenbalg was the first to make the study of Tamil possible in Europe by the publication of his Grammatica Damulica, which appeared at Halle in 1716. Some time later the Jesuit father Beschi devoted much time and labour to the composition of grammars both of the vulgar and the poetical dialect. The former is treated in his Grammatica Latino-Tamulica, which was written in 1728, but was not printed till cleven years later (Tranquebar, 1739). It was twice repunted, and two English translations have been published (1831, 1848). His Sen-Tamil Grammar, accessible since 1822 in an English translation by Dr. Babington, was printed from his own ms (Clavis humansorum Isterarum sublimioris Tamulici idiomatis) at Tranquebar in 1876. This work is especially valuable, as the greater portion of it consists of a learned and exhaustive treatise on Tamil prosody and thetoric. (See, on his other works, Graul's Reise, vol. IV p. 327.) There are also grammars by Anderson, Rhenius, Graul (in vol. ii of his Bibliotheca Tamulica, Leipzig, 1855), Lazarus (Madras, 1878), Pope (4th edition in three parts, London, 1883-85), and Grammaire française-tamoule, by the Abbé Dupuis (Pondicherry, 1863). The last two are by far the best. The India Office library possesses a ms. dictionary and grammar "par le Rév Père Dominique" (Pondicherry, 1843), and a copy of a ms. Tamil-Latin dictionary by the celebrated missionary Schwarz, in which 9,000 words are explained About the like number of words are given in the dictionary of Fabricius and Breithaupt (Madras, 1779 and 1809). Rottler's dictionary, the publication of which was commenced in 1834, is a far more ambitious work. But neither it nor Winslow's (1862) come up to the standard of Tamil scholarships; the Dictionnaire tamou français, which appeared at Pondicherry in 2 vols. (1855-62), is superior to both, just as the Dictionarium latino-gallico-tamulicum (ibid, 1846) excels the various English-Tamil dictionaries which have been published at Madras.

F. Müller, Grundriss der Sprachwissenschaft, Vienna, 1884, m 1 162-246; G. U. Pope, First Lessons in Tamil, 7th ed, Oxfond, 1994, and The Mäddiyár, Oxford, 1893, and J. Vinson, Manuel de la langue tamoule, Paris, 1903 (R Rr, X)

TAMLUK, a subdivisional town of India, in the Midnapore district of Bengal on the nver Rupnaryan. Population (1941), 12,079 Under the name of Tamralpita, it was a scaport at which the Chinese Buddhist pilgrims enhasted, it may also be identified with Tamalites noticed by Ptolemy as being on the rivet Ganges The channel connecting the town with the sea survived till the riph century, when the Portuguese had a settlement here, and then silted up. Tamluk is now 60 m from the sea, and the issue of the old city the deep beneath inver sit

TAMMANY HALL. Quite as old as the US government, this powerful political organization in New York city has, with only occasional intermissions, not only ruled that city since the year 1800, but at times has execised great influence in state administration and even in national affair.

Its Origin—Before the Ameican Revolution groups proclaiming featly to King George III were organized in societies bearing the names of St. George, St. Andrew and St. David. To counter their aims the revolutionsits formed associations called the Sons of Laberty or the Sons of St. Tammany Tammany or Tammanend was an Indian chief noted for his wisdom, benevolence and love of liberty. In ridicule of the imported saints, revolution is studied Tammany a saint. With the achievement of American independence the Sons of Laberty and the Sons of St. Tammany dissolved.

When the delegates of New York state met to adopt a federal constitution, the discussions evidenced the existence of a unified aristocratic group During the Revolution many estates owned by opponents of the American cause had been confiscated. But there remained some large estates in possession of tamilies which either supported the Revolution or were not hostile. The proprietors of these estates, often vested with almost feudal powers, constituted the core of the aristocratic party To resist these influences, William Mooney, an upholsterer in New York city, founded the Society of St Tammany or Columbian Order, on May 12, 1789, a fortnight after the establishment of the national government. His purpose was the creation of a society native in character and democratic in principle and action. Its officers were given Indian titles, the society's chief was Grand Sachem and his fellow chiefs Sachems The democracy comprehended in Tammany's original period was not, however, that of later times For more than three decades after its organization Tammany represented the middleclass opposed to the pretensions and power of the aristocratic

class opposed to the pretensions and power of the aristocratic party; it did not then represent the lower classes.

At first, the Society of St Tammany was nonpartism in the sense that it had no distinct political miniators but expressed its democratic factor of the property of the pro

"Sammany Hall Organized"—Caseff critisjens made by the opposition that a private society was engaging in polities resulted in a separation of social from political functions. In 1805 the Society of St. Tammany obtained from the legislature a charter incorporating it as a benevolent and charitable body on the charter incorporating it as a benevolent and charitable body in militation was now created as an apparently distilled to the controlled the political mechanism; the leaders of the two organizations were either identical or the men directing the political arm had their representatives as Sachems. The political organization had their representatives as Sachems. The political organization by in the fact that the society was continuously the owner of the Tummany like that the society was continuously the owner of the Tummany and garden house to the Tummany and part of the party regularity became binding upon a majority of voters, to factled the evited could proporly claim to be the Tummany organization or

any part of it. This happened in 1828, 1838, 1853 and 1857 when the Sachems, as trustees of the building, evcluded factions from meeting in Tammany Hall

Until 1806 Tammany Hall remained an agitational political club, Democratic, party In that year was begun a thorough organization of Democratic voters The main features of this comprehensive plan were general, nonunating, corresponding and ward committees. In the meetings and of making all necessary arrangements for elections Composed originally of 30 members, this committee was gradually expanded until it had many thousands of members penetrating every Tammany Hall's strength was greatly increased when, in 1820, it

decided as a matter of policy to support a New York state constitu-tional amendment abolishing property qualifications for voting Effec-tive in 1822, this amendment brought a new and ever-increasing voting tive in 1622, this amendment origin a new and ever-increasing voting element into politics and generally into Tammany Hall. The change produced by manhood suffrage was not immediate. For some years more Tammany was led by bankers and merchants who used their power for self-enrichment. The Workingmen's party, in 1829, and

more Tammany was led by bankets and metchants who used their power for self-enthement. The Workingment's party, in 1829, and its successor, the Equal Rights party, or against on 1829, as successfully a more than the general communities and Tammany Hall of this element.

Gang Control and "Boss" Rule.—The period especially from 1826 onward was one m which heavy immigration, notably flish, pouted into New York city Impecunous and objects of religious and scan prepatice, numbers of the Irish, unable to get work, banded and a call prejudice, numbers of the 1 rish, unable to get work, banded in street gangs Unlike other political parties, Tammany Hall wel-comed immigrants, facilitated their naturalization and gave then their The astute, unscrupious and engaging Fernando Wood organized the gangs as a political power within Tammany Hall, securing his own advancement, 1s well as assuring Tammany the redoubtable support of men equally useful in overawing opposition, packing primaries or committing frauds at the polls Wood had been a powerful but not a supreme leader With the ascendency of William M Tweed but not a supreme reason with the ascendency of william M feed on 1867, Tammany Hall came under the sway of a single leader or boss. The son of a chairmaker, Tweed had won his way through ward politics, had been a member of "The Forty Thieves" board of aldermen in 1851-52, manipulating his unprincipled way to the rule of Tammany Hall. Corruption reached its climax under Tweed when York city was plundered of an amount conservatively estimated at \$45,000,000 in direct spolation, but innging as high as \$200,000,000 when reduced taxes and fraudulent bond issues are also considered Only \$876,000 was ever recovered Tweed died in jail, but most of

Univ spychocow are ever recovered. Twees died in jul, but most of which we will be a many and the late of the most of the most of the most of the most of the most of the most of the most of the late of the most m overthrowing I weed to reorganize Tammany Hall. Superficial, this move in movies affected the composition and characteristics of the Tammany organization at large. The real resuscitating factor was the attachment of New York city's tenement house masses to an organization the distinct leaders of which evercised a human relationship, coming into direct contact with them, treating them politically as equals and giving a helping hand to those in want or trouble. This one large service outweighed all of the denuncations of Tammany by Republican business opponents who often had their own less spec

one large sevice outweighed all of the denincations of 'Assmany by incular but more indicate system of corruption. After Kelly's death in 1886, Richard Croker succeeded as Tammany Halls boss and he was followed by Charles F Murphy in 1992. During this period many were perhaps no greater than the contemporary frauds and corruptions committed by financial, insuance and other corporations. Tammany In Rocent Years—with the accession of Judge Commany in Rocent Years—with the accession of Judge Commany in 1994, came evidence of a still more altered Tammany Hall. Different from his predecessor, Judge Olvany was a university graduate and lawyer, having served in the court of peneal sessions, in contrast allower, having served in the court of peneal sessions, in contrast allower, having served in the court of peneal sessions, in contrast allower, having served in the court of peneal sessions, in contrast allower, having served in the court of peneal sessions, in contrast allower than the contrast of the court of the court of the contrast of the court prompted Welker's resignation and Samuel Seabury's report, prompted Welker's resignation and discredited Curry Tammany leaders refused to indorse the moderate reforms made by acting mayor isaders retused to indorse the moderate reforms made by acting mayor McKee and choes John P. O'Brien of the old school to fill out the unexpired term. The city rose in revolt and a Fusion tacket formed under Seabury's direction successfully ran Procello H. LaGuardia for mayor. These successive defeats weakened Curry's leadership and in July 1934 he was replaced by James J. Dooling.

During the 13 years of the LaGuardia administration, which has been called the best administration New York city ever emboyed, a farmanay's hardy was characterized by the organization, defended a consistency of the organization, defended a consistency of the organization, defended a consistency of the organization of the consistency of the organization of the consistency former postmaster general and Prasdent Roosevelt's campaign maser until the block with the president over the third term issue in 1940, extressed considerable influence in Tammany Hall's afturs from 1940, extressed considerable influence in Tammany Hall's afturs from 1940, extressed considerable influence and the state of the term of the term of the state of the Tamman and the state of the Tamman and the state of the Tamman and the state of the Tamman and the Tamman Democratic national chairman in 1940, controlled the party Kelly and Plynn between them exercised greater influence on the affairs of the Democratic party in New York city during that period than any of

Democratic party in New York city during that period than any of the leaders of Tammany Hall Thomas E. Dewey, who had won a seputation for gang busting as district attorney, easily defeated the Tammany candidate for governor of New York, John J. Bennett, J., who also was strongly supported by President Roosevelt There was

wuo aiso was strongy supported by President Roosevelt. There was more gloom in Tammany Hall and additional predictions in the press that Tammany was finished forevel in the munerapid election of 1945, when LaGuardia was no longer a candidate, Tammany supported William O'Dwyer again for mayor O'Dwyer, who also had strong support of the American Lebor party, DAMPET, who aso had strong support of the American Labor parks sletchy was elected by one of the largest pluralities in New York's history It is significant that although before its echapse by the LaGuardan administration candidates had considered Tammany endousement an asset, during the municipal campaigns of both 1941 and 1941 the Demociatic manyoralty candidate thought it waste to tepudate Taministration of the control Exemoviate mayorany canoniate mought it wiset to repudiste Tammany Tammany's ability to turn out the vote for its candidates was once more established, however, in 1945
See Gustavus Myers, The History of Tammany Hall, 'The New Tammany,' The Centery Magazine, Aug. 1256, D. T. Lynch, Boss Tweed, M. R. Werner, Tammany Hall (1928) (M. R. W. X.)

TAMMERFORS: see TAMPERE

TAMMUZ, Sumerian, Babylonian and Assyrian god, who died and lose annually with dying and reviving vegetation, originally Dumu-zi, "the son who rises, goes forth (from the nether world)," but generally interpreted "faithful son" Philologically both interpretations are correct, and no Accadian commentary exists to explain which meaning was accepted by them.

The interpretation as "the son who rises," "the resurrected child," accepted in this article, is new and differs from all views held in the standard works on this cult It is clear, however, that the main principle of this cult is the resurrection of the dying god. and the verb zi stands for the root zig to rise up, not zid, to be and the verb 22 stands for the root 22 to rise up, not 322, to be faithful (See S Langdon, Sumerian Laturgies and Psalms, p. 287, 17, 18 tubba-za usrga-za, "In thy fall and in thy resurrection.")

There are many titles of the youthful god, loved by his sister,

the earth and heaven goddess, Innini (Ishtai), who descends yearly into Aralû (under-world) at the time of his death to bring him back to earth in her bosom. Since he represents the mystery of life and death, as seen in the withering vegetation of the hot Mesopotamian summer, and the rapid renewal of its life at the season of the spring rains, Tammuz is the patron of flocks and irrigation as well as of vegetation Titles such as god Sipa, the shepherd, umun mirsi, lord of the flood, god Ab-ú, father of vegetation, god Zulumma, god of the date palm, are not so old as those which reveal theological speculation concerning the brother, lover and husband of the earth mother. Theology gave rise to this, the most widely spread and profoundly religious aspect of West Asiatic and Egyptian religion (where it appears as the cult of Osiris and Isis). Dumu-zi appears in the oldest texts without a divine title, c. 3200 B.C., and in Sumerian texts of Eannatum of Lagash (c. 2850 BC.), as god Dumum-apsu, "risen child of the deep," describing him as the son of the god of the nether sea of fresh waters, Ea, Enki, a title confined apparently to early Lagash, where he appears more often under the title Ningiszida. "Lord of the faithful tree," a title which developed into an independent deity. In the legend of Eridu, in which Adapa is sent to the gates of heaven for judgment because he had broken the wings of the south-wind, he found Tammuz and Ningiszida at the gate of heaven; they offered him bread and water of life, which he, on the advice of the water god of Eridu, refused and

been identified with the stars Castor and Pollux or, perhaps, Procyon and Sirius

The liturgical wailings for Tammuz during the period of his sojourn in Aralû are numerous and describe every aspect of the theological doctrines concerning him They are invariably composed in Sumenan, rarely with Accadian interlinear translation. These wailings occurred at midsummer, and the sixth month of the calendar at Lagash from the 28th to the 24th centuries is named the "month of the festival of Tammuz," corresponding to September if the year began near the spring equinox. There is a variant name for this month at Nippur, called "month of the mission of Innini," referring to her descent to Aralû in search of her departed lover The Babylomans retained the old name of the fourth month and for some reason described it as the "month Tammuz," corresponding to July, retaining the name "month of the mission of Innini" for the sixth month (Elul). In this month (fourth) Tammuz is said to have been bound, and the liturgies speak of his having been drowned among flowers which were thrown upon him as he sank beneath the waves of the Euphrates. He is described as the shepherd who left his flocks, as the shepherds sat in the fields wailing for Tammuz

There is a strange inconsistency in the hymns of these wailings concerning the relation of the mother goddess to her lover, Tammuz. In the early Sumerian texts she is his sister, but soon the Semitic view that she is his mother prevails. The two theories appear inconsistently together throughout the entire history of the cult He is, however, invariably the husband and lover of the otherwise consistently described virgin goddess of love, Innin, Gestinanna, Bêlit-sêri (queen of the field of the lower world), and the cult is particularly associated with the great city Brech, home of the cult of Anu, the heaven god, and Innini In all ceremonies connected with his cult his mother or sister is invariably associated with him, and it is the one aspect of Sumerian and Babylonian religion which may be described as universal and not largely confined to any local tradition Badtibira, Pantibiblas of the Greek, near Erech, seems to have been the original seat of the cult, and in the Sumerian tradition of the ten pre-diluvian kings, the name of one at Badtıbıra is Dumuzisipa, "Tammuz the shepherd"; one of the names of Tammuz is Tibira. No great temple was built to him, and a few casual references to a temple of Tammuz at Umma, Ur, Lagash, Agade, clearly refer to shrines in the temple of the local deity reserved for the wailings and mystic ceremonies of the cult Worship of Tammuz spread far beyond the lands to which the Sumerian religion was principally confined. Ezekiel speaks of it as firmly installed at Jerusalem in his time; it is mentioned in the Christian era in Mandean and Syriac literature, and survived among the Ssabeans at Harran as late as the middle ages. At Byblus, in Syria, he was identified with the West Semitic Adonis,

In astrology Tammuz was identified with Aries; in the magic rituals he is symbolized by a white kid, and he is also connected with the ram, which led to this astral identification. Under the title Sibzianna, "faithful shepherd of heaven," he was identified with Orion. During the period of deified king worship in the Dungi period of Ur, and in the time of the Isin dynasty, the deified kings habitually identified themselves with Tammuz and were worshipped as husbands of the mother goddess. For this reason it has been argued that the cult arose in prehistoric times. when a king was put to death as a sacrifice to the earth mother in order to secure the good will of the desty of vegetation. There is, however, no evidence for this in the earlier texts, and so far as Sumerian religion is concerned, the theory must be dismissed as unproved He was held to be a god of healing, bestower of health, and one who, like all other deities, had power over the demons

It is obvious that a cult which is based upon the death and resurrection of a propitiating god, and upon the love of a divine mother who walls for her son, has direct connection with the facts and the theological views based upon them, which gave

thus lost immortality Tammuz and Ningišzida appear to have Marduk of Babylon was identified with Tammuz At the Nisan or new year festival at Babylon, Bêl (Marduk) was said to have been imprisoned in the lower world, and a priestess weeps at his sepulchre A malefactor was slain with Bêl and they descend together to the land of darkness Beltis, his wife, descends to hell to seek him, and Bêl's garments are given Ishtar (mother of Tammuz) Bêl was laid in a sepulchre, from which he soon comes forth. This Marduk transformation of the national Tammuz cult is only another effort of the priesthood of the capital to enlarge the worship and importance of the local cult It obtained nowhere else in Babylonia and Assyria, and may be regarded as a true interpretation of what transpired regularly in the Tammuz cult itself. That the cult had direct influence upon the origins of Christianity cannot be denied, and the Greek cult of Adons owes its essential content to the Sumerian Tammuz

of Adons owes its essential content to the Sumerian Tammus Bibliotocarky—S. Langdon, Tammus and Bibliato (Oxford, 1914); H. Zimmern, Der Babylonische Gest Tamis (Leipzis, 1909), W. W. Baudssin, Adons und Einnin, for connections with West Semitic capitale cults (Leipzis, 1917). For the hymns of the Tammus-Inhita wainings, St. Lammerin, Samerust-babylonische Tamishider (Paris, 1909). H. Zimmerin, Samerust-babylonische Tamishider India Litteries, pp. 60–63, e4–60, Paris, 1919); Hugo Radau, Sumeran Litteries and Palains, pp. 285–290 (Philadelphia, 1910); Hugo Radau, Sumeran Litteries and Palains, pp. 285–290 (Philadelphia, 1910); Hugo Radau, Sumeran Litteries and Palains, pp. 285–290 (Philadelphia, 1910); Hugo Radau, Sumeran Litteries and Palains, pp. 285–290 (Philadelphia, 1910); S. Tor the Marduk-Hel ritual of the new year festival at Babylon in the late Marduk, 1918). S. Langdon, The Babylonaux Epit of Creation, (Colford, 1921). Death and Resurrection of Bel-Marduk, 2006. (Oxford, 1923).

TAMPA, a city on the west coast of Florida, U.S., at the head of Tampa bay (Gulf of Mexico), 330 mi S.E. of Pensacola and 220 mi N.W. of Key West; a port of entry and the county seat of Hillsborough county It is on federal highways 41 and 92, has two municipal airports with breakwater to accommodate seaplanes.

The city is served by Eastern and National air lines, by the Atlantic Coast Line and the Seaboard railways, steamship lines, operating to both U.S. coasts and foreign ports, and motorbus lines, covering Florida and adjacent territory and connecting with lines to all principal cities in the U.S. The population was 124,073 in 1950 and 108,391 in 1940.

The city hes at the mouth of the Hillsborough river, which flows into Hillsborough bay, an arm of Tampa bay The climate is delightful with an average temperature of 71.8,° an average annual precipitation of 49.36 in. and an average of 67% of the "possible sunshine" in the year. Tampa first became a resort in the 1880s, hotels are open the year round. It is a centre for tarpon fishing and winter headquarters of the Cincinnati Reds, major league baseball team, Royal American Shows, and annual meeting place of the National Pistol tournament, Tin Can Tourists of the World, Women's Open Golf tournament and Dixie Tenms tournament.

It has a municipal golf course, tennis courts, yacht basin, fishing pier and provision for all the usual sports and recreations. The Gasparilla Carnival and Florida State fair is an annual event of national prominence in February,

Thousands of visitors stop in the city during the year, and the city provides adequate facilities for their entertainment. It is the industrial city of the state, ships more phosphate rock (1,582,-369 tons in 1949) and manufactures more clear Havana cigars (535,013,758 in 1040) than any other city. Its water-borne commerce was 5,436,202 tons in 1949. Industries include shipbuilding and manufacture of canned citrus fruit, cement, tin containers, fertilizers and boxes.

The city has many public schools, a university and vocational schools. There are more than 150 cigar factories. Tampa has a large wholesale and retail trade. In 1927 after seven years under a commission-manager form of government, the city modified its charter to provide for a mayor with broad authority and a council of 12 district representatives.

Tampa was the name of the Indian village which De Narváez birth to Christianity. But the form of the cult which apparently and De Soto found there in 1528 and 1539. The harbour, accordmost directly affected the origins of Christianity is that in which ing to tradition, was a favourite resort of pirates, including the picturesque Capt José Gasparılla, whose memory is kept alive in the annual carnival In 1823 the US government established a fort (Fort Brooke, an important base of supplies in the second Seminole War, abandoned in 1860) and around it grew up a civil settlement. In Nov 1862 Tampa was taken by Federal gunboats During the Spanish-American War (1898) it was the point of embarkation for US troops that invaded Cuba Theodore Roosevelt and his Rough Riders were encamped there for several weeks In 1880 the population was only 720 Between 1880 and 1800 the cigal industry was established, the first railroad reached the city and the first hotel for tourists was built. By 1890 the city had a population of 5,532, which was shown to have increased to 15.839 in 1900, 37,782 in 1910 and 51,608 in 1920 The opening of the Panama canal (1920) greatly enhanced the importance of the post, and within a few years its traffic was doubled Tampa was one of the principal foci of the Florida "rush" of 1924-25. The city was incorporated in 1855

TAMPERE, formerly Tammerfors, an industrial city of Finland in 61° 28′ N, 23° 45′ E, on the rapids connecting Lakes Nasi-jarvi and Pyha-jarvi, and at a railway junction Pop (est, 1040) 80.005′ If manufactures textiles, paper and leather goods

TAMPICO, a city and leading port of Mexico, in the state of Immulipas, on the north bank of the Pánuco river, about 6 mi. from the Gulf of Mexico. In summer the climate is hot and humid, although a sea breeze modifies the temperature somewhat In winter the temperature falls to freezing on occasional days when "northers" blow down along the Gulf coast. Tampico is almost surrounded by swampy lands and lagoons

The eastern and poorer part of the town stands on low ground only or of at howe the nuver, and is subject to inundations. However, a modern sewer system, up-to-date street paving and a better water supply, constructed after the beginning of the 20th rentury, greatly improved the sanitary condition and reduced the death rate from epidemics. The western part rises about 150 ft, consists largely of residential districts and 15 provided with still better sanitary equipment. The business section is well built, largely of stone and brock, while many of the newer structures are of reinforced concrete and rise to six and seven stories. The city is well sumbled with say and electric help.

Tampico has excellent transportation facilities, one railway line running north-northwest to Monterrey and another westward to San Luis Potosi, connecting there with the railway to Mexico City; a third short but important line leads southwestward through the oil fields to Pánuco. Although a bar exists at the mouth of the Pánuco river, jetties have been built and the depth was increased by dredging so that vessels drawing up to 33 ft. can approach the water front of the city, while scows and other boats of light draught can go up the river for more than 100 mi. The Chijol canal, begun in 1901, affords a waterway 6 ft. deep and 25 ft wide for about 75 mi, southward through the oil fields to Túxpan Modern port works, spacious enough to accommodate at the wharves 14 vessels at a time, steel sheds and warehouses, a union railway station within easy reach of the water front and excellent equipment for loading oil tankers make Tampico the most un-todate harbour in Mexico. Excellent air service is available to Mexico City, Veracruz, Brownsville, Tex., and other points,

Tampico owes its importance to the fact that four of the most productive oil fields in the country (the Ebano, Paiuce, Husateca and Tüpan) are situated within about 100 mi, of its site. Until 1901 it was a second-rate port, outlet of the fertile but relatively undeveloped hinterland, with a very bad reputation for health and sanitary conditions. The raped exploitation of petroleum resources resulted in a marked increase of population from about 10,000 in 1900 to 14,956 in 1921 and 10 \$34.47\$ in 1940. Population (census 1950) was 94,342. For several years Tampico ranked as the greated of the the world. Clusters of steel petroleum-storage tanks extend along the river, particularly on the southern shore, from its mouth to a few miles above the city. Pipe lines lead from the near-by fields, while fleets of scows bring oil from farther up the river. Pipe lines and barges together are capable of transporting approximately 1,200,000 bbl. of oil daily from the fields to the port of Tampico.

Up river from the port agricultural activities have been stimulated, fruits, vegetables and grams being grown to supply the local food demands. Up-standard standard 
Besides the connected directly with the oil business, the inmatter of the connected directly with the oil business, the indirect of the connected directly and for the building of rought
busts, and electic light and power plant, factories for making
ice, clothing and fruit preserves, sawmills, etc. In addition to
petroleum, the exports meduce silver building (from San Luis
Potosi, Aguascahentes, Torreón and Monterrey), xitle fibre, sugar,
thides, live cattle, cottonseed cake, honey, fustic, sarsaparilla,
coffee and copper ores. Substantial imports of all commodities
are received for the surrounding territory. (J. W. May.)

TAMWORTH, mumcapality, Inglis county, New South Wales, Austr, on the Peel and Cockburn rivers, 285 mi by rail north of Sydney. Pop. (1947) 12.071. It is the centre of the Liverpool plants, and near by at Bungera diamonds are found It is also the market of a pastoral and agracultural distinct. Brewing maling, steam, saw and flour milling, coachbuilding and the manufacture of boots and galvanized iron are its principal industries.

TAMWORTH, market town, municipal borough, Lichfield parliamentary division, Staffordshire, England, on the river Tame The rural district of Tamworth is in the Tamworth division, Warwickshire Pop. (1951) 12,889 Area, 4.18 sq mi It is 110 mi NW, of London on the London Midland Region railway castle, situated above the Anker, is chiefly of the Jacobean period, but is enclosed by massive ancient walls. After being bestowed on the Marmions by William the Conqueror, the castle was for many years an important fortress. The town was formerly surrounded by a ditch of which only traces remain. The church of St. Editha (8th century) was rebuilt, after the Danes burned it, by Edgar, who made it collegate, the existing Decorated building was erected after a fire in 1345 The free grammar school, refounded by Edward IV, was rebuilt in 1677 and again in 1867. The charities include Guy's almshouses (1678), endowed by Thomas Guy, founder of Guy's hospital, London Coal, fire clay and blue and red brick clay are dug in the neighbourhood. In the town are a clothing factory, paper mills and manufactories of small wares. The borough was extended in 1932 and given additional powers. Tamworth (Tamwurda, Thamworth, Tomworth) is situated near the Roman Watling street. It was burned by the Danes and restored in 913 by Aethelflead, who built the fort which was the origin of the later castle The town was again destroyed by the Danes in 943. It is mentioned in Domesday Tamworth was incorporated by Elizabeth in 1560 by letters patent, which state that it is an "ancient mercate town," and suggest that the charters had been lost or burned. The governing charter in 1835 was that of Charles II, incorporating it under the title of the bailiffs and commonalty of the borough of Tamworth in the counties of Stafford and Warwick. Edward III granted two fairs, still kept up in 1792, to be held respectively on St. George's day and the day of the Translation of St Edward; another ancient fair, in honour of St. Swithin, or perhaps originally of St. Editha, is still held (July 26). Tamworth sent two members to parliament from 1562 to 1885.

TANA, a lake of northeast Africa, chief reservoir of the Abhai or Blue Nile. Tana lies between 11° 36′ and 12° 10′ N. and 37° 27′ and 37° 40′ E., 5,650 ft. above the sea, on the northeen portion of the Abyasimian plateau. Its greatest length is 47 mil, its greatest breadth 44 mil, and it covers approximately 1,100 sq. mil, having a drainage area, including the lake surface, of about 5,200 sq.mil. The shorts are well defined, generally flat, but at places the mountains descend somewhat abruptly into the water. Elsewhere the land rises in gentle undulations, except at

the mouths of the larger tributary streams, where are alluvial plains of considerable size At the south-east end the lake forms a bay about 11 miles long, and from three to eight miles across From this bay the Abbai issues The whole coast-line is considerably indented and many narrow promontories jut into the lake The island of Dek (eight m long by four broad) is in the south-western part of the lake. Near it is the smaller island of Dega Numerous islets fringe the shores

Lake Tana is fed by three large rivers and by many petty streams The chief tributary is the Little Abbai, which enters the lake at its south-west corner This river, and the Abbai itself or Blue Nile which issues from the lake, are regarded as one and the same stream and a current is observable from the inlet to the outlet Next in importance of the affluents are the Reb and Gumara. which run in parallel courses and enter the lake on its eastern side The outlet of the lake is marked by openings in a rocky ledge, through which the water pours by two or three channels, in a succession of rapids, uniting within a couple of miles into one river—the Abbai with a width of 650 ft

The average annual ramfall in the Tana catchment area is estimated at 31 ft, and the volume of water received by the lake yearly from this source and from affluents at about 6,572,-000,000 of cubic metres The average seasonal alteration of the

lake level is not more than about 11 metres

Three technical missions have been sent by the British and Egyptian Governments conducted respectively by Mr. Dupuis (1903), Mr Buckley (1916) and Mr Grabham (1920-1) to report on the feasibility of utilizing the lake as a reservoir with the object of regulating the supply of water (3,500 million cu m in a normal year) discharged from the lake into the Blue Nile for irrigation needs in the Sudan and Egypt. As a result a scheme of works has been proposed, and it is estimated that these works, in addition to securing a more even distribution of water during the year, would by storing the surplus water in years of heavy rainfall form a reserve of 8,000 million cum to tide over the deficiency in years of bad supply. The Abyssinian Government, however, has consistently opposed the project.

Tana has been identified with the Color Palus of the ancients, which was described by Ptolemy as a chief reservoir of the Egyptian Nile and the source of the Astapos, which was certainly the Blue Nile In 1625 it was visited by the Portuguese priest Jeronimo Lobo, and in 1771 by James Bruce. It was formerly known by the name of Dembea.

Known by the name of Demicia.

See Ninz and Absyssinia, and the authorities there cited. The British Blue Book, Egypt, No. 2, 1904, which contains a special report (with mass) upon Lafe Tana. Also the mest valuable Report of the Mission to Lake Tana (1920-21) issued by the Egyptian Ministry of Public Works in 1925.

TANA, a river over 500 m. long, in Kenya Colony, which gives its name to the Tanaland province of that British protectorate. Its sources are along the watershed close to the eastern wall of the eastern rift-valley, and it enters the Indian Ocean in 2° 40' S., about 110 m. north of Mombasa. One series of its numerous headstreams traverses the Kikuyu plateau north of the Athi, others flow from Mount Kenya, all following a south-easterly direction until intercepted by the main stream which flows northeast until, when nearing the equator, it turns eastward afterwards sweeping southward to the sea. It receives tributaries only along its upper course but on entering the plain it flows along a tortuous course, has low banks, is in part forested and inundated at high water, but away from the river the country appears to con-sist of dry plains covered with mimosa scrub. The river fre-quently divides in its lower course, has many backwaters and has often changed its course, especially its place of entering the sea. It is navigable for 150 m. from its mouth. North of the Tana is the Ozi, a small river connected with the Tana by the Belazoni canal

TANAGER, the name of birds of the family Tanagridae, allied to the Fringillidae (see FINCH), and distinguished by their feebler conformation and more exposed nostrils. They are confined to the New World, and are specially characteristic of the tropical forests of Central and South America, only in a small proportion reaching Mexico, and four species breeding in the U.S.A.

The tanagers have been examined systematically by P L Sclater, he admits the existence of 375 species, which he airanges in 59 genera, forming six subfamilies, Procniatinae, Euphoniinae, Tanagrinae, Lamprotinae, Phoenicophilinae, and Pitylinae These are of very unequal extent, for, while the first of them consists of but a single species, Procesas tersa, the third includes more than 200.

Nearly all are birds of small size, the largest barely exceeding a song-thrush Most of them are remarkable for their gaudy colouring, and this is especially the case in those forming the genus Tanagra Generally among the tanagers, both sexes are nearly alike in plumage. Insects, especially in the larval condition, and bernes afford the greater part of their food. They have a pleasing song, and build a shallow nest, in which the eggs, generally three in number, and of a greenish-blue marked with brown and purple, are laid

The scarlet tanager (Piranga erythromelas) nests in the eastern USA, west to the Plains and north to New Brunswick and Manitoba, wintering in South and Central America The male is scarlet, with black wings and tail, the female is olive green, lighter below, with dusky wings and tail. The song is reminiscent of the Ameri-

can robin, but is inferior

The summer tanager (P. rubra) does not reach farther north than New Jersey and Kansas The male is 10sy 1ed, the female olive-yellow above, dusky saffron below. The song is superior to that of P erythromelas

The remaining species, P ludoviciana, the males of which are mostly yellow and black, with the head only red, does not appear eastward of the Missouri plains, and has not so northerly a range Another species, P hepatica, has shown itself within the limits

of the United States. In all these the females are plainly attired TANAKA, GIICHI, BARON (1863-1929), Japanese statesman and general, born in Yamaguchi, graduated at the military cadet's school in 1886, and the staff college in 1802. He was minister of war in the Hara and Takahashi cabinets in 1918-21, and 1920 He became leader of the Seivukwai Party in 1926, and formed a government in April 1927, himself taking the ministry

of foreign affairs He died on Sept. 28, 1929
TANAQUIL, the Etruscan name of the wife of Tarquinius Priscus, or of one of his sons After her immigration to Rome she is said to have received the name Gaia Caecilia. She was famous for her prophetic gifts. There was a statue of her as Gaia Caecilia in the temple of Sancus, which possessed magical powers She was celebrated as a spinner of wool, and was supposed to exercise influence over Roman brides. Tanaqual and Gata Caecula are, however, really distinct personalities. The anecdotes told of Gaia Caecilia are aetiological myths intended to explain certain usages at Roman marriages

See Livy, 1. 34, 41; Pliny, Nat. Hist, viii. 74, xxxvi 70; Schwegler, Romische Geschichte, bk. xv. 8.

TANCRED (d. III2), nephew of Bohemund and a grandson of Robert Guiscard on the female side, was the son of a certain Marchisus, in whom some have seen a marquis, and some an Arab (Makrizi). He took the Cross with Bohemund in 1096, and marched with him to Constantinople. Here he refused to take an oath to Alexius, escaping across the Bosporus in the disguise of a peasant; but after the capture of Nicaea he followed the example of the other princes, and became the man of Alexius. At Heraclea, in the centre of Asia Minor, he left the main body of the Crusaders, and struck into Cilicia, closely followed by Baldwin of Lorraine. He made himself master of Tarsus, and when he was evicted from it by the superior forces of Baldwin, he pushed further onwards, and took the towns of Adana and Mamistra. He joined the main army before Antioch, and took a great part in the siege. In the beginning of roop he was in Raymund's army, but he soon left the count, like many other pilgrims (see Ray-MUND IV); and he joined himself to Godfrey of Lorranc in the final march. After the capture of Jerusalem he went to Nablous, and began to found a principality of his own. He took part in the battle of Ascalon in August; and after it he was invested by Godfrey with Tiberias and the principality of Galilee, to the north of Nablous. In 1100 he attempted, without success, to prevent Baldwin of Lorraine (his old enemy in Cilicia)

from acquiring the throne of Jerusalem Failing in this attempt, and being urgently summoned from the North to succeed Bohemund in the government of Antioch, he surrendered his smaller possessions to Baldwin He acted as regent in Antioch until 1103, when Bohemund regained his liberty. He regained the Cilician towns for Antioch (1101), and recaptured Laodicea (1103); he imprisoned Raymund of Toulouse, and only gave him his liberty on stringent conditions, and he caused the restoration of the deposed patriarch of Jerusalem, Dagobert, if only for a brief season, by refusing to aid Baldwin I on any other terms When Bohemund was set free, Tancred had to surrender Antioch to him In 1104 he joined with Bohemund and Baldwin de Burg (now count of Odessa in succession to Baldwin of Lorraine) in an expedition against Harian, in which they were heavily defeated. and Baldwin was taken prisoner. Tancred, however, profited doubly by the defeat He took over the government of Edessa in Baldwin's place; and in 1105 Bohemund surrendered to him the government of Antioch, while he himself went to Europe to seek reinforcements. Ruler of the two northern principalities. Tancied carried on vigorous hostilities against his Mohammedan neighbours, especially Ridwan of Aleppo; and in 1106 he succeeded in capturing Apamea. In 1107, while Bohemund was beginning his last expedition against Alexius, he wrested the whole of Cılıcia from the Greeks; and he steadfastly refused, after Bohemund's humiliating treaty at Durazzo in 1108, to agree to any of its stipulations with regard to Antioch and Cilicia To the hostility of the Mohammedans and the Greeks, Tancred also added that of his own fellow Latins. When Baldwin de Burg regained his liberty in 1108, it was only with difficulty that he was induced to restore Edessa to him. But it was against the emirs of Northern Syria that his arms were chiefly directed; and he became the hammer of the Turks He died in 1112, leaving the government to his brother-in-law, Roger de Principatu, until such time as Bohemund II should come to his inheritance

SUCH LIME AS BOHEMUMG 11 SHOULD CORE TO HIS IMPLEMENTS BELLEGARDY—TARRICKS Getal were recorded by Ralph of Caen, who drew his information from Tancred's own conversation and reminiscences. Kuglier has written a work on Bohemund and Tancred (Tahmeen, 1869); and Tancred's career is also described by Rey, in the Levie de Toffent Lein, iv. 334-340.

TANCRED (d 1194), King of Sicily, an illegitimate son of Roger the eldest son or King Roger II, was crowned in January 1100 in succession to William II. (q.v.). He was supported by the chancellor Matthew d'Ajello and the official class, while the rival claims of Roger II.'s daughter Constance and her husband, Henry VI , king of the Romans and emperor, were supported by most of the nobles. Tancred was a good soldier; but he was illsupported in his task of maintaining the Norman kingdom, faced with general apathy, threatened by a baronial revolt, and menaced by Richard Coeur-de-Lion, at Messina, 1190. Henry, skilfully winning over Pisa, Genoa and the Roman Commune, isolated Tancred and intimidated Celestine III., who, on April 14, 1191, crowned him emperor at Rome. He, however, failed to capture Naples in August and retired north, leaving garrisons along the frontiers of the Regno. Tancred now sought to win over the towns by extensive grants of privileges, and at Gravina (June 1192) was recognized by the pope, whose ineffectual support he gained by surrendering the royal legateship over Sicily. In 1192 and 1193 he successfully opposed the Apulian barons, but his death at Palermo (Feb. 20, 1194) a few days after that of Roger, his son and joint-king, made Henry's path clear.

TANDY, JAMES NAPPER (1740-1803), United Irishman, born in Dublin in 1740, was a prominent reformer and supporter of Lucas and Grattan. He first won popularity by his attacks on municipal corruption and his proposal to boycott English goods in retaliation for the restrictions imposed on Irish commerce. In 1780 Tandy was expelled from the Dublin volunteers (see Flood, HENRY), but he continued his revolutionary agitation, and in 1791 co-operated with Wolfe Tone in founding the Society of United Irishmen, of which he became the first secretary. A challenge sent to the attorney-general resulted in his

he joined a number of Irish refugees. Having gained the ear of the French Government, Tandy was given command of a coivette, a small force of men, and a quantity of arms for distribution in Ireland Arriving at Donegal, however, he learnt that Humbert's expedition had failed, and he thereupon fled to Hamburg. The refugees were surrendered on a peremptory demand from the British Government Condemned to death, he was finally reprieved owing it is said to Bonaparte's intercession.

Tandy's exploits completely captured the popular imagination, and he is still remembered as the hero of the "Wearing of the Green" In France, where his release was regarded as a French diplomatic victory, he was received in March 1802, as a person of distinction; and when he died, on Aug. 24, 1803, his funeral was attended by the military and an immense number of the

civil population

civil population
See R. R. Madden, The Liver of the United Iribinen, 7 vol.
Obblin, 1843-40), Wu. J. MacNeven, Pieces of Iribi History (New
Obblin, 1843-40), Wu. J. MacNeven, Pieces of Iribi History (New
Oblitica, vol. Octobon, 1859), W. I. Fitzupatrick, Secret Service
under Pitt (London, 1893), Sir Kichard Musgrave, Memorir of Rebelium in Iribinal, 2 vols. (Dublin, 1802), J. A. Froude, The English in
Iribinal in the Englishenik Century, 3 vols. (London, 1872-74), Casistereals Correspondence, i, ii, Cornaulik Correspondence, ii, iii, Cornaulik Correspondence, ii, iii.)

TANEGASHIMA, an island south of Kyushu, in Kagoshima prefecture, Japan, in 30° 50' N. and 131° E, 36½ mi long and 7½ mi broad at its widest part The first Japanese word for firearms was Tanegashima, because it was there that Fernão Mendes

Pinto landed c 1542, carrying a musket.

TANEIEV. SERGIUS (1856-1915). Russian composer and theorist, was born on Nov 13, 1856, in the Vladimir government He studied under Nicholas Rubenstein and Tschaikowsky at the Moscow conservatoire. After a short career as a concert pianist he went back to Moscow as professor of instrumentation, then first professor of pianofotte and, in 1885, director. He died at Moscow on June 15, 1915 His published works include a symphony, five string quartets, a dramatic work, Orestes (performed in St Petersburg 1895), a cantata, John of Damascus, and choruses for male voices and for mixed voices. He also wrote a treatise on counterpoint.

TANEY, ROGER BROOKE (1777-1864), American jurist, was boin in Calvert county, Md, March 17, 1777. He graduated from Dickinson college, Carlisle, Pa, in 1795, and began studying law at Annapolis in 1796 He served in the State Senate in 1816-21, was attorney general of Maryland in 1827-31; and in July 1831 entered President Jackson's cabinet as attorney general of the United States. He was the President's chief adviser in the attack on the U.S. Bank, and was transferred to the treasury department in Sept. 1833, for the special purpose of removing the Government deposits. As a result, the Senate refused to confirm his appointment as secretary of the treasury

On Dec. 28, 1835, he was nominated chief justice of the U.S. Supreme Court. After strong opposition, the nomination was confirmed on March 15, 1836. During President Jackson's administration (1829-37), the personnel of the supreme bench was entirely changed. Five of the seven judges in 1837 were his appointees. The majority of them were Southerners who had been educated under democratic influences As a result, the State sovereignty influence was occasionally manifest, as for example, in the opinion (written by Taney) in the *Dred Scott* case (1857, 19 Howard, 393) that Congress had no power to abolish slavery in territory acquired after the formation of the National Government. Judge Tancy died Oct. 12, 1864.
An authoritative biography is Samuel Tyler's Memoir of Roger Brooke Tancy (1872).

TANGA, a seaport of Tanganyika, East Africa, opposite the random, a scaport of langanyira, East Arrica, opposite the island of Pemba in 5° of S., 39° 7′ E. Pop. (1948) 5,546 non-natives including 335 Europeans and 3,953 Asiatics. In 1952 the population was 22,100. The town is regularly laid out on elevated ground on the southern shore of Tanga bay, amid coconut groves and avenues of mango trees. The harbour is entered by a broad imprisonment (1792), but on his release Tandy assisted in raising but tortuous channel five to eight fathoms deep. Tanga is the then fied to America, and in 1798 proceeded to France, where At one time par, of the sultanate of Zanzibar, Tanga passed into German possession in 1888 In 1914, a British force from India attempted to capture the town but was compelled to reembark It was occupied by the British under Gen Jan Christiaan Smuts, July 7, 1916. In 1937, 33% of Tanganyika exports passed through the poor. (P. W. I)

TANGANYIKA, A British trust territory of east central Africa, is bounded on the east by the Indian ocean, on the south-east by Mozamboque, on the southwest by Nyassland and Northern Rhodesia, on the west by the Belgian Congo, on the northwest by Nyaunda-Urund and Uganda and on the northwest and north by Kenya II includes Mafia island The total area is 362,688 sq mi. which includes 1,9,982 sq mi! of landa waters.

#### PHYSIOGRAPHY

Geology—Most of Tanganyika is composed of ancent crystalline rocks of sevenil Pre-Cambran systems In the west, however, Archaean or early Palaeosoic unnetamorphosed unfossilierous sedimentary systems, the Karagwe-Ankolean and Bukoban, cocur, the latter with associated volcanics. Rocks of Karroo Age, mainly nomantin, ear fairly widespread; they have their greatest extension in the south central area of the country, with small outcrops scattered between there and the northern coastal area; coulbearing strata are known only in the southwest region of the territory.

Mesozoic and later marine sediments occur in a belt along the coast, widest at about the parallel of 7° S and narrowing especially to the north. The oldest dated Mesozoic marine rocks are of Bajocian Age, although Liassic beds have been believed to be present. In a number of inland basin areas, lake sediments of Pleistocene to Recent Age occur, and surface "duricrusts" are widespiead, especially in the granitic plateau areas. A northern volcanic area of the territory is a continuation of that more extensively developed in Kenya Volcanic activity has continued since Tertiary or possibly late Cretaceous times, at present being very slight. The rocks are mainly of alkaline types. A smaller volcanic focus is situated in the southwest of the territory near the northern end of Lake Nyasa. The rocks of both areas are termed "rift volcanics," being associated with the great disturbances of Tertiary and Quaternary times, which gave rise to the East African rift valleys and associated faults that control the major tectonic features of the (C. B. Bt.)

Physical Features — Through the middle of the country runs, from north to south, the Great Rift valley, which for much of its length has lost the troughlike characteristics so noticeable in Kenya and is seen as a cliff of varying health, the eastern wall being scarcely discentible. The rift forks just north of Lake Nyasa, one arm containing lake Tanganyaka and, outside the territory, Lakes Klvu, Edward and Albert; the other containing Lake Manyara, Lake Natron and, in Kenya, Lakes Magadi, Navashan and Rudolf. The greater part of the country consists of an immense plateau, varying in allitude between 3,co and 4,co of t.

The mountain systems are grouped mainly in the northeast and southwest, but there is a great ridge of high land between the two. In the north are the peaks of Kilimanjaro (19,565 ft.) and Meru (14,566 ft.) and the "winter highlands" further west, containing the famous game-filled Ngorongoro "crater." To the southeast of Kilimanjaro, running down toward the port of Tanga, are the Pare and Usambara ranges. In the south, grouped round the northern of Itake Nyssa, are the Luvingstone mountains, the Kipengeer nage, the Porton mountains, Mt. Rugwe and, further west, the Utipa highlands. To the east of the broad ridge of high land connecting the two main mountain systems is the isolated block of the Uluguru mountains, just south of the Central railway at Morogoro. In the Songea district of the Southern province lies another range, the Matengo highlands.

The country, although appearing well watered on the map, has few permanent rilyers and the greater part of the vast central plateau is devoid of running water for half the year or more. The main rivers flowing into the, Indian ocean are the Pangani, which rises in the snows of Kilimanjaro; the Wami, whose tributary, the Mkondoa, is one of the two major rivers to pierce the central

idge, the Ruvu or Kingani; the Rubij, with its many tibuaries from the south and centre of the country, chief among them the Rusha, the Kilombero and the Mbaragandu, and farther south the Matandu, Mbemkuru, Lukuleda and Ruvuma, the last forming almost the whole of the southern boundary. The only rivers navigable for any distance are the Rufin, navigable for about 50 m for small vessels, and the Kagera, similarly navigable for about 90 mi. The Mort, Mara and Kagera flow into Lake Victoria, the Malagaras into Lake Tanganyika and the Songwe and Ruhuhu nto Lake Nyasa. The Wembere, Manyonga and Sibiti, which have a seasonal flow only, drain a large part of the eastern side of the central plateau and discharge into Lake Eyasa, which lies in a subsidany fissure of the eastern Rit't valley.

Although it has no rivers of any great consequence, Tanganylka forms the divide whence the three greatest nivers of the African continent take their rise, namely, the Congo, the Nile and the Zambezi, flowing respectively into the Atlantic, the Mediterranean and the Indian ocean. The watersheds of the three systems do not meet at any one point, being separated by a large depression (in the central plateau) which has no outlet to the sea

Lake Victoria (26,828 sq.m.) is about the size of Scotland and lies 3,717 ft. above sea level. Lake Tanganyika (qv) is about 470 m. long and on the average about 30 m. wide and lies 3,534 ft. above sea level. Other lakes are Rukwa in the southwest and Eyasi, Manyara and Natron in the north. (The whole of Lake Nyasa is in Nyasaland—the boundary running down its eastern shore)

Climate.-The monsoons play a prominent part in the climate of the country The northeast monsoon sets in about November and gives way to the southeast monsoon (which becomes the southwest monsoon north of the equator) in March or Apul, the latter continuing to blow until it in turn is replaced by the northeast monsoon Altitude is another factor in deciding the kind of climate which any particular place will have Those sides of the mountains (eg, Kılimanjaro) which face the prevailing winds receive several times as much rain as those in the "rain shadow" on the leeward side Very broadly, the country may be divided into three zones (r) The northern coastal belt, an area about 100 mi, wide, extending from Dar es Salaam to the Kenya border, (2) the lake region within about 50 mi of Lake Victoria; (3) the interior plateau, with which must be associated the southern coastal belt. The northern coastal belt is characterized by high humidity, two pronounced rainy seasons-one from November to January, the other from March to May-and by temperatures which range from an average of about 72° F in the cool season (June-September) to an average of about 85° F. in the hot season. The average annual rainfall at Dar es Salaam is about 40 in.

In the lake region the lake exercises a moderating effect on the temperature and there is a diurnal variation of only about 13° F or 14° F. In the cool season the temperature is about 63° F. and in the hot season about 82° F. The presence of this great body of water has also a pronounced effect on the rainfall of the region: those areas which lie to the east of the lake receive about 30 in, to 40 in. per annum; while those to the west, where the prevailing winds blow, receive as much as 80 in to go in The interior plateau is characterized by a single rainy season (although this is often broken in places by a long gap, with disastrous effects on the local crops), by a wide diurnal range of temperature (which at Tabora sometimes exceeds 36° F.) and by a somewhat meagre and often badly distributed rainfall, averaging between 30 in, and 40 in over most of the area, although at Rungwe at the head of Lake Nyasa it reaches as much as 100 in, per annum. The cool season temperatures average about 60° F. and the hot season about 83° F.

Vegetation.—Characteristic of the coastal regions are the cocount palm, mangrove and casuarina; of the central areas the miombo (Brackystegia) woodland, the grotesque baobab and the symmetrical candelabra (a species of Euthoria); and of the forests myule (Chlorophora excelsa), yellowwood (Podoarpiu) and cedars of various kinds. the last three being vuluable commercially.

Fauna.—The country is unsurpassed in the number and variety of the wild life to be found within its borders Among the large animals elephant, giraffe, rhino, hippo and buffalo are widespread.

Antelope of numerous varieties occur, including impala, Thomson's and Grant's gazelle, duker of vaious kinds, bushbuck, teedbuck, waterbuck, topa, oyv, puku, eland, wildebeeste, harrebeeste, roan, sable, orbh, dik-dik and greater and lesset kudu Of the carmwores there is a similar warrety lion, leopaid, cheetah, serval and civet cats, hyensa and hunting dogs being common in many areas

Rareties are the chumpanzee, found only in the mountains to the north and south of Kigoma on Lake Tanganyka, the stuttinga, an antelope found only in certain swamps, and the gerunuk, another antelope, found in a few places in the Northein and Tanga provinces only. There are many varieties of snakes, lizatids, chameleons and amphibbans, and over 1,000 varieties of birds, including a litre number of same birds.

More than two-thirds of the country is infested by the tsetse fly, of which there are several varieties, Glossina morsitans being the most widespread.

HISTORY

Written records prove that knowledge of the east coast of Africa—
—the Azaman coast—has evasted in parts of Asa and Europe ence
before the Christian era. The Persphia of the Erytheraem Sea
contains a detailed mariner's guide to the coast, from the Rea
to what is now Portuguese East Africa, or Mozambique. In it reference is made to the island of Menouthis and to the town of
Rhapta. The former was either Zamabai or Pemba, the latter is
thought to be either Pangani or a town in the delta of the Ruji
river. There are also Egyptian records of still earlier times, although debut factation of the places they name is difficult. Plotted
writing about A. D. 150, gives some account of East Africa as it was
then known.

It is not surprising that contact should have been established with the neighbouring coasts of Arabia, Persia and India, since the monsoons or trade winds could hardly have been better devised for such traffic For part of the year they blow from the northeast, carrying the voyager directly to the East African coast, and for the remainder of the year they blow from the southwest, carrying him directly home again. The earliest settlers were Arabs and Persians who established themselves at easily defensible places, or small islands, such as Lamu, Mombasa, Pangani, Zanzibar, Mafia and Kilwa In these places, certainly from the 10th century AD and probably from very much earlier times, they built up flourishing civilizations of their own, the relics of which are still clearly to be seen The kind of civilization which the Portuguese were so surprised to find on their arrival in these waters in 1408 was predominantly Arab (though with a strong Persian flavour in places) and Mohammedan

The Portuguese were only interested in these settlements as stopping places on the road to India and the far east and it was essential for their purposes that the "Moors," as they called them, should acknowledge the suzeranty of Portugal The history of the coast in the 14th and 15th centuries is one long account of rebellion, bloody repression and further rebellion on the part of first one and then another of the petty coastal kingdoms. When they invoked the aid of the Omani Arabs the end of Portuguese domination was hastened, and after 1727, when the Arabs took Mombass, the Portuguese retired to the south of what is now Tanganyika and never again recovered their power over the Azanian coast. During their 200 years "rule they had made little or no altempt to colonize (in the modern acceptance of the term) or to explore the interior.

It was not until the imam of Museat, Seyyid Said bin Sultan, moved his capital to Zanzabri in 1828 and encouraged his Omani Arabs to journey into the interior that anything further was known of it. Seyyid Said was a remarkable man, who realized the strategic position of Zanzibra and whose deliberate policy it was to encourage trade and to build up his little island as the entrepôt of East Africa. He introduced the clove to the islands of Zanzibra and Pemba and today they produce the great bulk of the world's supply. Less to his credit was his encouragement of the save trade in the interior. Arabs, financed by Indian traders from Cutch, Gnijarat and other places on the west side of India, penetated further and further into the hinterland and brought back,

Antelope of numerous varieties occur, including impala, Thomson's as well as slaves and ivory, stories of the vast lakes far in the

These stories teached the ears of the first missionaries at Mombass, and J. L. Krapf and J. Rebmann compuled from them their stories and the properties of the stories of the stories and the stories of

Then came the Germans, including Franz Stuhlmann and O Baumann, but in particular Karl Peters In 1884 Peters founded the Union for German Colonization and later that year set off for East Africa, journeyed inland from Bagamoyo, and concluded various treaties with chiefs in the interior. In Feb. 1885 he obtained an imperial charter of protection. In 1886 a joint commission consisting of Great Britain, France and Germany defined the extent of the sultan's dominions as a ten-mile strip along the coast in addition to the islands of Zanzibar, Pemba and Mafia Germany's sphere of interest over a large part of the interior was recognized Its attempt to occupy the country was, however, bitterly opposed by the Arabs, and fighting occurred at many places on the coast On Jan r, 1891, a protectorate was proclaimed and the country was thenceforward administered by the imperial German government. But for many years the history of German rule was one of almost incessant bloodshed, the Chagga, the Nyamwezi, the Gogo, the Hehe and other tribes having in turn to be suppressed. Probably the most serious and widespread of all the uprisings was that in 1905-06 of the tribes between Lake Nyasa and the sea, known as the Mau Mai rebellion.

The Germans were thus faced with a difficult problem of admistration, and it was not surprising that in attempting to solve it they took steps to reduce the power of the chiefs, in many places removing them altogether and replacing them by haufts or abidos, usually of Arab or Swahil extraction and alien to the area. The Germans devoted much time, money and energy to the development of plantation agriculture, introducing such trops as susal, rubber, ice and cinchon, and experimenting with many others They built two railways, the Tanga line from Tanga to Moshi, and the Central line from Dar es Salam to Kigoma

World War I set back the developing economy of the country considerably For more than four years the German forces, under the skilled and daring leadership of General von Lettow-Vorbeck, defied the numerous British, Belgian and other Allide columns gathered to defieat them. The linabitants suffered from the passage through the country of large bodies of troops and in particular from the demands of both sides for porters.

On Jan. 31, 1920, a royal commussion was issued, appointing Sir Horace Byatt administrator of German East Africa—soon to be renamed the Tanganyika Territory and entrusted to Great Britain as a mandate Belgium assumed a mandate at the same time over the provinces of Ruanda and Urundi.

The necessary reconstruction after the upheaval caused by the war was taken in hand, but with the limited resources available proceeded slowly. In April 1935 Str Donald Cameron was appointed governor and soon after his arrival set to work to establish in Tanganyika the system of indirect rule which had proved so successful in Nigeria.

The authority of the chiefs was revived, native treasuries were set up, and native courts established in which the local customary law was administered. At the same time considerable economic advances were made, a railway was built from Tahora to Myanza and the Tanga line extended to Arusha, roads were improved, and considerable attention devoted to the production of economic crops by the local inhabitants. A legislative council was established in 1926, World War II again retailed development greatly, and the necessity to devote the country's resources to the furtherance of the war effort meant that social and other services suffered in consequence. The territory received 5,000 Polish refugees and 5,000 Ralians as part of its war effort and housed them in special camps Through the country, along the Great North road, passed the motorized convoys proceeding from South Africa to the middle east. Africans from Tanganyika served in the forces, mostly in the 6th battalon of the King's African Rifles and in the battalions formed from it, and a small Tanganyika Naval Volunteer force was also formed.

In 1946 a ten-year development and welfate plan was drawn up and a separate development budget prepared. Consideable progress was made with the implementation of the plan, later replaced by another which covered the years 1950–56. The failure of the groundnut scheme dumng 1947–21 was a butter disappointment to those who had sought to utilize the wide open speces of Tanganyika for the production of falts but they had barguined without the conditions of soil, weather and transport obtaining in the marginal areas chosen and had badly miscalculated the value and reliability of machinery on such land. The scheme was converted into one of large-scale agricultural research and experiment in these marginal areas.

Alongaste development in the economic sphere considerable progress was being made in local government. The accent was no longes so much on reinforcing the authority of the chief or other native authority as on broadening the basis of rule by the gradual introduction of more representative arrangements, especially by the establishment of councils on which commoners as well as the traditional rulers held places. Advances in this sphere were notable in some areas and among certain of the more progressave tribes.

In 1949 a committee was set up to review the constitutional structure in the territory and make representations for future constitutional developments. The most important recommendation was that proposing parity of representation in the legislative council for the tree many groups—Europeans, Aanan and Africans This recommendation was accepted by the British government for immlementation at a later date.

# POPULATION

The total census of 1048 showed that the numbers of the three main groups were as follows: Africans 7,332,539, Asians 59,512; Europeans 10.648. The 1952 partial census showed that the Asians had increased to nearly 80,000 and the Europeans to nearly 18,coo. The African population was not counted in 1952, but it was calculated that several of the large tribes were increasing at the rate of about 2% per annum and that in 1953 the total was about 8.000.000. About 120 tribes are generally recognized, but research may show that this number should be increased The great majority of them are Bantu but there has been a considerable intrusion of Hamitic influences with some Nilo-Hamites and, in one area, Nilotes. The Masai, perhaps the best-known outside Tanganvika of its many tribes, are Nilo-Hamitic in origin and have retamed almost unimpaired the characteristics peculiar to their race. In the south there have been intrusions of Zulu (Angoni) people, and traces of their influence remain, not only in the Southern province, but in isolated areas as far north as Lake Victoria.

The largest tribes are the Sukuma, numbering nearly 1,000,000, buding in the Lake province; the Nyamwea, numbering nearly 4,00,000, and the Ha, numbering nearly 3,00,000, both of whom live in the Western province; the Makonde, also numbering nearly 3,00,000, living in the Suthern province; the Gogo, numbering about 27,000, living in the Guttal province; the Haya, numbering about 27,000, living in the Bukoba district of the Lake province, and the Chaga, numbering about 25,000 and living on the slopes of Mt. Killmanjaro. Other tribes, with numbers varying between 15,000 and 20,000 are the Hele, Nyahyus, Nyaturu, Luguru, Zaramo, Iramba and Bena, Tribes of special ethnological interest are the Mubul (Tarpey) whose langues has so far defeated all attempts at classification, the Sandawi, who speak a "click" language allied to that sooken by the Hottentets of South

Africa, and certain aboriginal tribes such as the Hadzapi (or Tindiga) of the Lake Eyasi area, and the Kiko oi Nyahoza, who live in the Malagarasi swamps

The Arabi were the first non-Africans to settle in the country and although in 1952 they numbered only 13,000 in the past they exerted a very great influence, especially on the coastal area, where the Lingua franca, Swahili, developed from intercourse between them and the local people, and where the great majority of the population is Mohammedan. Indian influence has been more recent, although there have been Indian traders for several generations in some of the coastal lowns. They are nearly all engaged in commerce or trade, most of the retail trade and a considerable amount of the wholesale trade being in their hands. They are also to be found as clerks, artisans and skilled workers in a great variety of occupations. The 1952 census showed that, of the Asian population, 1,1,000 were Hindus, 30,000 Mohammedans, 3,000 Sikhs and 3,000 Gons and 3,000

The vast bulk of the African population is pagan, but in 1952 there were thought to be about 1,500,000 Mohammedans and about 1,200,000 Christians Twenty different Christian missions operate in the territory.

Chief Towns.—The principal seaports of Tanganyika are Dare Salaam (pop 100,000 and Tanga (22,100). Mtwara, lyng near the Portuguese border, is an entirely new port with deepwater berths and is espected to become a town of considerable importance with the development of the Southern province. Other ports are Pangani (2,400), Bagamoyo (3,700), once famous as the starting point of most of the early expeditions into the in-

terior, Kilwa (2,00), Lindi (10,800) and Mikindani (6,300). The chief inland towns are, Moregoro (1,400), Kilosa (3,100), Dodoma (13,800), Tabora (14,000), Kigoma (1,600), all on the Central line, Korogwe (3,000), Mobil (3,000) and Arusha (7,700) on the Tanga line; Mwanza (13,800) and Bukoba (3,600) on Lake-Victoria; Timga (3,000) and Mebya (5,500) in the Southern Highlands province. Ujiji, near Kigoma, has a population, almost wholly African, of nearly 10,000.

Education .- In the early days education was largely in the hands of the missionary societies, but beginning about 1024 the government increased the services provided, and in 1952 nearly £1,000,000 in a budget of £14,000,000 was spent on education There are European, Asian and Goan education authorities who are responsible for the organization of education for their respective communities, for the maintenance of schools, and for the control and management of funds A ten-year plan for education was drawn up in 1947 and was revised as circumstances and requirements altered. Many of the voluntary agencies and private schools receive grants-in-aid from government. Teacher training colleges are situated at suitable centres throughout the territory. Higher education is provided at Makerere college, Uganda There is a trade school at Ifunda near Iringa in the Southern Highlands province and in 1953 a technical college was being built in Nairobi. There is also a natural resources school at Tengeru near Arusha in the Northern province

In 1932 about 250,000 children were attending primary schools and 17,500 attending middle and secondary schools. Fifty-three Tanganyika Africans were attending courses at Makeiere college in 1952. Adult and community education has received special attention in recent years and a separate department of government (the social development department) has been set up to deal with these matters.

# ADMINISTRATION

The bases of the administration of the territory are the trusteship agreement approved by the general assembly of the United Nations at New York on Dec 13, 1946, and varnous orders in council. In practice the system does not differ greatly from that in neighbouring British dependences, the country being administtered by a governor who is assisted by an executive council consisting of official and unofficial members. The laws of the territory are enacted by the governor with the advise and consent of a legislative council, on which again there are both official and unofficial members, the officials being in a majority.

The governor is a member of the East Africa high commission. an interterritorial body with legislative and other powers, which administers certain services common to Kenya, Uganda and Tan-

ganyika, such as posts and telegraphs, railways and harbours There is a high court, with other courts (in particular the district courts) subordinate to it, and there is a system of local or

native courts administering local customary law

Local government in rural areas is in the hands of native authorities, consisting of councils on which, as a rule, traditional chiefs and commoners are both represented. There are 30 towrships and one municipality (Dar es Salaam) The membership of jownship authorities varies but usually consists of the district commissioner as chairman, a number of officials such as a medical officer and a representative of the public works department, and a number of unofficial persons of the various races concerned, who are usually in a majority

### ECONOMICS

Resources, Production and Trade.—Before the advent of the European, Tanganvika's principal products were ivory and slaves The Germans made great efforts to establish various plantation industries, principally and most noticeaply sisal, but also coffee, tea, cinchona, rubber and cotton. Under British administration more attention was paid officially to the development of economic crops by the indigenous inhabitants and the result has been that the bulk of the cotton, maize, rice, groundnuts and simsim is produced by Africans, who are also responsible for most of the production of hides and skins, clarified butter, beeswax and honey, and for a large percentage of the coffee production. At the same time, the sisal industry-the premier industry in the country-was built up, largely by non-African enterprise, until it occupies its present position, Tanganyika being the world's biggest exporter of sısal.

There is an important livestock industry, the stock population being estimated at approximately 6,000,000 head of cattle and about the same number of sheep and goats. Pigs are kept in a few areas. Meat in various forms is canned at a large factory near Dar es Salaam The clarified butter industry produced 40,233 tins (of 36 lb) in 1952, and hides and skins to the value of £688,421 were exported in that year.

The country is primarily an agricultural one, but the mining industry has grown steadily until, in 1952, exports of minerals amounted to £6,230,000 or 13 2% of total exports. The principal minerals making up this percentage were diamonds, gold, tin, salt, mica, kaolin, lead concentrates, tungsten concentrates, magnesite, copper, lime and graphite Williamson's diamond mine at Mwadui near Shinyanga in the Lake province is potentially one of the richest in the world and was largely responsible for the rise in the value of diamonds exported to £4,600,000 in 1952. The area to the east of Lake Tanganyika, in the Mpanda region,

is proving to be highly mineralized. A branch railway line has been constructed to reach it and a considerable production of silver-lead (galena) and other minerals is expected.

Forest products do not occupy a prominent part in the territory's economy, accounting for only 1.2% of exports (£566,822) in

Total exports in 1952 amounted to £47,019,948, of which £27,-439,006 was to the British Commonwealth, the United Kingdom accounting for £19,673,945: trade with other countries amounted to £19,567,437 of which the U.S.A. accounted for £9,955,872. Total imports were valued at £37,494,783, £25,399,053 worth from the British Commonwealth, of which £17,669,801 was from the United Kingdom Imports from foreign countries were valued at £11,430,497, the U S.A. accounting for £1,647,194.

Trade figures for 1951 were: imports £31,642,000; exports £41,-497,000. In 1939 the corresponding figures were: imports £3,275,-004; exports £4,264,838. The chief imports are textiles of all kinds, especially cotton piece goods, machinery (including agricultural machinery), food products, beverages, tobacco, chemicals, clothing, base metals and manufactured goods of all kinds. These imports come mainly from the United Kingdom, India, Japan, Kenya and Uganda, South Africa, the United States, Ger-

many and the Benelux countries The principal exports, in older of value, in 1952, were sisal, coffee, cotton, diamonds, gold, oil seeds, hides and skins, and meat

and meat products The principal countries of destination of these exports were the United Kingdom, the United States, Australia and Germany. The main items of revenue are customs and excise, licences; various taxes such as the native house and poll tax, the non-native

poll tax and income tax, fees, rents and royalties, and various other miscellaneous sources.

Communications.-One of the great handicaps has been the lack of adequate means of communication over such a vast countiy The Germans built two railway lines, the Central line from Dar es Salaam to Kigoma on Lake Tanganyika (773 mi) and the Tanga line from Tanga to Moshi (219 mi.) Under Bitish administration a branch line was constructed from Tabora to Mwanza on Lake Victoria (238 mi ) and another from Kaliua to Mpanda (131 mi.), the Tanga line extended to Arusha (54 mi ), and a new line built in the Southern province from Mtwara to Lumusule Juu (205 mi ). The Central and Tanga lines are linked by a road between Morogoro and Korogwe. There is a hik with the Kenya system at Voi The possibility of a link with the Rhodesian system has been examined On Lakes Victoria and Tanganyika there are regular steamship services linking the main ports

A large program of road works was begun in 1949, and it was expected that when completed this would give the territory four north-south main roads of good standard and also four main eastwest roads, it would open up road communication with the capital and put an end to the situation wherein, during the rains, Dai es Salaam was cut off from the rest of the country by road. In addition to the main roads there are some 14,000 mi of secondary roads of varying standards, but many with good gravel surfaces

Local air communications are largely the concern of the East African Airways corporation, which is subsidized by the East African governments and which provides regular services between the more important towns and with the neighbouring territories Communications with the Congo are provided by Sabena an lines and there is air communication with the rest of the world by such air lines as the British Overseas Airways corporation, South Aftican airways, Central African airways, as well as by other lines through Nairobi

The Tanganyika government has two aeroplanes of its own. which are used for survey work and for cross-country journeys by its officials. The country is unusually well supplied with aerodiomes and landing strips.

There is telegraphic and telephonic communication between the

main towns and Dar es Salaam, and a radio telephone service to most parts of the world. Some remote stations, to which there is no telegraphic service, are served by post office radio stations. The territory is well served by shipping lines, no less than 15

operating regular services to and from Dar es Salaam.

1935—); Annual Reports on Tanganyika to the United Nations (Lake Success). For a full bibliography see Handbook of Tanganyika (London, 1954). There is a considerable German literature, especially H. Meyer, Dav Deutsche Kolondinietich, 2 vol. (Leping and Vienna, 1950) which contains a bibliography.

"ANC-MYNIKA, LAKE, which gives its name to the British trust territory of Tanganyika, is situated in East Africa. It is the least through the contains a bibliography.

longest freshwater lake in the world (420 mi.) and the second deepest (4,708 ft.) but is comparatively narrow, varying in width from 15 mi, to 50 mi. It covers an area of about 12,700 sq.mi. and forms the boundary between Tanganyika and the Belgian Congo. It occupies the southern end of the western arm of the Great Rift valley and for most of its length the land rises steeply on both sides from its shores. Although its waters are drinkable, they tend to be slightly brackish

The lake was first visited in 1858 by R. F. Burton and J II. Speke, who reached Ujiji, the place where in 1871 H. M. Stanley "flound" David Livingstone. The southern half was first circum-lavagated by V L. Cameron in 1874, when the Lukuga outlet was discovered, and the whole lake was surveyed by Stanley in 1876. The lake is fed by a number of rivers but is not the centre of an extensive dranage area.

The largest river is the Malagarasi, which rises to the north of Kugoma and describes a huge arc before discharging into the lake only some 50 mi due south of its source. Others are the Russisi (Ruzza), which carnes the overflow from Lake Kivu, and the Kalambo, on which is situated one of the highest waterfalls in the

world (over 700 ft )

The lake is stuated on the dividing line between the floral regions of east and west Africa, and the oil-palm, so characteristic of the latter, is found on its shores. Rice is grown in suitable areas on the lake littotal. An agreement was being negotiated in 1953 with the Belgian authorities to stabilize the level of the lake. Fishing for dagaa, a small fish not unlike whitebalt, is carried on by African shstermen in diagrout cances at night by the light of flares, and dired fish valued at over £125,000 was exported to the Congo in 1951.

Hippopotam and crocodiles abound m the waters of the lake, and n places the rare west Afracan sharp-mouted crocodile, erocodilus cataphractus, occurs. The butd lite is most varued, because of the lake's situation between the east and west Afracan regions. The mountains north and south of Kigoma are the only places in Tanganyuka where the chimpanzee is to be found

There had been considerable traffic across the lake before the arrival of the European, but this had nearly all been from west to east, so that many of the numerous tribes now living on its eastern borders trace their origins to areas in the Congo They are predominantly Bantu, with traces of Hamitic (Tusi) millioned in the north and of Zulu (Angony) in the south. The areas of both sides of the lake suffered heavily in the past from the depredations of slave traders.

The chef (towns on the lake are Usumbura, Uvrza, Albertville (all Belqua), Kgoma, Ujij, Karena, Mtakuja, Kpuh, Mpulungu (all Brutsh). Both British and Belgaan steamers ply on the lake traversing its length in about four days. Communications across the lake are from Kigoma, the terminus of the railway line from Dar es Saham, to Albertville, whence there is a rail link to the Lualash river.

Binilomatrix — Accounts of the discovery and early exploration of lake Tanganyida are to be found in the works of such explorers as Sr R F. Burton, David Livingstone, V L. Cameron, H. M. Stanley, K. Cameron, L. Cameron, H. M. Stanley, M. Cameron, C. Lappig, and V. Stanley, M. Stanley, M. Cameron, C. Lappig, and V. Stanley, M. H. Schner, C. Cameron, C. Lappig, and V. Lappig, and

T'ANG DYNASTIES: see China: History; Chinese

PAINTING; CHINESE SCULPTURE.

TANGENT: 588 GEOMETRY; TRIGONOMETRY.

TANGENTIAL CO-ORDINATES: see CO-ORDINATES.
TANGERINE, a small thm-skinned type of orange belonging to mandarin orange species (Citrus retuculata). The principal distinguishing characteristic of the tangerine in comparison with the rest of the mandarin species is deeper orange yellow colour

of the peel of the tangerine. (See Orange.)

TANGERMUNDE, a town in the Prussian province of Savony, Germany, on the Elbe, 43 mi. N.E. from Magdeburg by rail. Pop. (1939) 13,790.

Tangermunde has iron foundries, shipbuilding yards, refineries, and other industrial establishments, and enjoys a considerable river trade in grain and leather. It has numerous brick buildings of the 14th and 15th centuries.

The castle, built in the 14th century, was the residence of the margraves of Brandenburg.

margraves of brandenourg

TANGIER (locally TANJA), is a seaport of Morocco, on the Strait of Gibraltar, about 7 mi. E. of Cape Spartel, between two

eminences at the northwest extremity of a spacious bay.

As seen from the sea, the town rises gradually in the form of an amphitheatire, with the citadel, the remainder of the English mole and York castle to the right, the commercial quarter in the central valley, and the road to Tetuan running along the beach to the left. The main thoroughfare leads from Bab el Maiss (Gate of the Wort) to the Bab el Suk (Gate of the Market piace) known to the English as Catherine Gate. New European quarters have been built, to the north of Tanger (the Marchan quarter) to the west (on the 'Mountain') and to the south (quarter the beach good in all weather except during a strong east wond, but large vessels have to anchor about a mile out. A deep-water harbour was begin in 1025 but was far from complete in 1045.

The population of the city was 79,886 in 1940, of which 50,250 were Moslems, 7,100 Jews, 15,486 Spanish, 1,642 French, 1,389 English and 4,017 others, in 1947 the total was estimated as 104,000 The trade of Tangier amounted to 106,074,116 fr in 1936 (imports 94,693,880 fr, cyports 11,380,986 fr.) but decreased considerably during World War II. After 1945 however, Tangier's financial postion, as the only free money market, was extemply good, and it was one of the few administrations with a large budget surplis

History to 1923.—The ancient Tingis stood very near the modern site of Tangier Under Augustus i became a free city of the Roman empire, and when Otho placed the western half of Mauretana under a procurator, he called it Mauretana Tingian It was held successively by Vandals, Byzantines and Alabs, and when Mulai Idins passed from Tiempen to Fee in 798, Tangier was "the oldest and most beautiful city" of the Maghrib After many futle attempts the Portugues obtained possession of it in 1471, it passed with Portugal to Span in 1580, returning to the independent Portugues in 1656

In 1652, as part of the downy of Catherme of Braganza on her marrange to Charles II, it came unto the possession of the Englanhy, who defended it against Mulai Ismail in 1680 but in 1684 decided, on account of expense, to abandon it to the Moors The sulfans made Tangier the seat of foreign representation, to keep Fee free from extraneous influences, and captuilatory rights were granted to western nations (1630–1880) as well as certain powers of samtary control.

A special regime for Tangier, growing out of the interest of Great Britann in the Straits of Gibralbar, was envisaged in the Moroccan arrangement of 1994 between Britann and France on the one hand and France and Spain on the other, and in the Algeciras act (1906) Tangier's international character was fully recognized. The principle was reiterated in the protectorate convention of 1912 and in the France-Spains convention of the same year.

In 1913 Great Britain, France and Spain began negotiations to create a "Tangier zone" with an international regime When, however, World War I broke out Spain withdrew, apparently in the hope of acquiring Tangier for itself.

The Statute of 1923.—It was not until 1923 that Tangier's status was at last regulated Though France's position in Morocco had become stronger, Britain was still determined on an international form of government; and Spain supported this demand,

Negotiations culminated in the statute of Tanger, which remained in force down to 1940. It was signed by Britain and France in 1933 and by Spain in 1944. All states signatory to the Algedras act (except the Central Powers and Russa) were immediately invited to adhere to it, and all did so except Italy and the ILS.A

The statute was declared valid for 12 years from the date of ratification (1924), with automatic renewal for further like periods unless a contracting party demanded revision at least six months before expiry. Its main provisions were as follows.

1. The Tanger zone was to be permanently neutralized, though roops proceeding to or from the French or Spanish zone of Morocco might cross the territory after notification to the administrator. A police force, not exceeding 250 Moroccans, under a Belgian officer with French and Spanish subordinates, was to be at the disposal of the administrator.

- 2 Native administration and control over all Moslem institutions was to be entrusted to a mendoub representing the sultan.
- 3 A legislative assembly of a6 members was to be instituted, consisting of 17 Europeans (four French, four Spanish, those British, two Itahan, one American, one Belgian, one Dutch and one Portuguese, nominated by their respective consuls) and 6 Moslem and 3 Jewish subjects of the sultan (nominated by the mendoub)
- 4 A committee of control, composed of the consuls of powers signatory to the Algeciras act (former enemy countries excluded), was given a power of veto over the enactments of the legislature and charged with ensuing observance of the statute
- 5 An administrator-general, head of the executive, and two asstant administrators for health and finance, were to be appointed for an initial period of six years by the sultan at the instance of the committee of control, these were to be of French, Spanish and British autonably respectively. Appointments after this were to be assigned by the assembly to nationals of the signatories of the Algerizas act.
- 6 An international mixed court was to administer justice in all matters affecting foreigners. It was to consist of one French, one Spanish, and two British judges, with a Frenchman and a Spaniard as public prosecutors for crammal and civil matters (all capitulatory rights were therefore abolished, save in the case of Italy and the US A).
- 7 A port commission was also established, consisting of one member of the sultan's government, one of the legislative assembly, one of the committee of control.

The statute was clearly a compromise between the conflicting ambitions of France and Spain to incorporate Tangier in their respective zones and the British determination to preserve its intenational character. France secured preponderance in the administration, helped by the fact that as the international zone was a concession from the Moroccan government, itself under French protection, native and foreign affairs were virtually in French hands, Spain was allotted a secondary role

The interests of Tanger uself were in the main disregarded; the city had no say in the administration but was burdened with heavy administrative and judicial expenses and largely baulked of its natural economic interland by the fiscal policy of the French and Spanish zones. After 1933 budget deficits were chronic and were met only by unwilling contributions from the French and Spanish governments. There was also a heavy unfavourable (tade balance.

An Italian request for participation and Spanish dissatisfaction with the working of the whole system led to the revision of the statute in 1928. Italy acquired a share in the administration roughly equivalent to Britain's, se, three Italians were administed to the legislative assembly. An additional assistant administrated to the Italian nationality was appointed as director of judicial services for the remainder of the first six-year period, and an Italian magistrate was added to the mused court. Spain secured a more effective suppression of arms-smuggling and of political disturbances.

But Spain, still aspiring to incorporate Tangier in its zone, subsequently presented demands for joint control with France over the native Moslem and Jewish population; for a rotation of Frenchisen and Spaniards as chief administrators; and for posts in the customs. These demands, provever, were not favourably restricted to the customs. These demands, provever, were not favourably restricted to the customs. After an unpublished Francessan and the Spaniah civil vars. After an unpublished Francessan and a redistribution of posts had been drawn up in agg, the leg dastive assembly put forward a proposal to appoint a Spanish definition of the state of the custom of the state of

Spanish Occupation, 1940-45.—After the collapse of France and Italy's entry into World War II, Spanish troops occupied Tanger on June 14, 1940; and in Nov. 1940 the Spanish authorities incorporated it into the Spanish zone of Morocco, dissolving the

international administration and appointing the Spanish commander of the occupying forces as its governor-general, to act as

delegate of the Spanish high commissioner in Morocco
Early in 1941 Britain concluded an interim agreement with
Span, which, without prejudice to British and third-party rights
under the intensitional statute, guaranteed free entance into and
departure from Tanger to British subjects and the continued
functioning of British enterprises in the zone. Spain also formally
undertook to keep the zone demnithatrazed.

Post-War Provisional Regime.-In August 1945 a conference on Tanglei was held at Paris by representatives of Britain, France, the United States and the USSR. It was found impossible to draw up a new international statute since the USSR refused to co-operate with Gen. Franco's Spain; Britain, France and the United States, on the other hand, held that Spanish interests could not be ignored. Finally a compromise was reached. if Spain withdrew its troops at the request of the four powers, a provisional regime, based on the statute of 1923, as modified in 1928, was to be set up for six months, Spain was to be allowed to participate in this regime by having a Spanish consul on the control committee and a Spaniard sitting in the legislative assembly, the United States and the USSR, were to be invited to collaborate; and after six months had elapsed (by which time, it seemed, Franco's regime might have been overthrown), a new conference was to be held, to which all powers signatory to the Algeciras act (excluding former enemy countries) and the USSR were to be invited, to draw up a permanent international statute for Tangier USSR agreed to this arrangement only after declaring in the strongest terms reservations about Franco's regime and its intention of sending no representative to Tangier as long as Franco's Spain was allowed to take part in its administration Spain accepted the decision of the Paris conference, though protesting strongly that it had been reached without consulting Madrid, and the provisional regime came into force in Oct. 1945 Spanish troops were withdrawn; the mendoub was restored, and a Portuguese administrator, Admiral Luiz Antonio de Magalheas Correia, took over from the Spaniards

Under the Paris agreement it had been decided that the principal interested powers, France, Spain, and Britain, should no longer hold any of the most important posts in the administration, these were to be left to smaller powers, such as Belgium, the Netherlands, Portugal and Sweden. Britain renounced its former preponderant share in the administration of justice Spain retained only its membership of the control committee and the legislative assembly France renounced the right to have a Frenchman as administrator general but managed to insert clauses in the agreement which stipulated not only that a Frenchman should remain as second in command of the police but also that a new post, that of assistant administrator of Moroccan affairs, should be created for a Frenchman. Moreover, before anyone else had arrived, the French succeeded in recruiting enough officials to staff the administration and all the necessary police, and also, as under the statute of 1923, they continued to nominate the Moroccan members of the legislative assembly, while Moroccan interests in the control committee were represented only by a French consul-general.

France thus retained a preponderant share in the administration, though the influence of the United States, preserving its capitulations there as elsewhere in Morocco, made itself increasingly felt. After six months, General Franco's regime was still in power in Spain, no new conference on Tangier was called, and the provisional administration was maintrance.

A new factor in the situation after World War II was the growing dissatisfaction of the Morocans with their subordnate position. Though they had nine representatives (six Moslems and three Jews) in the legislative assembly—more than either France and Spam (four each) or Britain and the United States (three each)—they had no representative on the control commission which could veto the decisions of the assembly and was the real governing body. The sultan of Morocco, on his visit to Tangler in April 1947 (the first visit of any sultan since 1889), was said to have suggested that a new statute should be drafted in the near future granting fuller nghts to Moroccans under his authority.

1948, after signing a peace treaty with the Allies, on the invitation of France and Britain with the concurrence of all the signatories to the Algeciras act (except those excluded in 1919) and the U S .-

On March 30, 1952, the 40th anniversary of the Fez treaty which had imposed the French and Spanish protectorates on Morocco, a violent riot of the Moroccan Nationalist party took the international authorities by surprise. In June it was decided to create a motorized police corps with a Spaniard as its commander and a Frenchman as his deputy

Bibliography — E. M. G. Routh, Tangier (London, 1912); Admiralty, Handbook of Morocco, vol. 1 (London, 1941); H. M. Stationery Office, Tangier Convention and Final Protocol of Conference on Amendment (Command Papers 2203 and 3216); Royal Institute of International Affairs, Survey of International Affairs, 1925, vol. I (Oxford, 1926) and same, 1929 (1930), E Rouard de Card, Le Statut de Tanger de'après la Convention du 18 décembre 1923 (Paus, 1925); G H Stuart, The International City of Tanger (1931); C Baldom, Le Zona de Tangeri nel diritto internazionale e nel diritto Marocchino (S. E. CE.)

TANGO, a slow, graceful dance in two-four time It probably originated with the African Negroes; in 1911 it became popular in a modified form in America and subsequently in Europe. It has much in common with the Cuban habanera.

TANG SHAO-YI (1860-1938), Chinese statesman, a native of Kwangtung, the first foreign-trained Chinese to rise to high office, was one of the leaders of the Chinese nationalist movement. He was educated at Columbia university, New York city, and in 1896 became consul general in Seoul in succession to Yuan Shih-kai He organized the Tibet convention of 1906 He was appointed special envoy to the United States (1908) In 1912 he became first premier of the Chinese republic. He retired in 1923 but became a special adviser to the new nationalist government in 1927 Tang was assassinated in his home at Shanghai on

Sept 30, 1938.
TANGUAY, EVA (1878-1947), U.S vaudeville and musical comedy star, who was born in Marbleton, Que, Can., went to the US with her paients at an early age. An expressive child, she showed a talent for acting and obtained her first footlight role at the age of eight in Little Lord Fauntleroy. She later went "through the mill," acting in variety, stock troupes and musical comedies, and by the time she was 20 she was regarded as a finished comedienne At the turn of the century, Miss Tanguay shocked Victorian audiences with her daring costume-or lack of costume -and her risqué songs, and by 1910 she was an established and popular star of the theatre. Her earnings were phenomenal but she lost her fortune during the stock market crash of 1929. Simultaneously her health and vision failed, hrmging her career to an abrupt end. She spent the last two decades of her life a virtual recluse, bedridden and mostly forgotten. She died at her Hollywood, Calif, cottage, Jan. 11, 1947.

TANISTRY, a custom among various Celtic tribes, by which the king or chief of the clan was chosen from among the heads of the septs and elected by them in full assembly. He held office for life and was required by custom to be of full age, in possession of all his faculties and without any remarkable blemish of mind or body. At the same time and subject to the same conditions, a "tanist" or next heir to the chieftaincy was elected, who, if the king died or became disqualified, at once became king. Usually the king's son became tanist, but not because the system of primogeniture was in any way recognized; indeed, the only principle adopted was that the dignity of chieftainship should descend to the eldest and most worthy of the same blood. Tanistry was abolished by a legal decision in the reign of James I and the English land system substituted. See Bremon Laws.

TANJORE, a city and district of India in the Madras presidency. The city is situated on the right bank of the river Cauvery, and is an important junction on the South Indian railway, 218 mi S. of Madras. Pop. (1941) 68,702. As the last capital of the ancient Hindu dynasty of the Cholas, and in all ages one of the chief political, literary and religious centres of the south, the city is full of interesting associations. It was the scene of the earliest

Italy was readmitted to the committee of control in March labours of Protestant missionaries in India. The modern history of Tanjore begins with its conquest by the Mahrattas in 1674 The British first came into contact with Tanjore by their expedition in 1740 with a view to the restoration of a deposed raja In this they failed, and a subsequent expedition was bought off The Mahrattas practically held Tanjore until 1700, when the district was ceded to the East India company The raja retained only the capital and a small tract of country round. He died in 1833 and was succeeded by his son Sivaji, on whose death in 1855 without an heir the house became extinct. Among buildings may be mentioned the palace within the fort, and the great temple of the 11th century, enclosed in two courts, surmounted by a lofty tower and including the exquisitely decorated shrine of Subrahmanya. The city is famous for its silk brocade, jewellery, carnets, inlaid copperwork, modelling in pith, etc.

The DISTRICT OF TANJORE has an area of 3,738 sq mi. It is irrigated by an elaborate system of dams, cuts and canals and the soil is exceedingly productive The delta of the Cauvery occupies the flat northern part, which is highly cultivated, dotted over with groves of coconut trees and densely populated The staple crop is rice, grown on about five-sevenths of the cultivated area, and rice milling has also developed. Soap and mats are made and fishing carried on The district is traversed by the main line and several branches of the South Indian railway. The chief seaport is Negapatam. The population of the district in 1941 was 2,563,375 See Tanjore District Gazetteer (Madras, 1906).

TANKARD, a type of drinking vessel. The word was formerly used loosely of many sizes, usually large, of vessels for holding liquids; thus, it was applied to such as held two or more gallons and were used to carry water from the conduits in London in the 16th and early 17th centuries The word is now generally applied to a plain, flat-bottomed drinking vessel of silver, pewter or other metal, or of glass or pottery mounted on metal, with a hinged cover and handle, holding from a pint to a quart of liquor (See DRINKING VESSELS ) The derivation is obscure. It appears in O Fr as tanquart It may have been metathesized from Gr. κάνθαρος, Lat cantharus, a large vessel or pot

TANKS are self-propelled combat vehicles embodying the military characteristics of fire power, mobility, crew protection and shock action.

### PREDECESSORS

The modern military tank is a direct outgrowth of World War I. but the idea underlying its development-protected, mobile striking power-had been used throughout the history of warfare The Assyrian war chariots of about 3000 BC, the armoured elephants of Kublai Khan and the Chinese armoured "war carts" of the 12th century BC, represented early exploitations of this idea. A later predecessor of the tank was the mediaeval knight, who with his horse and armour ruled the battlefield from the 5th century to the 15th century AD. The introduction of gunpowder ended the knight's supremacy and spurred the development of various types of battle carts, heavily armed and usually providing protection for the combatants they transported and the men or horses used to propel them Conrad Keyser's horse-drawn battle car (1395) was an early example. Roberto Valturio in 1472 suggested wind as a motive power. Both Leonardo da Vinci (1482) and Holzschuher (1558) described battle vehicles of the period and set forth tactics for their employment which are remarkably prophetic of modern tank tactics.

The modern amphibious tank was presaged in an armed and armoured wooden vessel propelled by hand-rotated paddle wheels, described in 1588 by Agostino Ramelli. By 1599 Simon Stevinus had built two small "land ships"-armed sailing vessels on wheels. During the 17th century the most successful designs utilized horses protected within the structure, while as late as 1755 there was another unsuccessful attempt to use wind propulsion

About 1769 a Frenchman, N. J Cugnot, produced a steampowered road vehicle, and later another to be used as an artillery tractor. Cugnot's vehicle was impractical, but it is credited with turning thinkers of his day, including Napoleon I, toward use of automobiles in war. By 1770 the Englishman R. L. Edgeworth

track so important in the evolution of the tank. With Thomas German's invention in 1801 of the first crude version of the caterpillar track, the tank was brought another long step toward actuality. William Palmer in 1812 and John Barry in 1821 experimented with similar devices, and in 1846 Boydell designed an engine with footed wheels In 1855 James Cowen and James Sweetlong (British patent no 747) evolved a steam-propelled war vehicle, while the American Civil War brought forth in 1861 a steam tractor mounting a cannon and bulletproof cone for the cannoneers' protection, invented by Chailes S. Dickinson

During the remainder of the 10th century there appeared several innovations which were to prove significant in the development of the tank About 1862 a vehicle was built to mount a cannon in a turret capable of all-around traverse, in 1882 the endless track was improved by lengthening the rails to equal the distance between the axles of the vehicle, in 1886 the Applegarth tractor used a track the forward portion of which inclined upward, facilitating climbing and traversing obstacles, and in 1887 the Batter tractor employed a double track like those later used in World Wai I vehicles.

Gottlieb Daimler's invention of the internal-combustion engine in 1886 opened the way for the first really practical self-propelled fighting vehicles While interest in tracklaying vehicles and improvements in their design continued in England and the United States during this period, the perfection of a reasonably efficient internal-combustion engine stimulated experiments in both these countries and in Europe, with various types of armoured automobiles F. R Simms of England is credited with building the first automobile designed for combat purposes, it was a light four-wheeled motorcycle mounting a Maxim machine gun and an armour shield, and appeared in 1898

In the same year a US army officer, R P Davidson, designed a three-wheeled automobile similarly armed and armouned, built by the Duryea company of Peoria, Ili Davidson experimented also with steam-driven combat cars, as did the Russian engineer Lutski and the English during the Boer War. In 1000 the first true English armoured car, gasoline-powered, appeared Called the Pennington, it had a 16-h p. engine and o 25-in. skirt armour, and carried two Maxim guns protected with shields In 1901 the French firm of Charron, Girardot and Voigt built a military automobile with very similar characteristics. In 1904 this firm, on order from the Russian war office, built the first armoured automobile embodying the same general design and appearance as later equipment of this kind. Weighing 3 2 tons, it carried o 23-in armour and a Hotchkiss 79-mm machine gun in a revolving turret; it utilized a 30-h p engine and was pneumatic-tired. In the same year the Austro-Daimler firm in Wiener-Neustadt built an armoured car which interested the German general staff and was demonstrated on manoeuvres in 1905 and 1906. Advanced for its day, this car carried o 12- and o 15-in. armour, weighed 3 3 tons and was powered with a Daimler 35-h.p. engine Its maximum speed was 28 m p h, and its radius of action 155 mi.

About this time Sir W G. Armstrong, Whitworth and Company, Ltd, in England built a semiarmoured car armed with a shielded one-pounder pom-pom Utilizing solid rubber tires, it was powered by a 40-h.p engine and carried a light steel cable to be used with power take-off pulleys on either side of the hull, for pulling itself out of difficult spots. Its designer was the same Walter G Wilson who later was prominent in design and production of English tanks during World War I.

With the attention given the dirigible balloon after the turn of the century, as a reconnaissance instrument, it was only natural that an antiballoon armoured car such as the German Ehrhardtwagen should appear. Though lightly armoured, it weighed 3 5 tons, was powered with a 50- to 60-h p. engine, and had a speed of 20 m p.h. In 1900 and 1910 Davidson in the United States was adapting unarmoured Cadillac automobiles for this same purpose. His "balloon-destroyers" mounted Colt automatic guns.

Meanwhile, the sultan of Turkey had displayed interest in armoured cars and in 1909 had purchased four such cars built by the French Hotchkiss company. These are interesting primarily

had produced the "footed wheel," a foretunner of the caterpillar for their relatively powerful engine (60 hp), their top speed of 60 mph and for the Hotchkiss 79-mm machine gun they mounted In 1910 an amphibious fighting vehicle was designed by a Swiss, Col Schleyer It utilized a 20-hp rear-mounted engine and a screw propeller, and carried a single machine gun. This novel device earned no more encouragement for its creator than did the design of Austrian army officer Gunther Burstyn for an excellent tracklaying combat vehicle, submitted to the Austrian war ministry in 1911 Significant because this vehicle, if adopted, would have given the Austrians and the Germans the first actual tank, Burstyn's proposal was received coolly by both governments

The Burstyn Motorgeschutz was superior in many respects to the early British and French tanks of World War I silhouette vehicle, it used cable-type tracks with spring suspension, mounted a small rapid-fire gun, and was designed for a crew of three or four men It was expected to have a speed of 18 mph on roads and about 5 mph. maximum cross-country. For aid in crossing obstacles, it had four wheels on extension arms which could be raised or lowered, the rear pair being driven while the front pair, which were not, could be used in steering.

In 1912 the first Italian armoured vehicle, built by Isotta Fraschini, appeared This machine carried one rapid-fire gun in a revolving turret, it saw action in Africa during the Italo-Turkish War in 1912 An improved Italian car, the Bianchi, later incoiporated features derived from this experience. The Bianchi weighed 3 4 tons, carried a crew of three or four, and mounted two Fiat machine guns, one in a revolving turret and one in the rear of the hull This car was used considerably during World War I, and later in Italy and Hungary until 1930 In 1913 Russia entered the field with a four-wheeled pneumatic-tired armoured car carrying three Maxim guns.

By 1914 the French were using in their armoured vehicles for the first time a weapon heavier than a machine gun. The Renault car, and two models of the Peugeot car, all built in that year, each mounted 37-mm. guns The Peugeot cars were relatively heavy, weighing 5.5 tons, and carried 0.217-in armour, yet they still were capable of speeds as great as 25 mp h. The Peugeot car included an additional set of controls in the real which permitted driving backward

During the years immediately prior to World War I, the tacticians of the major powers which were to engage in that struggle seem not to have envisioned the part such a combat vehicle could play. The Germans expected a quick victory without the aid of such contrivances. Lieut Fhecz of the French army and Gen (then Capt.) J. F. C. Fuller of the British army, as late as 1913 and 1914, respectively, predicted the machine gun would bring about static trench warfare, and suggested greater emphasis on means for overcoming it. But it was not until the soundness of their ideas was clearly demonstrated along the Aisne in 1914 that serious attention was given to armoured, trench-spanning vehicles.

## WORLD WAR I TANKS

In Oct. 1914 E D. Swinton of the British aimy suggested adapting the American Holt caterpillar system to an armoured car. One month later a fellow British officer, T. G Tulloch, submitted ideas for a "land cruiser" capable of dealing with light enemy fieldpieces. In Jan. 1915 Winston Churchill, then first lord of the admiralty, endorsed these proposals in a now famous letter to Prime Minister H. H. Asquith. By June 1915 trials were held of a 105-h.p. Foster-Daimler tractor designed to bridge trenches, and of a 125-hp. Holt tractor fitted to Tulloch's specifications. Neither was satisfactory. Work had also been done during this period on a pedrail armoured car in which Churchill was interested, but when he left the admiralty this was discontinued and efforts were turned to adaptation of Holt tractors, under Swinton's direction By Sept 1915 the first Foster company model, called "Little Wilhe," was completed but was found unsatisfactory, and its successor, "Big Willie," was begun. About this time the "cr-periments committee" of general headquarters in France submitted these specifications for a suitable "landship:"

1. It must be proof against rifle and machine gun fire (but not artillery),

2 It should carry one small cannon and at least two machine guns

3 The crew should number six, two for the cannon, one for each machine gun and two drivers.
4 It must be able to traverse craters 12 ft wide and 6 ft deep, with sloping sides, to cross barbed-wire entanglements, and to

with sloping sides, to cross barbed-wire entanglements, and to span 4-ft trenches

5 It must maintain a speed of 2½ mph. over bioken ground and carry fuel for six hours' action.

6 Its tractive elements should be either of the pedrall or caterpillar type—whicheve proved better for crossing maishy ground. Since the machines were to be used on wide fronts with infantry, the committee suggested numbers of small "landships" were preferable to a few large ones.

In late Sept 1915 a wooden model of "Big Willie" was accepted It was of it long, It it wise and 81 ft high Detachable sponsass for mounting small cannon or machine guns added three feet to its width I law as to mount two Openuder (5g mm) cannon and two machine guns, and carry a crew of one officer and nine men. Weight of 22 tons, speed of 3g mp), trench-spanning abhity of 8 ft and obstacle climbing abhity of 4g ft were specified. In December of that year the cover name "tank" was adopted to conceal the seal nature of these machines By Feb 8, 1916, the first tank had been completed and approved both by the British war office and general headquarters, and within another month too had been ordered. By mid-August the first detachment of 13 was shipped to France, to be followed by other increments during the remander of that month.

Britan Tanks—On Sept 15, 1016, the tank met its first test in the battle of the Somme, 40 of these new machines were used, apparently taking the Germans by surprise. The German and army chief of staff reported after the action "The nemmy have employed new engines of war as cruel as (they are) effective." Unforseen difficulties were experienced by the British, however, in this first action, 17 tanks bogged down or failed mechanically before reaching the line of departure, another 15 were unable to leave the line of departure at the appointed time; 5 more bogged down during the action and only of carried out their missions.

This first British model, designated the "Mark I." was produced in two types, a "male" weighing 31 tons and mounting two 6pounder and four machine guns, and a "female" weighing 30 tons, mounting six machine guns. They were 26 ft 5 in, long, 13 ft o in wide and 8 ft I in high, powered with a 105-hp Daimler water-cooled engine Maximum speed was 3 7 m p h, with a "fuel distance" of 12 mi. They could traverse obstacles 4½ ft high, span trenches II ft 6 in. wide and climb a 22° slope. They used the rigid-type suspension on rollers, with steel tracks. Armour thickness varied from 0 2 in, to 0 4 in A total of 150 Mark I tanks was built, and they were used in nine engagements, the last on Nov 1, 1917. As early as April 8, 1917, at the battle of Arras. they were reinforced with the improved Mark II, and thereafter the British tank underwent constant development, the last war model being designated the Mark V. In the latter, specific improvements included an increase in speed to 4 6 m p.h., an increase in maximum armour thickness to 0.47 in., and the substitution of a Ricardo 150-h p water-cooled engine, plus a better planetarytype transmission. In addition, the Mark V had twice the fuel distance possessed by the Mark I.

Dunng World War T the British also built a "Medium A" or "Whippet" tank weighing 15.7 tons which used a crew of only three men, and had greater speed and fuel distance than the heavy tanks; and an enlarged version of the Mark V, which was used to transport up to 25 infantrymen into battle.

French Tanks.—Though the Bruish were the first to use tanks in battle, the French had actually preceded them in experimentation in this field. The Schmeider tank was produced in quantity during 1916, about 400 of this model being used in mue actions between April 16, 1917 (Chemin-des-Dames), and Sept 26, 1918 (Argonne forest). An equal number of the St. Chamond tank was built during the same year and saw action in 11 engagements from May 5, 1917 (Laffaux mill), to Sept 26, 1918 (Champagne). During 1917-184 the Renault factory delivered about 500 of a third

type, a light, two-man tank. The Renault, first committed on May 31, 1918, was used in at least 40 battles by the end of Oct

The Schneider and the St Chamond were similar as to armsent (one 3-rmm gun and two machine guns), speed (five mules per hou), suspension (co.l spring-hogie type), and tracks (stellate type). The Schneider was lighter (14,9 tons compacted to 25 3 tons) and smaller in over-all dimensions, the difference being accounted for by the bulkner power-transmission system used in the St Chamond. This consisted of a four-cylinder 9-b p water-cooled engine with a dynamo and two electric metors, plus storage cells. In addition, the Schneider used a six-man crew, while the St Chamond Tengured nine me

The Renault was armed with a 37-mm, gun or a machine gun, possessed a speed of six miles per hour, weighed only 7 4 tons and was smaller in over-all dimensions than either of the other French tanks

German Tanks .- Though the Germans had opportunities before and during World War I to take the lead in development of the tank, their leaders refused to consider the possibility of stalemated trench warfare, and the appearance of the tank on the Allied side marked an advantage Germany was never able to overcome It was not until the capture at Cambiai (Nov 20, 1917) of a number of British tanks, that the Germans possessed any serviceable armoured vehicles of this type. The captured tanks were assembled and repaired at Charleroi, where German experts studied them, but the idea of copying them was soon abandoned Instead, reliance was placed on a model of German design which was already well along. A few of these were delivered in time to participate in the battle of St Quentin on March 21, 1918, and in five additional actions before the Armistice in November. The Germans also used a few captured specimens in various actions. but they never had tanks in numbers at all comparable to those of the Allies

The German model made during 1018 was built by the Daimler company, and was known as the "A7V" It weighed 33 tons, was powered with two Mercedes-Daimler four-cylinder engines of 150 hp. each, carried a crew of 18 men and mounted one 6-pounder gun and six machine guns Perhaps its most interesting feature was the thickness of 1ts armour, which varied from 0 59 in. to 1.18 in., and was desuged to be proof against 37-mm gunfire

U.S. Tanks.—Entry of the United States into the war found it with only a few experimental tank models, and with no definite construction program. It was not until late Dec. 1917 that the first official step was taken to create a U.S. tank force, when Gen. John J. Pershing designated Col. S. D. Rockenbach as chief of tank service for the American expeditionary force. A month later this became the tank corps of the U.S. army, a separate arm, with Col. Rockenbach still at its had. By the summer of 1917 experiments were under way with two U.S. models, one of the wheeled type, the other using caterpliar traction. Both gas-electric and steam power plants were tested in conjunction with these models, neather of which was satisfactory.

By Sept 1917 it was decided to copy British and French designs, and plans were made to build a Maik VIII talk resembling the British Mark I to Mark V tanks, and a U.S. version of the French Remault. About half (1,500) of the projected Mark VIIIs were to be joint Anglo-US, products, with England furnishing hulls, gurs and ammunition, and the United States supplying power plants and other components. An additional 1,450 Mark VIIIs of all-US construction were ordered, but none of this latter group was finished in time to see war service. After some delay in converting the specifications for the Remault tank from the metric to the English system of measurements, contracts were let for 4,400 units, parts for which were made in about 20 different plants, Final assembly for these units was done in three plants, one in Cheveland. O. and two at Daviton. O

By 1918 the U.S. tank program included two more models. One of these was the Ford three-ton tank, using a crew of two, carrying one machine gun and capable of eight-mile-per-hour speeds This tank, costing only \$4,000, was to have been produced in large quantities, but, the program was terminated by the early end of the war,

was an improved version of the Renault. It was to carry both a 37-mm gun and a machine gun and was to use a three-man crew instead of the two-man crew used in the Renault About 1,000 units of the U.S. Mark I were ordered, but none was actually delivered pilor to the armistice. While the US tank building program was attended by mefficiency, confusion and lack of coordination between various interested agencies, most of the difficulties were overcome, and at the war's end, work was completed or in progress on a total of 23,405 tanks of various types Meanwhile, U.S. tank forces had been organized and equipped with such models as were available from the Alhes The 304th US tank brigade, first to see combat action (St Milnel, Sept 12, 1918), was equipped with about 90 Renaults, 36 St Chamonds and 24 Schneiders In this action, only 25 tanks reached Nonsard ahead of the infantry, the remainder being immobilized by terrain difficulties, mechanical failures or enemy mines and gunfire US tank units participated in 7 actions during the St. Mihiel operations and 14 more during the Meuse-Argonne campaign, and in addition assisted British offensives in 7 other actions Aside from the fact that they were equipped with tanks of foreign make, U S units participated on an equal basis with the tank forces of their Allies, once they were organized and committed to action.

#### TANKS BETWEEN WORLD WARS I AND II

The two decades following World War I were a period of continuous development and improvement in the tank as an instrument of war. It became a standard weapon of most armies, and all the major powers conducted experiments with successive new designs, each searching for an ideal balance between the three conflicting requirements of mobility, armament and armoun Neither the giant tank (up to 80 tons) nor the very light tank, or tankette (3 to 8 tons), was entirely neglected, but the general trend was toward tanks of medium weight (18 to 36 tons) yielding the best all-around performance and utility. At the same time it was possible, through development of vastly improved power plants, to build tanks carrying larger and heavier armaments, with gradually increasing armour thicknesses. Speeds increased greatly (up to 45 m p h), horsepower per ton rose materially and fuel distances of 200 mi were achieved. Each of the major components of the tank underwent steady refinements Air-cooled engines were introduced, as were rubber rollers and tank treads, doublecoil springs and volute springs for suspension systems, short-wave radio communication, intercrew communication systems employing throat microphones, oil cooling systems for motors, gas filters and blowers, fans for cooling crew compartments and many other improvements contributing to the tank's reliability and effectiveness, as well as crew comfort and efficiency.

The wastly improved mobility and power of the full-tracked, armoured whiche led to experiments with this chasses for a number of special purposes, such as troop carriers, gun carriages, flame throwing and snoke laying. These were later to result in the development during World War II of a whole family of special-purpose armoured vehicles, all related to the tank, and some so similar in design as well as purpose as to make their differentiation from tanks somewhat arbitrary. The remainder of this article, however, is confined to the true tank—an armoured, self-propelled, tracklaying vehicle, possessing heavy fire power and intended, on suitable occasions, for direct assault and overrunning of defended positions

Great Britain.—The British royal tank corps, though its sensience was in doubt for a penord numediately after World War I, continued as a separate arm. It was required during this penod to operate on limited appropriations, so that through expediency at first, and later as a matter of doctrine, it tended toward the use of very small armoured vehicles, but in sufficient numbers for training. At the same time, the British continued to build more experimental tanks—susually only one specimen of each model than any other country. From 1919 to 1939 the British built more than 75 different full-tracked armoured whicles, all of which could be classified as tanks. Notable among these were the Carden Lloyd serves, light two, and three-man tanks, with several

United States.-For some years after World War I, tank development in the United States was affected even more senously by the same difficulty that retarded the British program-lack of funds Until the early 1930s, the large numbers of Renault-type light tanks and the heavy Mark VIIIs on hand were used for training, and some improvements were attempted upon them Meanwhile, the US program paralleled the British in another respect. single specimens of various experimental types were built by the ordnance department, or were bought from private builders. U.S. models during this period included a 23-ton medium tank (1922); a 75-ton light tank (1928); a 15-ton medium tank (1929); a 11.25-ton medium tank (1930), an 85-ton light tank (1931); a 15-ton medium tank (1933), a 13-ton medium tank (1933); and two light tanks (1935) weighing 9 75 and 3 tons, respectively. As World Wai II approached, the United States possessed a light infantry (or cavalry) tank and a medium infantry tank which were excellent for their day, though they existed in quantities sufficient only for very limited training. The final model of the light tank (which was essentially the same in both cavalry and infantry versions) had a turret of rounded plate with welded construction, mounted a 37-mm gun with coaxial machine gun, a machine gun in the bow and a third machine gun outside the turret as an antiaircraft weapon Fourteen feet 10 in. long, 7 ft 4 in. wide and 7 ft 6 in high, it weighed 14 tons, had a speed of 35 m p h and a crew of four Fifty-four gallons of fuel carned it 100 mi It employed a 250-h p radial air-cooled engine. The US medium tank in 1939 was laiger in each dimension, weighed 23 tons and attained a 30-mph speed with a 400-hp. radial air-cooled engine It travelled 130 mi on 136 gal of fuel Its maximum armour thickness was one inch, and it mounted one 37-mm gun and eight machine guns. Turret and hull were welded

Germany .- Immediately after World War I, the German A7V tanks which had not been destroyed or captured were transferred to Poland Several light tanks and a supertank weighing 165 tons and mounting four 77-mm guns had been completed or nearly completed by 1918. All of these were destroyed under the Armistice terms, but the plans for the LK light tank were transferred to Sweden Here its designer, Vollmer, later supervised the building of a similar Swedish tank in the German-controlled Landskrona factory. For a few years, while relations with the USSR. remained friendly, a number of German-designed armoured cars were built in that country Adolf Hitler's rise to power ended German-soviet co-operation in this field, but led to a similar arrangement with Poland. Prior to 1934 Germany secretly built some experimental tanks and armoured cars and by 1935 when the treaty of Versailles was abrogated, it was ready to show publicly a number of small tanks and other armoured vehicles. Experience gained in the Spanish Civil War led to the building of a number of armoured troop carriers and tanks ranging from 8 to 40 tons in weight. By 1938 Germany was able to freeze designs on four medium tanks, which underwent only minor modifications thereafter. These models employed steel tracks with rubber bogie tires and spring or torsion bar suspensions. Generally well designed, they provided liberal crew space, excellent sighting equipment, low silhouettes and auxiliary escape hatches. Their greatest general weakness was mechanical unreliability.

France—The French tank program after World War I was affected by the large numbers of Renaults in service at the war's end. France could not afford to purchase more modern designs in quantity until 1330. Meanwhile, study and development continued, though not on the scale of British experimentation (be-

while the French produced only 15) During this period work was continued on a huge break-through-type tank which had been started during World War I The French made notable progress in armour production, besides making considerable use of cast armour, they pioneered in work with welded armour. They were successful in combining thick, well-shaped aimour with light suspension systems, thus holding down over-all weights The French were among the first to use controlled differential steering. After the Russian Revolution, M Kegresse, the Russian designer who had developed the half-track vehicle, sought refuge in France where he worked with the Citroen automobile firm to produce a number of tanks and half-track armoured cars employing flexible rubber track devices As early as 1924-25, a Citroen-built tank used tracks with jubber treads.

French tank strength just prior to its entry into World War II was estimated at about 3,500, including a number of World War I Renault light tanks, three types of medium (12-15 tons), two heavy tanks of 30- and 74-ton weights, respectively, and a minethrowing tank carrying an 81-mm trench mortar

U.S.S.R .- Although the Russians had followed closely the development by other nations of armoured vehicles and had actually built a few such vehicles incorporating elements of original Russian design, they possessed little really serviceable armoured equipment throughout World War I. Even in the years after the Revolution, tanks and other armoured vehicles used by the Red army were either purchased in quantity from other countries or reproduced from foreign designs The most notable Russian contribution to tank development prior to 1920 was Kegresse's half-track design. After the Revolution, a number of British Mark V. Medium A and Medium B tanks and French Renault and Chamond tanks which had been lent to the White Russians were taken over by the soviets Some modifications were made on these, and in 1025 an 80-ton tank was built. In 1926 the soviets purchased some British Vickers medium Mark II tanks, and by 1028 were producing the T-18, the first entirely Russian-designed tank. It was similar to the Renault, using a two-man crew and mounting a 37-mm gun and a machine gun. The T-26, built during this period, was a light infantry accompanying vehicle weighing about 10 tons and mounting a 45-mm gun It continued in service until the summer of 1941 Beginning in 1930 the T-27, a Russian version of the British Carden Lloyd Mark VI tankette, was built in large numbers This was a small two-man vehicle weighing only 1.9 tons and mounting a single machine gun. It was followed by the T-37, a two-man amphibous tank, also patterned after a British model The BT tank was the Russian version of the 1931 U.S. Christie, a fast 10.5-ton vehicle capable of running either on tracks or on wheels (The Russians apparently never operated the BT on wheels.) The T-28, similar to the BT series except for slightly greater weight (11.2 tons) and heavier gun (76 mm.), was produced in quantity and served well on the Finnish front in 1940.

As early as 1935 the German Gen. Heinz Guderian reported that the soviets possessed 10,000 tanks, and praised their organization, tactics and training. By 1941, according to reports published after the war, Russian tank strength was 21,000. Starting in the mid-1020s with almost no tank forces worthy of the name, and limited technical knowledge and productive capacity in this field, the soviets had by 1940 attained a place with respect to armoured strength, training and doctrine at least equal to that of other major European powers.

## WORLD WAR II

Germany's lightning conquest of Poland in Sept. 1939 and its rapid march through France and the Low Countries the following summer were spearheaded by panzer divisions built around the tank models that had been standardized by 1938. Postwar studies indicated that early successes of German armour in World War II were caused more by its bold and skilful employment in a manner not fully anticipated by its opponents, than by superiority in quality or numbers. (According to Guderian, when the west was overrun in 1940 German tank strength was less than 2,800, while

tween 1918 and 1930 the British evolved at least 27 types of tank, the French alone possessed about 3,600 tanks, most of which were superior in armour and fire power to those of the Germans) Among the nations which were to confront German armies early in the war, the Russians alone seem to have sensed correctly the potentialities of armour and to have prepared-at least in numbers. Here again, however, novel German tactics and their boldness and skill of execution were sufficient to match Russian material superiority. In the summer of 1941, 2,000 German medium tanks were sent against the more powerful Russian 31-ton T-34 medium and 48-ton KV heavy tanks, but by September the Russian tank losses exceeded 17,000 compared to only about 500 for the Germans

Allied military leaders in 1940-41 took note of the importance of morale and teamwork, as well as organization, tactics and technique, in the German successes, and revised their own doctrines accordingly Yet, there was a mistaken tendency in some circles to attribute German victories solely to superiority in weapons and equipment. This had a commendable effect on the Allied tank production programs, for no effort was spared to develop combat vehicles capable of coping with the vaunted panzers The Germans, for their part, continued to turn out new models, and in the resulting race for material advantage the tank as a war machine underwent constant and accelerated refinement Differences in tactical concepts were reflected in the designs produced by different armies—the Germans and Russians particularly tending as the war went on to build more heavily armed and armoured monsters. sometimes at the expense of mobility and mechanical reliability The days when strategic surprise with large masses of armour was possible for one or another opponent gave way to fierce encounters between forces more equally matched in armour Numbers, skill and daring were still to prove decisive in many actions, but the tank design race became one essentially between projectile and armour.

Under the stimulus of World War II, many refinements were produced, such as the gyroscopic gun stabilizer to improve accuracy of moving fire, power-operated turrets with integrated fighting compartments, or turret "baskets"; hydramatic transmissions; frequency modulation voice radio with effective ranges of ten miles or more, long-tube high-velocity guns with muzzle brakes to reduce gun flash; waterproof sealing combined with periscopelike air intake trunks for fording or landing operations; and many other technical improvements Before the war ended, the tank had demonstrated its versatility in many types of action in all theatres It had been used in open desert warfare, in jungles, in ice and snow and in landing assaults. On at least one occasion (the British landing in Normandy on June 6, 1944), light tanks participated in an air-borne operation.

The tank served most usefully in World War II when employed in mass on suitable occasions (and withheld on unsuitable ones) by commanders who fully appreciated what it could and could not do. Again, it was most effective when used as a member of an integrated team including all the other ground arms and supported by suitable aircraft,

Germany .- In the campaigns of 1939-40, the 6-ton, two-man PzKw I, mounting two 7.9-mm, machine guns and carrying armour sufficient only for protection against small arms, was one of the two tank types comprising the bulk of German armour. The other was the PzKw II, a three-man, g-ton vehicle with about twice the armour thickness of the PzKw I, and mounting a 20-mm, antiaircraft machine gun. In the early months of the war these were reinforced with the PzKw III and PzKw IV, both medium-weight tanks mounting infantry support weapons adapted for tank use By 1942 German experience in tank-v.-tank actions, especially in Russia and Africa, had clearly demonstrated the need for more powerful guns. Accordingly, the 1943 model of the PzKw mounted a high-velocity 75-mm. gun. By this time the Germans were ready to abandon light tank production and concentrate on models of 20 tons and more, with thicker armour and even more powerful weapons. By April 1942 the first of the famous "Tiger" tanks was delivered, and by the following fall it was available in sufficient numbers to be used on the Leningrad front. Officially designated the PzKw VI (later PzKpfw Tiger), this tank weighed

and companies, and for use in strategic roles.

In early encounters with the Russian T-34 medium tank, the Germans were impressed with the latter's well-sloped armour, and hastened to incorporate a similar hull design in their PzKw V (Panther) which went into production in late 1042. The Panther resembled the Russian T-34 in appearance, and carried 80-mm frontal armour It mounted a high-velocity 75-mm gun with muzzle brake, was manoeuvrable and had a speed of 20 m n h Soon after, a more heavily armoured version of the Tiger appeared Weighing 75 tons, it carried six-inch frontal armour and, though underpowered, it was adequately mobile, being capable of 24-m p h speeds. Its designers had provided tracks 32 5 in. wide, a feature which gave it good mobility over soft or muddy ground This model was known as the Komestiger (Royal or King Tiger).

Although Hitler correctly sensed the psychological value of such seemingly invincible tanks, the haste with which he insisted they be produced seriously affected their mechanical reliability Even the notorious "88" gun, which was for a time the master of the field with its muzzle velocity of 3,340 ft per second which enabled it to penetrate 6 6 in of armour at 2,000 yd, was reduced in effectiveness by the short life of its tapered-bore tube. The firing of several hundred rounds of high-velocity ammunition was sufficient to make it dangerous to its own crew, so that it required replacement-a time-consuming operation.

A combination of factors, including lack of dependability, lack

of strategic mobility, limited numbers, fuel shortages and piecemeal commitments in the later stages of the war, prevented the German Panther and Tiger tanks from being the decisive weapons which Hitler, at least, seems to have expected them to be. Total German tank production from 1030 to 1044 has been estimated

at 23,000

Great Britain .-- In May 1040 when the Germans invaded the Netherlands and Belgium the British had in France about seven mechanized cavalry regiments and two tank battalions plus an armoured car regiment These were armed principally with the Matilda I tank, discussed below. During the last days before the fall of France the British 1st armoured division, equipped with cruiser tanks, landed in France and joined the action at Calais and on the Somme. Although most of these troops were evacuated, their equipment was lost and it was not until early 1941 that armoured units were re-equipped in England New armoured divisions were formed, and soon were in action in Africa and the middle east. By the end of 1941 experience in tank actions in Libya, Greece and Burma had already suggested design features which were to be incorporated in new British models.

The British had entered the war with five standard tank types; the light tank Mark VI B; the infantry tanks Marks I and II; and the cruser tanks Marks I and III. The light tank Mark VI B was a speedy, rehable machine, weighing just over five tons and mounting two machine guns The 12.3-ton infantry tank Mark I was the Matilda I referred to above, and had been designed with crew protection as the primary consideration. The result was that its three inches of armour could withstand a 75-mm. projectile, but it was underpowered and slow, and its single machine gun was no match for the German tank armament of that day

The infantry tank Mark II, known as the "Waltzing Matilda." was a much more efficient tank. With armour up to 3.5 in. and a two-pounder gun, it weighed 26 tons, but was faster than the Matilda I. The crusers Marks I and III had been designed for speed and fire power. Weighing 14 tons, they carried a two-

pounder gun and attained a speed of 18 m.p.h.

As the war progressed, these tanks were modified a number of times and eventually replaced by models reflecting the general trend toward thicker armour and greater gun power. Typical of the British tanks developed by the end of the war were the Valentine X and the Cromwell VII, both cruisers; the Churchill VII, an infantry tank; and the light Tetrarch tank. The Valentine X weighed 17.2 tons, mounted a six-pounder gun, carried a threeman crew and had a speed of 15 m.p.h. Its maximum armour thickness was 2.56 in. The Cromwell VII weighed 28 tons,

about 60 tons and mounted an 88-mm anti-arcraft gun. It was mounted a 75-mm gun, used a crew of five and was capable of mitended for issue not to panzer divisions but to GHQ battalions 31-mph speeds. The Churchill VII was a five-man tank also, weighing 39 5 tons, carrying armour up to six inches and mounting a 75-mm gun Its speed was 13.5 mp.h The light Tetrarch tank was used by the British in the Normandy air-borne operation Very lightly armoured (maximum 62 in ), it mounted a three-inch howitzer, carried a three-man crew and attained a speed of 25 mnh Its weight was 7.6 tons

United States .- By 1939 the United States had begun to rearm, and orders had been placed for added numbers of the light tank M2A4 and the medium tank M2A1, which were then the current standard models It was soon realized that a better gun than the M2A1's 27-mm, would be needed against the Germans Accordingly, the M-3 medium tank was designed and ordered in quantity This tank, which reached Africa in time to play a significant role in the British victories there, was known as the Grant While similar to the M2A1, it mounted a 75-mm gun in the hull The M4 medium tank, known as the Sherman, with added armour and the 75-mm gun placed in the turret, was in production by Oct. 1941, and it also reached Africa in time to influence the action there Undergoing continual development during the war, the M4, or Sherman, became by far the most widely used tank in the war A total of 49,234 were produced Its components featured simplicity and ruggedness. Of particular interest were the volute spring bogie-type suspension, the highly developed V-8 engine and the rubber-block, rubber-jointed tracks used on the Sherman. A life of 3,000 mi, was not unusual for these tracks, compared to about 600 mi for the metal-jointed German tracks Aside from the fact that the numbers of the Sherman tank supplied to Allied armies made possible the massing of superior tank forces in critical areas, its speed, manoeuvrability, and capacity for sustained operation under severe conditions made the Sherman tank a vital factor in Allied victory.

It is interesting to note that one year before the famous German Tiger appeared the U.S. army ordnance department, visualizing a need for such supertanks, had produced the M-6 heavy tank, weighing 65 tons, mounting a high-powered three-inch gun, the most powerful ever placed in a tank to that time (though not the largest calibre). The M-6 had the couvalent of four inches of armour and a nine-cylinder, 1,000-h.p radial air-cooled engine gave it a speed of 22 m.p.h. Its general performance characteristics compared favourably with those of the Sherman tank, with which it had been designed to work as a team. The general staff, however, preferred to use available shipping space to transport two 35-ton medium tanks for every M-6 heavy which could have been shipped, and, in addition, suitable engineer bridges for the M-6 were not available. Therefore, production of the M-6 was

discontinued after about 40 had been built

In Sept, 1942 development was begun of a tank which would have the armour protection and fire power of the M-6 without its great weight. The result was the heavy tank M26 (General Pershing), weighing 45 tons, mounting the 90-mm. gun and having an armour equivalent to nearly seven inches. The Pershing reached Europe in time to participate in the final attack on the Germans in the spring of 1945. Utilizing the 500-h.p. V-8 engine designed earlier for the Sherman series, the Pershing had a speed of 20 mp.h. Like the medium series, it used a five-man crew. A unique feature of the Pershing was its torquematic transmission. which combined the hydramatic transmission with a torque converter. In this model the ordnance department departed from the volute spring suspension in favour of a torsion bar system U.S. light tanks, designed originally as fighting reconnaissance

vehicles, were fast and dependable, though lightly armoured. They also were constantly improved during the war. The M-2 series soon gave way to the M-3 and later the M-5, both mounting the 37-mm gun, and in the M-5 utilizing a hydramatic transmission and dual V-8 Cadillac engines. These tanks, weighing about 16 tons and having a speed of 40 m.p.h., saw sustained action in Africa and Europe as organic equipment of U.S. tank and armoured cavalry units. By 1945 a light tank known as the M-24, designed to employ a light but powerful 75-mm. gun built originally for use in aircraft, was delivered. It was highly sucfor all US light tank units. Weighing slightly more than 19 tons and using Cadillac dual engines, it had a speed of 35 m p h.

and armour equivalent to 2 5 in

Worthy of note as part of U.S. tank development during World War II was the so-called "swimming device," consisting of metal box floats attached to the tank to permit it to disembark from a ship several miles offshore and proceed ashore under its own power A tank thus equipped could move through the water at six miles per hour, firing its weapons while affoat, and jettison the swimming device after landing, without necessity for the crew to dismount. This device was used successfully in the Normandy andings and in the Pacific

U.S.S.R .- After the Finnish "winter war" of 1030-40, which apparently awakened the soviets to the need for greater armout thicknesses, the T-28 was radically modified until, with two-inch armour, its weight reached 34 tons The Russians also had at the war's beginning a relatively thin-skinned heavy tank, the T-35 Weighing 40 tons, it could make 18 m p h, and mounted a 76-mm. gun along with a considerable array of lesser armament, but its

maximum armour was only 1 18 in

It was the models laid down in 1938-39 and produced by 1940 which were really to revolutionize soviet armour The 26-ton T-34 medium was one of these. It was of the Christie type, with wide (24-in.) tracks, a low silhouette and a 30-m p h speed provided by a good 500-h p. hquid-cooled diesel V-12 engine was armed with a 76-mm. gun.

Another 1940 model was the KV heavy (named for Klim Voroshiloff, soviet minister of defense), which weighed 52 tons and mounted a 76-mm gun The KV was much more heavily armoured than the T-34, which accounted for its greater weight, since in other respects it was much like the T-34 With these early wartime models the soviets came into their own as designers, producers and users of fighting tanks. Before the war's end another heavy tank, the Joseph Stahn, was to appear It was a logical step from the T-34 and the KV, in the progression toward thicker armour and more fire power

#### TANKS AFTER WORLD WAR II

Few details about Russian armoured strength or tank models were available after 1945, but the U.S.S.R was believed to have about 40,000 tanks, and organized tank units were estimated unofficially as equalling at least 35 armoured divisions. The JS III, a later model of the Stalin tank, was reputed to have the equivalent of ten inches of armour, to weigh about 56 tons and to be powered with a 600-h.p. engine. It was said to mount a 122-mm. gun and to possess exceptionally well-sloped armour Other reports mentioned another tank, the T-44, but little was known of it except that it was listed as a heavy tank, presumably even more formidable than the Stalin

Great Britain and France also proceeded with tank experi-mentation and development after World War II. Under the Military Assistance program, North Atlantic treaty nations were scheduled to receive some United States equipment. The western democracies individually and collectively were maintaining far less active armoured strength than the Russians, but were attempting to remain abreast of them in design and development of tanks.

Meanwhile, one postwar United States model was a superheavy tank announced in 1947, described as the heaviest vehicle ever built for the ordnance department Weighing nearly 100 tons, it mounted a 105-mm, gun and a 50-calibre machine gun, the whole assembly heavily armoured Another was the M-46 General Patton, weighing about 47 tons and mounting a 90-mm. gun. As a combat vehicle, it was essentially an improved version of the Pershing tank, since its performance characteristics, fire power and armour and the general types of mission for which it was suited appeared to be very similar to those of the Pershing.

No radical changes in tactical doctrine for employment of tanks emerged immediately after the war; the cardinal principle of mass utilization-heavy concentrations in depth on relatively narrow fronts-combined with deep penetrations and rapid ex-

cessful in the spring offensive of that year, and became standard ploitations still was adhered to by most military thinkers. New emphasis on air-borne operations suggested a design requirement for air-transportable tanks (or planes which could carry standard models) It also suggested at least one important mission—that of striking powerfully and rapidly overland to make a ground "link-up" with air-borne troops The effect of the atomic bomb and other related weapons on ground was fare, including armoured operations, remained largely a matter of speculation,

operations, remained argety a matter of specimition, and the control of the contr (Sept-Oct 1949), G Underhill, "The St Armored Cavalry Journal (May-June 1949)

TANNA: see GAON

TANNAHILL, ROBERT (1774-1810), Scottish song writer, son of a Paisley silk weaver, was born on June 3, 1774 He was apprenticed to his father's trade at the age of 12, and, inspired by the poetry of Robert Burns, he wrote verses as he drove the shuttle to and fro He began in 1805 to contribute verses to Glasgow and Paisley periodicals, and published an edition of his poems by subscription in 1807 Three years later, on May 17, 1810, he committed suicide Tannahill wrote some charming songs "Loudon's Bonnie Woods and Braes," "Jessie, the Flower o' Dunblane" and "Gloomy Winter's Noo Awa" are the best.

Tannahil's centenary was celebrated at Passley in 1874 See edition by D Semple (1876) for details of his life, also Brown's Paisley Poets,

ll 1 (1889).

TANNENBERG, BATTLE OF. No portion of the earth's surface has been more fought over than East Prussia It was in 1410, on the field of Tannenberg, that the Teutonic knights were utterly routed by their enemies the Poles and Lithuanians, and the German victory of 500 years later was in some degree the reversal of this defeat.

The Tannenberg of 1914 was the greatest victory achieved by any of the combatants at the beginning of World War I, and its strategic and moral effect upon the struggle were far-reaching France and Russia had been joined by military convention since 1802 and their chiefs of staft had made careful arrangements for concerted action In case of war with the Central Powers it had been agreed that Germany was the main enemy and that the principal military effort must be made against it.

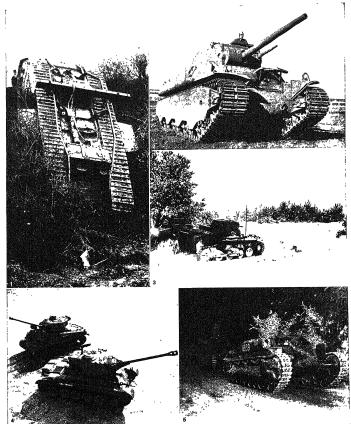
Because of the vastness of its territory and the comparatively undeveloped state of its railways, Russia's rate of concentration was considerably slower than that of France, so much so that there was a danger of the latter's being crushed before the attack on Germany in the east could begin to exert its effect. Unfortunately, under the pressure of French insistence, the good will and optimism of Russia's military leaders exceeded practical possibilities and the outbreak of war found Russian military plans in some disorder. All Russia's initial operations in East Prussia were in fact hasty improvisations.

Geographically, East Prussia points forward into the heart of Slavdom and constituted a difficult problem of defense for Germany. True to its policy of concentration of force at the decisive point. Germany had decided to advance against France with its main forces while maintaining only a minimum of strength in the east. Not wishing to abandon national territory without a blow, the Germans had decided to concentrate this minimum strength in East Prussia, despite the dangers involved in such action. Germany's strength in the east was to consist of 11 divisions, 6 first-line and 5 second-line, with but a single cavalry division.

Taking the East Prussian front as it appeared to the Russians, it can be divided militarily as follows:

1. Königsberg Area - A more or less fortified area extending over the Königsberg peninsula, of a depth of 19 mi. from north to south. In the centre lay the obsolete fortress, strong against anything but heavy artillery. The area could be reinforced by sea through the canal from Pillau It formed a strong flanking position from which to attack any force to the south

2. Insterburg Gap .-- A gap of 43 mi, of open country, down



PROTOGRAPHS, (1) TOPICAL PRESS AGENCY, (2) U S ARMY SIGNAL CORPS, (3, 8) ACME, (4) U S ARMY

## TANKS OF VARIOUS COUNTRIES

- 1. "Mark. Va" task, devolved by the British army soon after the battle
  of Combind, F. in World War. II tank, and the
  2. The M-G, U.S. heavy task developed in World War II
  3. The M-G, U.S. heavy task developed in World War II
  5. Japansee heavy tasks with exmediate
  S. Japansee heavy tasks with exmediate



PHOTOGRAPHS (1, 4) SOYFOTO, (2, 3, 6) BRITISH COMBINE FROM PUBLIT, (5) ACME

## TANKS OF WORLD WAR II IN ACTION

- Soviet medium tank, T-34
   Loading a U.S. "General Grant" tank with a fresh supply of ammunition after an engagement with German panzer units in the Libyan desert
   A British tank commander observing the field during action in Libya

- 4. The "Joseph Stalin," soviet heavy tank
  5 German tank proceeding over a road stewn with trees and other
  obstacles during the invasion of the Low Countries in 1940
  6. U.S. M-3 light tank moving forward to contact enemy forces in the
  Libyan desert in 1942

which ran the main Insterburg-Allenstein railway The River Angerapp running north and south blocks this gap It formed an excellent line of defense with the right flank resting against the impassable Lake Mauer

3 Masurian Lakes -A line of continuous lakes from Angerburg to the Russian frontier at Johannisburg, a distance of 50 mi. The narrow gaps between the lakes could be held with few troops, and the whole line presented an almost impregnable front behind which the Germans could operate to either flank

4 Johannishin g-Dzialdowo (Soldau) Front -A distance of 75 mi running east and west. On the Russian side the country had been left a desert as a defense against Germany

The Russian Plan of Invasion.-The Russian plan for the invasion of East Prussia was to advance with two armies north and south of the line of lakes, with the object of enveloping the German forces supposedly concentrating behind this line northern army under Paul Rennenkampf was to advance first, toward the Insterburg gap, with the object of drawing the Germans as far to the east as possible. The southern army under Alexander Samsonov was to advance to the line Rastenburg-Allenstein, with the object of striking the rear of the Germans opposing Rennenkampf

Rennenkampf's army crossed the frontier on Aug 17 with a strength of six and one-half divisions and five and one-half cavalry divisions On Aug 20 an action was fought with the German 8th army at Gumbinnen Max von Prittwitz und Gaffron, the German commander in the east, had concentrated his main strength to meet Rennenkampf, six divisions and a cavalry division, while leaving about two divisions to face Samsonov's army, which was concentrating on the River Narew

Rennenkampf had moved off without a great portion of his transport and found himself forced to halt on Aug. 20. witz advanced to attack him. There were serious miscalculations in the German movements, with the result that the action was indecisive, both sides suffering heavy losses. That evening the news arrived that Samsonov had not only started to advance, but that two of his corps were already close to the frontier and that he had at least five corps with him The German commander abandoned all hope of defeating Rennenkampf on Aug. 21 and contemplated a withdrawal to the Vistula. On communicating this on the telephone to the supreme command, he and his chief of staff were at once superseded.

The new commander, Paul von Hindenburg, had not yet been employed in the war His chief of staff, Erich Ludendorff, reached supreme headquarters at Coblenz on Aug. 22 and the situation in the east was explained to him He immediately ordered the troops retreating in front of Rennenkampf to halt at once and to prevent him from pursuing, and issued instructions for a concentration against Samsonov. General Hindenburg joined Ludendorff's train at Hanover and took over the command

at Marienburg on Aug. 23.

Luckily for the new command, Max Hoffmann, the chief of the operations section under Prittwitz, had already carried out many steps facilitating the concentration desired by Ludendorff, and the situation, though alarming, had not grown worse since the supersession of Prittwitz. Samsonov's right was indeed well over the frontier near Ortelsburg and his left between Neidenburg and Dzialdowo (Soldau), but the Russian advance appeared to be slowing up. The German 20th corps had taken up a position north of Neidenburg and was awaiting attack. The leading umts of the 1st corps were detraining south of Deutsch Evlau and were moving up on the right of the 20th corps. The 3rd reserve division had detrained at Allenstein and was moving up on the left of the 20th corps: A landwehr division and units from the Vistula garrison troops were also coming up Thus, a strength of about six or seven divisions had been collected to oppose ten divisions and three cavalry divisions of Samsonov's army

No decisive results could be expected from such strength, and decisive operations were the Germans' only hope. The most important feature of the situation, however, was that Rennenkampf had made no forward move since Gumbinnen and had lost all touch with the enemy in front of him. Ludendorff therefore con-

ceived the idea of withdrawing all the troops from Rennenkampf's front, with the exception of the cavalry division, and of directing them against the right flank of Samsonov's army. Another four divisions thus obtained would give him an actual superiority over Samsonov and the direction of their attack might indeed be de-

An Account of The Battle .- Samsonov, who in peacetime was the governor general of Turkistan, had arrived from sick leave in the Caucasus on Aug 12 He had seen neither his subordinate generals nor his staff before, and his immediate superior, Jilinsky, commander of the northwestern front, was urging him forward to cross the frontier on Aug 19 The original concentration areas of his army behind the Bobr and the Narew had been considered to be too far to the east and a general move of all corps to the



west was in progress. By Aug. 20, the right wing (6th and 13th corps) had reached the frontier, with the 4th cavalry division well behind on the right. The left wing (15th and 1st corps) was just short of the frontier, with the 6th and 15th cavalry divisions covering it Of the 23rd corps, one division was two days' march behind the left wing and the other had not yet detrained at Warsaw The troops had been marching for a week across the desert area north of Ostroleka, over execrable roads in very hot weather. Much of the transport had been left behind, the men were tired and unfed and numbers had been much reduced by sickness No contact had been gained with the enemy and the army was already more than 24 hours late in crossing the frontier Reports from Rennenkampf of his victory at Gumbinnen and, during his advance westward on Aug. 24 and 25, of the signs of a hurried retreat on the part of the Germans, brought further urgings from Jilinsky to Samsonov to hurry. Samsonov obeyed to the best of his ability, and by the morning of Aug. 26 his position was as follows:

His centre of two corps (13th and 15th) was advancing northwest and was close on the line Allenstein-Hohenstein. On his right was one corps (6th) and the 4th cavalry division at Rothfliess, at two days' march from the centre On his left was a corps (1st) and the 6th and 15th cavalry divisions near Koschlau, at one day's march from his centre. The 23rd corps troops which were up were moving into the gap between the centre and the left. His forces were thus much dispersed.

Reconnaissance had been bad and Samsonov had little information as to the enemy's dispositions. He seems to have thought that the Germans flying in front of Rennenkampf had already crossed his front in their march to the Vistula and that he was too late to cut them off. He had deviated from his instructions to advance with his left on Allenstein and now had practically the whole of his force to the west of that town. He had no knowledge of the whereabouts of Rennenkampf's army and did not realize that he was increasing the space between the two Russian armies and thereby facilitating the German operations. His supply system had broken down utterly and his men were half famished and worn out with the fatague of excessive marching. The signal service had also broken down and orders had been sent out to corps by wireless. The Russian signals were easily tead by the Germans, who thus had absolutely accurate information as to their

opponents' dispositions and intentions. Germans Attack Samsonov -The new German command had galvanized the dispirited 8th army from the first and hope of success ran high. The attacks on Samsonov's two flanks were to be launched simultaneously on Aug 26 On the right, the German 1st corps, strengthened by the Vistula garrisons, attacked only halfheartedly Hermann von François, the commander of the 1st corps, was short of some of his heavy artillery and he contented himself with driving in some of the Russian outposts On Aug. 27. however, he launched his attack in earnest. At dawn a hurricane bombardment was opened on the Russian 1st corps's positions on either side of Uzdowo. The famished Russians did not wait for the infantry attack but broke and ran By 10 P.M that night there was nothing left of the Russian left wing except a small rear guard just north of Dzialdowo, and that too had disappeared before the next morning

The rear of the Russan centre was now completely exposed and François directed his march on Neidenburg. Opposation there was none, and by the night of Aug 28 his leading troops had reached Muschaken, eight miles east of Neidenburg. By the night of Aug 32 he whole length of the road from Neidenburg to Willenberg was held by a line of entrenched pickets. The Russian retreat to the south was completely blocked. During Aug. 30 François was attacked at Neidenburg by fresh Russan troops coming up from Mlawa and actually lost the town for a time. He held stoutly on to the line of his pickets, however, and on Aug 31 Neidenburg was proccuimed.

On the left, the German 17th and 1st reserve corps, having turned their backs on Rennenkampf and marched due south, had arrived within striking distance of the Russian right at Rothlitiess on the night of Aug. 25. Their attack on the morning of Aug. 26 came as a complete surprise. The Russain oft Lorops withdrew in confusion, Josing 6,000 men and 16 guns. By the night of Aug. 27 the Russian right was 27 mil. So ft Rothlifiess and in a state of hope-

the Russian right was 3 mil. S. of Rathilies and m a rate of hopeless demonstration. The rear of the Russan centre was now exposed on its other flank. The German 17th corps continued its much to the south, while the ist reserve cops moved in closer toward Allenstein. The story of the fighting in the Russian centre is not so inglorious as that on the two flanks. In accordance with Samsonow's plan the centre (15th and 15th corps) continued their advance on Aug. 26 toward the line Allenstein-Holmstein. The 13th corps encountered no opposition, but the 15th had to fight its way steadily forward. For Aug. 27, the advance was 10 be

continued.

Second German Blow — Ludendorff, with his accurate information of the events on either flank, now decided that the German centre had retired enough. The remforced each copps was therefore ordered to attack on Aug 27. The battle which ensued between the Russian 13th corps and the German 20th corps was particularly frect, the Russians holding their own and even advancing a little on their left. The Russian 13th corps rendered no help to its neighbour. On Aug. 28 the Germans renewed their attacks and this time the hardly tred Russian 13th corps commenced to break. The 13th corps, moving down to assist, found itself assilied in the rest by troops arriving from Allenstein and for the second time brought no help.

When night fell the two Russian corps were on a line from Griestienct to Wapilitz and in Cose touch with the Germans. Hoping to escape from pursuit, they began to withdraw during the night. The withdraws soon became a rout, and a mass of troops and transport, both unfed and unwatered, became inextrically mixed in the depth of the Forest of Grinfinless. Determined attempts were made during Aug. 216 break through to the south

whole of his force to the west of that town. He had no knowledge of Muschaken and to the north at Kallenborn, but the German of the whereabouts of Renneimann's army and dd not realize ring held fast. Only about 1,000 men effected there escape. The that he was increasing the space between the two Russian armies greater portion of these two corps surrendered to the German and thereby facilitation; the German nonerators. His sumply was parties clearing the forest during Max 20 and 31

Samsonov himself had moved up to Nedenburg on Aug 27 in order bette to control the battle. He was greeted with the news of the disaster to both his flanks and met streams of stragglers coming into the town. He decided to go to the headquarters of the 15th corps and take personal charge, and left. Neidenburg on the morring of Aug. 28 with a small staff, all mounted on horses. At once he became mixed in the mass of transport in the forest and could exercise no effective command. He then decided to ride to the south, but during the might of Aug 28—29 he became exhausted after having walked for some distance. He drew aside in the darkness and his staff heard a single shot. A careful search brought no result and the staff continued its way, certain that its unfortunate commander had taken his own life in his despair at the turn which events had taken.

Results.—The practical result of the fighting from Aug. 36 to Aug 30 was the total annihilation of two Russaan corps and the reduction of three other corps to half their strength in numbers. The whole Russian and army was so demortalized and was so deficient in essential material, such as artillery and transport, that it was no longer of any fighting value. The Germans claimed 125, coop prisoners and 500 guns. It is certain that their body was very great, for 60 train loads of captured material left Puchallowen after the battle and the captured horses were driven in herds to improvised camps at Neidenburg. Although greatly inferior in the whole eastern theatre, the Germans had yet managed to concentrate a supernority on the field of battle. The Russains and 132 battlahons, 96 squadrons and 630 guns, including 12 heavy, while the Germans had 135 battlahons, 48 squadrons and 818 guns, including 128 heavy.

818 guns, including 128 heavy.

Birillocarany:—W. von Stephani, Mit Hindenburg bei Tannenberg (1921); H. von Franceis, Marnetchlacht und Tannenberg (1920); H. von Franceis, Marnetchlacht und Tannenberg (1920).

Rench (1922), J. Danhoff, Russland im Weltberg, 1914-19; (1932).

French trans, La Guerre Mondale (1927); M. Hoffmann, The War of Lot Opportunitely, trans, by A. Chamot (1923); Follorin, kitorya of the Chamot (1923); Follorin, kitorya of the Chamot (1923); Follorin, kitorya Chamotogo (1921); Color (1921); Co

TANNER, HENRY OSSAWA (1850-1937), US ariss, of Negro descent, was born at Pittsburgh, Pa, on June 21, 256, He was the son of Benjamin Tucker Tanner (born 1832), who became bushop of the African Methodset Episcopal Church in 1888 Henry Tanner was a pupil of Thomas Eakuns, in Philadelpina, and of J. P. Laurens and Benjamin Constant in Paris. He first exhibited at the Salon in 1895. Examples of his work are in the gallentes of Luxembourg; Chicago, Illi; Des Monnes, Ia, Los Angeles, Calif., etc. His "The Destruction of Sodom and Gomoriah" (1932) is in the Metropolitan Museum of Art, New York clicky. How was a knight of the Legion of Honour, a member of the Paris Society of American Painters, of the American Art association in Paris and of the National Academy of Design, New York

TANNHÄUSER or TANHUSER, German minnesinger of the 13th century, who lived for a time at the court of Frederick II. duke of Austria. After Duke Frederick's death he was received at the court of Otto II, duke of Bavaria, but he spent much time in wandering about Germany. He also went as a crusader to the Holy Land. His poems belong to the decadence of the minnesong, and combine a didactic display of learning with descriptions of peasant life. His adventurous life led him to be identified, in the popular imagination, with the knight Tannhäuser who, after many wanderings, comes to the Venusberg, or Horselberg, near Eisenach. He enters the cave where the Lady Venus-the Frau Hulda of German folklore-holds her court, and abandons himself to a life of sensual pleasure. By and by he is overcome by remorse, and, invoking the aid of the Virgin Mary, he obtains permission to return for a while to the outer world. He then goes as a pilgrim to Rome, and entreats Pope Urban to secure for him the forgiveness of his sins. The pope declares it is as impossible for him to

hauser departs in despair, and returns to the Venusberg. In three days the staff begins to put forth green leaves, and the pone sends messengers in all directions in search of the penitent, but he is never seen again

This legend was at one time widely known in Cermany, and as late as 1830 it survived in a popular song at Entlebuch in Switzerland, a version of which was given by Ludwig Uhland in his Alten hoch- und mederdeutschen Volksheder (1844) Among the attendants of Hulda was the faithful Eckhart, and in the preface to the Heldenbuch he is said to sit before the Venusbeig, and to warn passers-by of the dangers to which they may be exposed if they linger in the neighbourhood The legend was reproduced by several modern German poets, and by Richard Wagner in the famous music drama

Iamous music curins. The poetry, see F. H. von der Hagen's Mune-Fen Taminauer Blattech, Deutsche Liederfühler des 12 von 14 Jahrhunderts, 3rd ed, no. 47 (1893). See also F. Zandet, De 17 Taminauersag und der Munesager Taminauer (1838), J. G. T. Grasse, Die Soge von Taminauer (1846, and ed, 1861). A Öhlte, Zu. Taminauers. Leben und Dickfen (1890), J. Sebect, Taminauer, Inhalt und Form seiner Gedichte (1894)

TANNIN or TANNIC ACID, the generic name for a widely disseminated group of vegetable products, so named from their property of converting raw hide into leather (av) They are soluble in water, and their solutions, which have an acid reaction and an astringent taste, are coloured dark blue or green by ferrous salts, a property utilized in the manufacture of ink (q v). Some tannins appear to be glycosides of gallic acid, since they yield this acid and a sugar on hydrolysis (eg., oak tannin) while others yield protocatechuic acid and phloroglucinol (e.g., moringa tannin), common tannin, however, is a digallic acid

Common tannin, or tannic acid, C14H10O2 2H2O, occurs to the extent of 50% in gallnuts, and also in tea, sumach and in other plants It may be obtained by extracting powdered gallnuts with a mixture of ether and alcohol. When pure, the acid forms a colourless, amorphous mass, very soluble in water, less so in alcohol and practically insoluble in ether. It may be obtained artificially by heating gallic acid with phosphorus oxychloride or dilute arsenic acid, and conversely on boiling with dilute acids or alkalies it takes up a molecule of water and yields two molecules of gallic acid (HO)aC6H2 CO2H.

The tannin of oak, C19H16O10, which is found, mixed with gallic acid, ellagic acid and quercite, in oak bark, is a red powder; its aqueous solution is coloured dark blue by ferric chloride tannin of coffee, CaoHisOis, found in coffee beans, is not precipitated from its solutions by gelatin. Hydrolysis by alkaline solutions gives a sugar and caffeic acid, while fusion with potassium hydroxide gives protocatechuic acid. Moringa tannin or maclurin, C12H10O6 H2O, found in Chlorophora tinctoria, hydrolyzes on fusion with caustic potash to phloroglucinol and protocatechuic acid, Catechy tannin occurs in the extract of Mimosa catechy, and kino tannin is the chief ingredient of kino  $(q,v_*)$ . Tannic acid is employed either alone or in conjunction with antimony salts as mordant in dveing cotton with basic colouring matter. Medicine.-Tannic acid is officinal in both the British and

United States pharmacopoeias. It is incompatible with mineral acids, alkalies, salts of iron, antimony, lead and silver, alkaloids and gelatin. In the intestine tannic acid controls intestinal bleeding, acting as a powerful astringent and causing constination; it has been recommended to check diarrhoea, and is an antidote in metallic, alkaloidal and glucosidal poisons

Tannic acid is used in the treatment of various ulcers, sores and moist eruptions. The glycerin solution is used in tonsilitis and the lozenges in pharyngitis. For bleeding haemorrhoids tannic acid suppositories are useful, or tannic acid can be dusted on directly. The collodium stypticum is a valuable external remedy. Tannic acid is absorbed as gallic acid into the blood and eliminated

as gallic and pyrogallic acids, darkening the urme.

TANNING, a term describing the conversion of natural skins into leather. The word tan means the bark of the oak, which contains tannin or tannic acid; this has the power to combine with skin fibre and render it imputrescible. Modern tannage may

be pardoned as for the staff he has in his hand to blossom. Tann- be (1) vegetable tanning, i.e., performed with the water extract of barks, woods, nuts, etc., containing tannin, (2) mineral tanning, principally with compounds of chromium or aluminum; (3) combination mineral and vegetable tanning, (4) oil tanning, e, chamois leather (See LEATHER)

TANNU TUVA, part of the Russian Soviet Federal Socialist Republic of the USSR and formerly a region known as Urianghai, mainly of mountain and forest with a small steppe area, lying between the Savansk range on the north and the Tannu Ola range on the south, the former constituting its frontier with Siberia and the latter marking it off from Outer Mongolia has considerable timber resources and some wealth in minerals Its inhabitants, numbering fewer than 100,000, are for the most part primitive nomadic hunters of Turki origin, though there are some pastoral Mongols in the steppe country and a few thousand Russian immigrants in or near town settlements. Since Urianghai under the Manchu dynasty was treated by the Chinese as belonging to Outer Mongolia, and therefore part of the Manchu empire, the Chinese claim to sovereignty over Outer Mongolia had to be taken as applying also to Tannu Tuva

Historically, although tsanst Russia assumed direct control of Urianghai in 1911, it was not annexed to the tsarist Russian empire, and when it was declared an independent state by the Tuva People's Revolutionary party in 1921 it was recognized as such by the USSR. The republic of Tannu Tuva (with its capital at Kyzyl) was proclaimed in 1026, after some clashes with Mongol factions which had endeavoured to include Tannu Tuva in Outer Mongolia The USSR subsequently supported separation both political and cultural between Tannu Tuva and Outer Mongolia, although in 1924 it brought about, in partial settlement of Mongol claims, the cession to Outer Mongolia of a large tract of territory at the eastern end of Tannu Tuva inhabited principally by Mongol and not Turki tribes. In 1026 Tannu Tuva and Outer Mongolia recognized each other's independence In 1944 Tannu Tuva was incorporated into the R.S.F.S.R. (See also MONCOLIA)

TANTA, a town of Lower Egypt, in a central position nearly midway between the two main branches of the Nile, and converging point of several railways traversing the delta in all directions Population (1937) 95,260. It is the capital of the rich province of Gharbia, and is noted for its fairs and Moslem festivals, which are held three times a year and are sometimes attended

by 200,000 pilgrims and traders.

TANTALUM (symbol Ta, atomic number 73, atomic weight 180.88) was discovered by A. G. Ekeberg in 1802 One stable form, Ta181, and radioactive isotopes of mass numbers 180 and 182 are known The electron arrangement in the unfilled outer orbits (O and P) is: 5s2, 5p6, 5d3, 6s2. Tantalum is always found associated with columbium (q.v.) in its ores and this resulted in confusion on the part of the early investigators until J. C. G. de Marignac, in 1866, developed a method for the separation of the two elements, a method which has become classical and which is of great commercial value. The important minerals are tantalite. Fe(TaO<sub>3</sub>)<sub>2</sub>, and columbite, Fe(CbO<sub>3</sub>)<sub>2</sub>, found in commercial puantities in Australia, Brazil, Belgian Congo and South Dakota. Of less importance is the mineral microlite (6CaO.3Ta2Os.CbOFs) found in New Mexico These minerals may carry other elements such as titanium, tin, tungsten and manganese

Separation.—The pulverized ore is fused in iron pots with sodium hydroxide, which converts the tantalum and columbium into sodium tantalate and sodium columbate, compounds which are insoluble in water if some free alkali is present. At the same time compounds of iron, manganese, etc , which are soluble in hydrochloric acid are formed. The fused mass is crushed and treated with water and most of the free alkali is removed by decantation. The black residue is digested with hot hydrochloric acid to dissolve the iron and manganese compounds and to react with the sodium tantalate and columbate to form tantalic and columbic acids. These are washed by decantation and dissolved in hydrofluoric acid. Sufficient potassium fluoride is added to the solution to form the double fluorides K2TaF7 and K2CbOF5.H2O. The concentration of the solution is adjusted so that it is nearly saturated with the tantalum salt when hot (90° C.). On cooling

thus salt crystallizes out in the form of fine needles, leaving the (melting point 211° C, boiling point 241 6° C) columbium and most of the impurities in solution This method carbide, TaC, made by the direct union of the elements or by the of separation was first used by Marignac and its efficiency is the result of the relative solubilities of the potassium double fluorides of tantalum, titanium and columbium. In the order given the solubilities are 5 g, 12 g and 77 g, per litre at room temperature The tantalum salt can be purified further by recrystallization from water containing a small amount of hydrofluoric acid, and this potassium tantalum fluoride is used in the preparation of all other compounds of tantalum and the metal itself

Pure ductile tantalum was made by Werner von Bolton in 1905 The double fluoride was heated with sodium in evacuated tubes to bring about the reaction K2TaF7+5Na=2KF+5NaF+Ta The washed, finely divided metal powder was pressed into sticks which were melted down by drawing an aic between them and a watercooled table within a vacuum furnace The fused buttons were quite limited in size but could be worked into rod and fine wire In 1922 C. W Balke perfected a process whereby tantalum bars weighing up to ten pounds might be produced. The double fluoride is electrolyzed in iron pots provided with graphite anodes The current keeps the bath liquid and deposits the metal in the form of small crystals When the pot is full the electrolytic mass is pulverized and the salt is separated from the heavy tantalum powder with an air blast Final cleaning is done chemically to give a tantalum powder of high purity This is pressed into bars which are sintered in vacuum furnaces at a temperature not far below the melting point of the metal (2,996° C) The bar 15 heated by its own resistance to the passage of an electric current These bars are very ductile and can be worked into sheet, rod and wire This is done at 100m temperature, since the hot metal absorbs large volumes of the common gases and becomes brittle Tantalum resembles but is somewhat darker than platinum in colour and its specific gravity is 166 It is outstanding in its resistance to the action of acids and corrosive chemicals except hydrofluoric acid, concentrated sulphuric and phosphoric acids above 175° C, and solutions of the strong alkalies

Applications.—Tantalum was first used as a filament in electric lamps, but for this purpose it was soon replaced by tungsten Its first extensive use was in the manufacture of electrolytic rectifiers. These (trade name "Balkite") utilize the electrolytic valve action of tantalum, which allows an electric current to pass in one direction only when immersed in acid. It is used in electronic tubes. Large quantities of sheet tantalum are used in the construction of chemical equipment for use in handling corrosive gases and liquids Heat exchangers, evaporators, condensers and acid absorbers are built up from sheet by a special process of electric welding Tantalum produces minimal foreign-body reactions in the human body and is, therefore, used in nerve and

bone surgery with great success

Compounds of Tantalum.—Tantalum is usually pentavalent but in some compounds its valence can be two, three or four. The pentoxide, Ta2O5, is white in colour and is obtained by heating the metal in air or oxygen or by the ignition of tantalic acid, HTaO3,xH2O The latter is precipitated by the addition of ammona to solutions of the alkali double fluorides, by the addition of hydrochloric or nitric acid to solutions of the soluble tantalates or by the action of water on tantalum pentachloride. This acid gives rise to a large number of tantalates such as 4K2O.3Ta2O5 16H2O and 7Cs2O.6Ta2O5 38H2O Tantalates are most easily made by fusion of the oxide with the carbonates or hydroxides of the alkali metals. The addition of hydrogen peroxide to solutions of the tantalates produces pertantalates of which potassium pertantalate, K<sub>2</sub>TaO<sub>8.2</sub>H<sub>2</sub>O, is typical.

Anhydrous tantalum pentafluoride, TaFs, can be made by the direct action of fluorine on tantalum in the form of hydroscopic prisms (melting point 97° C., boiling point 229° C.). The tantalum fluoride, formed by the solution of the metal or acid in hydrofluoric acid, is really the acid H2TaF7, which forms many double fluorides with the fluorides of other metals. Tantalum pentachloride, TaClo, is made by the action of chlorine on heated tantalum or by the action of chlorine and the vapours of sulphur

action of carbon on the oxide, is a very hard yellow crystalline mass which is used in the manufacture of hard carbide tools for the machining of steel (see CARBIDES)

the macming of steet (see Condines) The Macming of See and Part-Book of In-organic Chemistry, vol v., part 111 (1939), C. W. Balke, "Recent De-velopments in Tantalum and Columbium," Ind. Eng. Chem., 39, p. p. 251-254, (1938), and "Columbium Tantalum," Ind. Eng. Chem., 39, p. p. 71 ro, pp. 116-69 (1934), Domaid F. Taylon, "Acid Corresson Resistance of Tantalum, Columbium, Zirconium, and Titanium," Ind. Eng. Chem., vol. 47, p. 693 (Part) 1550) (C. W. Ba)

TANTALUS, in Greek legend, son of Zeus or Tmolus and Pluto (Wealth), daughter of Himantes, the father of Pelops and Niobe He was the traditional king of Sipvlus in Lydia (or of Phrygia), and was the intimate friend of Zeus and the other gods, to whose table he was admitted But he abused the divine favour by revealing to mankind the secrets he had learned in heaven (Diod Sic, iv, 74), or by killing his son Pelops (q v) and serving him up to the gods at table, in order to test their power of observation (Ovid, Metam, vi, 401); another story was that he stole nectar and ambrosia from heaven and gave them to men (Pindar, (Ol, 1, 60) According to others, Pandareus stole a golden dog which guarded the temple of Zeus in Crete, and gave it to Tantalus to take care of But, when Pandareus demanded the dog back, Tantalus denied that he had received it Therefore, Zeus turned Pandareus into a stone, and flung down Tantalus with Mt Sipylus on the top of him (Antoninus Liberalis, 36) The punishment of Tantalus in the lower world was famous. He stood up to his neck in water, which flowed from him when he tried to drink of it. and over his head hung fruits which the wind wafted away whenever he tried to grasp them (Odyssey, xi, 582) This myth is the origin of the English word "tantalize" Another story is that a rock hung over his head ready to fall and crush him (Euripides, Orestes, 5) The sins of Tantalus were visited upon his descendants, the Pelopidae. Ancient historical reminiscences and natural phenomena, especially volcanic catastrophes, are at the bottom of the legend. The tomb of Tantalus on Mt. Sipylus was pointed out in antiquity, and has been in modern times identified by C F. Texier with the great cairn beneath Old Magnesia; but Sir W. M Ramsay inclines to a remarkable rock-cut tomb beside Magnesia.

The story of Tantalus is an echo of a semi-Greek kingdom, which had its seat at Sipylus, the oldest and holiest city of Lydia, the remains of which are still visible There was a tradition in antiquity that the city of Tantalus had been swallowed up in a lake on the mountain; but the legend may, as Ramsay thinks, have been suggested by the vast ravine which yawns beneath the acropolis.

J Hylén (De Tantalo [Uppsala, 1896]) considers the story of the thirst of Tantalus in the underworld to be the result of the Orphic interpolator in the Négura of the Odyssey, and the Pandareus story to be an innovation of the Alexandrine poets. The essay contains a copious list of authorities and a history of the legend. According to V. Henry (Revue des Études grecques [1892]). Tantalus is the sun. His betrayal of the secrets of the gods refers to the sun's unveiling the secrets of heaven; the slaving of Pelops denotes the going down of the sun

See PELOPS, PHRYGIA; Sir W. M. Ramsay in Journal of Hellenic Studies, ii., Sir James Frazer, Pausanias's Description of Greece, vol. ii., p. 555, vol. v, p. 392

TANTIA TOPI (c. 1819-1859), rebel leader during the Indian Mutmy, was a Mahratta Brahman in the service of Nana Sahib. He instigated the massacre of Cawnpore, and commanded at the battle of Bithur, where he was defeated by Gen H Havelock. With the aid of the Gwahor contingent he pressed Gen. C. A. Windham hard at Cawnpore on Nov 27-28, 1857, but was defeated by Sir Colin Campbell on Dec. 6. Together with the rani of Jhansi he was besieged by Sir Hugh Rose in the Jhansi fort, but escaped and collected a force of 20,000 men which Sir Hugh defeated without relaxing the siege This was the decisive action of the campaign in central India, and Tantia Topi was monochloride on the heated oxide. It is a white crystalline solid obliged to seek refuge in the jungles of Rajputana and Bundelkhand, where he was taken by Major Meade, condemned and exccuted on April 18, 1859 He was the only rebel leader in the Mutiny who showed any conspicuous military ability. (See INDIAN MUTINY)

TAOISM. The term Taoism has two meanings: (1) the philosophical system attributed to Lao Tzu (b. 604 BC) and Chuang Tzu (b 330 B C), (2) the popular religion of the Chinese

Taoism as a Philosophical System .- The term Tao originally meant the revolution or the way of the heavens about the earth This movement of the heavens was regarded as the cause of the phenomena on earth The Tao was located about the

celestial pole, which was considered to be the seat of power because all revolves about it In the course of time this concrete expression became abstract, and the Tao was viewed as the universal cosmic energy behind the visible order of nature This cosmic energy regarded as being is impersonal, omnipresent and eternal; viewed as becoming it works spontane ously, orderly, unselfishly and continuously for the highest good of all beings.

The Tao produced the vin and the yang, the negative and the positive, female and male principles of nature These by their interaction brought forth heaven and Reas earth Heaven and earth gave birth to all TAOIST PRIEST IN FULL beings The human order is the product of COSTUME. the eternal energy.



Philosophic Aspect .- Taoism has usually been regarded as a mystic religion, but it was also an economic and political philosophy It advocated frugality, simplicity and the joys of the peasant life in contact with the soil. It opposed the educational programme of the Confucianists, and advocated the theory that the people should be kept in innocence (not in ignorance) The Taoist philosophy is responsible for that remarkable trait of the Chinese, namely, their contentment in situations which offer a

minimum of comfort and their prizing of culture above possession. Political Aspect.-In politics Taoism opposed a highly centralized government and favoured the maximum autonomy for the people. Lao Tzu and his successors promoted the small village state which enjoyed full autonomy and lived in harmony with its neighbours. All forms of bondage and legal restraints were opposed. Non-resistance was exalted and militarism was condemned

The ethics of Confucianism met with the strongest opposition on the part of the Taoists. Such virtues as love, justice, reverence, wisdom and sincerity were regarded as the first steps departing from the harmony of the simple life in the Tao, and producing the distracting contraries which marred the purity of life.

The Taoists were mystics, but they were practical mystics, who hoped to realise the best social order through a harmonious relationship with the Tao. Their ideal was "this worldly." Their mysticism had three stages: (1) the purgation, casting out selfishness and self-secking; (2) union with the Tao, by which the individual lost his individuality with the distraction of the contraries; (3) power, which enabled the individual merged with the Tao to escape the limitations of time and space.

Taoism as a Religion.-Taoism as a religion is inherent in Taoism as a philosophy. The early mystics practised breathing and abstaining from food, and sought longevity and a future life in the Taoist paradise. The religious aspect did not become prominent, however, until the Han dynasty (206 B.C -AD 220), when the Taoists occupied themselves in compounding the elixir of life and in making journeys to the Isles of the Immortals. They also developed several sects which practised exorcism and fortunetelling and exercised considerable political power.

The rise of Taoism as a church is attributed to Chang Tao-Ling

(b. AD 34), who developed a high degree of magic power which he transmitted to his heirs, together with the political prestige which reputation for such power brought. These took part in a

successful rebellion in the latter part of the 2nd century, and established a state in Szechuan based on Taoist principles. The descendants of Chang Tao-Ling were recognized by the Government and in 1016 were given a fief at Lung Hu Shan in Kiangsi Their function consisted of a general oversight of the Taoist priests and monks and the rule over the world of the gods The system developed a hierarchy among the gods which corresponded to that of the government of China. At the head was Yu Huang Shangti, the Pearly emperor, who presided over an elaborate

Buddhist Influence.-Through contact with Buddhism in the first six centuries of our era the Taoists appropriated the Buddhis world view, adopted the monastic system and imitated the Bud dhist pantheon Lao Tzu was deified and was associated with Pan Ku and Yu Huang Shangti in the Taoist Trinity patterned after the Three Jewels of Buddhism Present-day Taoism is a

conglomeration of animism, polytheism and magic

alter the lines of minimum, polytheism and magic conglomentation of minimum, polytheism and magic conglomentation—II A Olits, Chung True (London, 1889), James Luge, The Tests of Tooton, pts.; and z. (SEE XXXIX and XL) (Coftord, 1891), Paul Carus, Lan-Tiset Tao Tesk-King (Chicago, 1893), Spurgeon Medhurny, Jacon (1901), E H. Parker, Studies in Chinese Religion (1901); D To Stunki, A Brief History of Early Chinese Philotophy (1914); II Dush, Researches into Chinese Sulper-sitentisty, vol. 17; III Shib, Landon (1914), Chinese Sulper-sitentisty, vol. 17; III Shib, Vol. 17; III Shib, Vol. 18; Vol.

TAORMINA, a town on the east coast of Sicily (ancient Tauromenum), in the province of Messina, from which town it is 30 mi SSW by rail Pop (1936) 4,293 (town), 7,580 (commune) It is a winter resort, chiefly on account of its situation and views It lies on an abrupt hill 650 ft above the railway station, and was occupied at least as early as the 8th cent B.C. (as the discovery of a Sicel cemetery of that period shows) It was refounded by the Carthaginian Himilto in 397 B.C., after the destruction, by Dionysius the Elder of Syracuse, of the neighbouring city of Naxos. In 392 Dionysius occupied it and settled his mercenaries there. In 358 the exiles from Naxos at last found a home there. It was the city at which both Timoleon and Pyrrhus first landed During the First Punic War it belonged to the kingdom of Hiero, and after his death it was allied to Rome. During the first Servile War it was occupied by Eurous and some of his followers, but was at length taken by the consul Publius Rupilius in 132 It was one of the strongholds of Sextus Pompeius, and after defeating him Augustus made it into a colonia In the time of Strabo it was inferior in population to Messana and Catana; its marble, wine and mullets were highly esteemed. In AD. 902 it was taken and burnt by the Saracens; it was retaken in o62, and in 1078 fell to the Normans.

The ancient town perhaps had two citadels; one the hill above the town to the W, now crowned by a mediaeval castle, the other the hill upon which the theatre was afterwards constructed There are some remains of the city walls. The church of San Pancrazio, just outside the modern town, is built into a temple of the 3rd century B C., dedicated to Serapis, the south wall of the cella of which is alone preserved. The other ruins belong in the main to the Roman period. The theatre, largely hewn in the rock, is of Greek origin, but entirely reconstructed. The stage and its adjacent buildings, especially the wall, in two storeys, at the back, are preserved. The view is of exceptional beauty, Mount Etna being seen from the summit to the base or the south-west, while to the north the rugged outlines of the coast and the mountains of Calabria across the sea to the northeast make up one of the most famous views in the world. There are also remains of a much smaller theatre (the so-called Odeum) and some large cisterns; a large bath or tank which was appar ently open, known as the Naumachia, measures 426½ ft. in lengtl and 392 in width. There are remains of houses, tombs, etc., o. the Roman period, and fine specimens of Romanesque and Gothiarchitecture (notably the Palazzo Corvaia) in the modern town See Rizzo, Guida di Taormina e dintorni, Catania, 1902.

TAPACULO, the name given in Chile to a bird (Pteropto chus albicollis) and applied in an extended sense to its allie forms, which constitute a small Passerine family, Pteroptochidae, peculiar to South America About 20 species are known.

The true tapaculo (P albicollis) has a resemblance to the

The true trajection (P. abrocous) and a resembance to the females of some of the smaller shites (Lanuta), but differs in its shortened wings and powerful feet. It rarely files, hops actively on the ground of among bushes with list fail erect, and continually utters various and stiange notes—some, says Darwin, are "like the cooling of dowes, others like the bubbling of water, and many defy all similes". The Turco, Hylactes megapodius, is larger, with greatly developed feet and claws, but is very similar in colour and habits. The Turco is distributed through central and northern Chile.

TAPANULI, a residency on the west coast of Sumatra, Netherlands Indies, area 14,760 sq mi, bounded north by Achin, east by the government of the East Coast of Sumatra, south by the residency of Sumatra's West Coast, and west by the Indian ocean. It is very mountainous, but has flat stretches of alluvial land on the coast between spurs of the great central range of mountains which traverses the length of the residency from north to south and forms a great massit from the centre of the residency to its eastern border which includes the mountain lake Toba. along the eastern shore of which the Tapanuli boundary runs. This lake, regarded as holy, was not seen by a European until 1863 (van der Tuuk). Previous attempts to reach it met with disaster, three Frenchmen and two Americans being murdered on their way to it, in 1835, while, in 1850, Ada Pfeiffer was obliged to turn back on account of native hostility. The lake, which is 3,000 ft above sea level, is 56 mi long, with an area of 23 sq mi and a greatest depth of 1,500 ft It has a large hilly island, Samosir, in the centre, divided from the mainland on the west by a narrow channel It is bordered on all sides by steep rocks, overhung with vegetation, and surrounded by mountains, and affords magnificent views. A good motor road runs to it from the coast, and there is a road around the lake from Balige to Prapat. There is also a motor boat service

The mountains of Tapanulı include Malea, in the south, 6,545 ft , Ulu Darat, in the centre, 7,010 ft., and Sibutan, on the northeastern border, 7,972 ft Small rivers flow westwards from the mountains to the sea, the Gadis, Turu and Sibundong, but they are almost useless for navigation. The coast is either rocky or marshy, but in Tapanuli Bay, which is surrounded by mountains and shut off from the effects of the southwest monsoon by Morsala Island, there is a good harbour with secure anchorage. Cultivation is confined to the valleys and the flat coastal strips, where maize, rice, coco-nuts, coffee, nutmegs and rubber are grown. Gold and silver are known in close association. Pop. (1930) 1,042,583, largely Batak (852 Europeans, 6,349 Chinese and other foreign Asiatics). The inhabitants consist of Mohammedans and Christians, while many remain pagans, with traces of Hinduistic practices mingled with their animism. (See SUMATRA.) They grow rice, coffee, tobacco and maize, also fruit and vegetables, and keep horses, cattle, pigs and buffaloes, build picturesque houses, are patriarchal in society, and are good crattsmen m wood, ivory and copper, while the women weave their own clothes. Cannibalism has been shed, the Bataks have become more amenable to outside influences. They have many languages.

The capital and chief port of Tapanuli is Sibolga, pop. 1co,765, the headquarters of the Resident, which is connected by road with Lake Toba and the interior generally, and, by the road round the southern end of Lake Toba, with Pennatang Siatar, the termines of the Sumatra East Coast railway, giving access to Medan and Belawan on the costs. A road through the Padag High-lands connect Sibolga with Padang, and a branch from this leads to Natal, a small port on the cost, in the south, while there is road connection between Sibolga and Barus, a small port in the north, connected by cable and overhead telegraph with Padang, and, by water between Barus, Sibolga, Natal and Padang, Bencolein and Batavia. Foreign exports of Tapanuli (1939) were 6,00,000 guilders, mainly rubber. Tapanuli was annexed piecemeal by the Dutch during the 19th century. Much of the residency was occupied by Japani March 1942.

TAPE MACHINE; see Ticker.

TAPESTRY. Tapestry is popularly assumed to be almost any land of heavy material, ordinarily wood, hand-sween, machine-woven, or even embroidered, used to cover furniture or walls, and this definition is justified in that it is the older mage, is the definition of the Latin tapes, and is still reflected in the parallel French derivative non lapisser, "uphoblesters" As continue there were specific designations for tapestry in the more immed sense, as Austaclesses or basseliars in French, and when the French therm scenaed to be current in England, "arras" there, from the French town which was for a time a centre of production. But now "tapestry" is more correctly reserved for one type of handwoven fabric, and perhass its machine-made imitation.

## TECHNIQUE

Tapestry differs from other forms of patterned weaving in that no wefts are carried the full width of the web, except by a very rare accident of design. Each unit of the pattern or the background is woron with a weft of the required colour, which is inserted back and forth only over the spot or section where that colour appears in the pattern. The weaving its, typically, in plandioth technique, the weft passing over and under the warps alternately, and on the return shoot, under, where before it was over, and vice versa. The wefts are pressed tightly together with a comb or the point of the bobbin, to cover the warps completely, which appear only as more or less marked parallel ridges in the texture—according to the coarsenses or finences

Where the margin of a colour area is straight and parallel to the warps, a slit is necessarily left, which may be treated in any one of five different ways First, it may simply be left open, as in the Chinese silk tapestries, which are called k'ssu, "cut silk," for that reason Second, it may be left open on the loom, but sewed up afterwards, as in European tapestries from the 14th to the 17th centuries, and also in some later types. Third, the weaver may dovetail his wefts along the colour-area contact, passing the west from one side, and that from the other, in turn over a common warp. This may be either "comb" dovetailing-single wefts alternating—or "saw-tooth" dovetailing—clusters now from one side, now the other. (For diagrams see: A U. Pope, ed., A Survev of Persian Art. 1938, iii, pp 2178-81.) Dovetailing has the double disadvantage of making the fabric heavier at that point and blurring the outline. Persian weavers of the 16th century developed a successful variant in silk tapestry rugs, whereby a black outline weft was dovetailed over two warps-one of each of the adjacent colour areas-effectively hiding the coloured wefts in the compacting of the weave, and providing strong clear drawing. The same device is found several centuries earlier in Peru, but if there was a common source, examples from it have not yet been noted.

The fourth treatment—interlocking—was introduced in the Gobelins factory in the 18th century. Here wefts of juxtaposed colour-segments are looped through each other between the two warps which mark, respectively, the margin of each colour. This gives a continuous surface of even weight and was prized by the French weavers because the resultant effect more closely approximated that of painting.

Finally, one curious variant would, in strictest definition, fall outside tapestry, though it starts with the tapestry conception: between every two rows of tapestry-woven wefts is a cloth-woven, individual shoot which makes the fabric solid. Because of the presence of the intercalated cloth wefts, this type would be rigorously classified as a brocaded cloth, but the idea is that of tapestry, with the cloth structure subordinate and the problem solved being one in tapestry weave. The device, rare everywhere, is found in Japan in the prin and 8th centuries, in east Persä in the roth century (Moore collection, Yale university), and in median-toth control (Moore collection, Yale university), and in median-with diffusion in the two opposite directions, and transmission (as in the case of various other textile techniques such as bark-cloth, feather-work, tre-and-dye, double-cloth) to the western hemisphere.

Haute-lisse and Basse-lisse.—European tapestry may be woven on either of two types of looms, haute-lisse or basse-lisse.

The former is a vertical frame, with heavy uprights (bâti, in French) holding a horizontal roller (ensouble) top and bottom, on which the warps are stretched Each warp passes through a loop of cord (the lisses), and the loops encircling the warps which correspond to uneven numbers are fastened to one slender cylinder. those to the even, to a second cylinder, both being above the weaver but within reach so that he can pull forward with his left hand now one, now the other set of warps (te, form the shed), in order to pass his bobbin (brocke) behind them, this being a short, pointed, slim cylinder of polished wood on which his weft-varn is wound

The basse-ksse loom, on the other hand, has the rollers on the same level at table height so that the warps stretched between them are horizontal, and the lisses are attached to two slats, each of which is connected with a treadle so that the weaver depresses the add-numbered, or even-numbered series of warps to form his shed with movements of his feet, leaving both hands free to manipulate his bobbin Production on this loom is nearly twice as fast as on the vertical loom, reducing cost proportionately The cylinders in both instances serve to roll up the finished portion and unroll a further length of unwoven warps so that the section in process is always in a convenient relation to the weaver. At both types of loom the weaver works from the back side and has a mirror into which he can look through the unwoven warps, and which is placed to reflect the portion in process; but while the haute-lisse weaver can examine his finished work directly by walking round to the other side of his loom, the basse-lisse worker has to tilt up his frame.

The design is rendered first as a drawing on paper, the petit patron: then it is enlarged to the size which the tapestry is to be. and is painted in exactly the correct colours on linen (later often paper) This is called the grand patron. Up into the early 16th century the patron, or cartoon, was sometimes called in French the portrait (or pourtraict). The artist specializing in designing (whether for execution in tapestry, or in other techniques and media such as embroidery, wood-carving and stained glass) was called a portrastist.

The grand patron was sometimes itself hung as a substitute for tanestry; and large-scale paintings similarly rendered on great sheets of heavy but flexible linen, called toiles peintes, or "painted linens," were made expressly for this purpose The most interesting collection of old toiles peintes, dating chiefly from the 16th century, belongs to the cathedral of Reims

The haute-lisse weaver has the grand patron which he is following hung beside him, but the basse-lisse worker has his laid under his warps, so he follows from immediately above his model In both cases the main outlines are drawn on the warps.

The design is executed, in all professional European work, at right angles on the loom so that in the finished hanging the warps run horizontally. This is aesthetically advantageous, since the warp-ribbing tends to create texture lines which are more or less re-enforced by linear shadows, and if vertical, these sever the design, but if horizontal they bind it into continuity. Practically, however, horizontal warps are disadvantageous since they mean horizontal slits, with weight from the heavy wool fabric pulling on them as the tapestry hangs, and thus accelerating deterioration. That the aesthetic consideration should have prevailed over the practical is noteworthy.

The extra weft-ends are left hanging loose on European tapestries, but they can be fixed with an additional twist and cut short. making a reversible fabric. This is a practice especially common in far eastern tapestry weaving. All European tapestries are relatively coarse up to the 18th century with, in general, from 10 to 18 warps to the inch. Transition from shade to shade is effected

with irregular "comb-tooth" hatching,

Twill Tapestries.—Instead of the plain-cloth binding com-monly found in tapestries, a twill can be used, i.e., a weave in which the weft is floated over two or more warps, then under one or more warps, with this underpass shifted always one to the right or left making the diagonal ribbing characteristic of serge. Such a weave, with the wefts over two, then under two warps (which means that the warps also pass over two wefts)

appears in tapestry for the first time, as far as can be determined, in Persia in a unique silk and metal-thread square, the design comprising a royal portrait, figures of angels, animals and plant motives (Pope, ed., Survey of Persian Art, ni, pp 2151, 2199, Pls 1090-91), and from the 17th century on (Moore collection, Yale university, Metropolitan museum) is used in goat's hair or wool, especially for shawls, in Khurasan and Kerman. The type is perpetuated in the well known Kashmir shawls, and was probably introduced into Kashmir from Persia, along with other crafts, in the 16th century

#### HISTORY

Early Examples.-The earliest known specimens of tapestry weaving of linen can be dated between 1483 and 1411 BC, for one bears the cartouche of Thutmose III of Egypt (1483-1451 BC), another of Amenhotep II (1451-1420 BC.); and the two, together with a third fragment carrying hieroglyphics, were found in the tomb of Thutmose IV (d 1411 BC) (see P Ackerman. Tabestry, the Mirror of Civilization, 1933, p. 12 and bib. p 344). The Amenhotep piece has the tablet bearing the king's name and titles upheld by uraes, set in a powdered pattern of lotus and papyrus flowers, with a narrow border on each side, one with lotus flowers and buds, the other with disks. Only the designs-in red, yellow, green, blue and brown-are tapestrywoven, the ground being plain cloth, in the tapestry areas the wefts are not kept straight, but curve to follow the drawing Thus the work is in effect bobbin-darning on warps left bare for the purpose

That these were made for Egyptian royalty does not by any means indicate that the technique was originally or distinctively Egyptian It is already fully evolved in these, the first examples, suggesting that the necessary prior development had been carried on in a region where conditions did not preserve textile fibres, and just at this period numerous Syrian ideas, techniques and undoubtedly also actual craftsmen were entering Egypt. That the craft was not indigenous can be assumed from the fact that, while countless mummy wrappings of the succeeding centuries have been unwound, comprising hundreds of yards of plain linen cloth of widely varying qualities, occasionally bearing some coloured stripes, no further instances of tapestry weaving are known to have been found in Egypt datable between this period and the 4th century AD, a lapse of some 1,800 years.

Fragments of wool tapestries in graves on the Kertch peninsula, datable in the 4th or 3rd centuries BC., carry stagheads and ducks in the Hellenistic style which was widely diffused but especially strong in Syria, and some 200 to 500 years thereafter the technique is represented again in a silk fragment, which though found at Loulan in central Turkistan (A. Stein, Innermost Asia, 1928, 1, pp. 242, 255, no L.C. vo2 a., Pls XXXI-XXXII) has close Sylian connections, This is a band showing in seven colours (three browns, one evidently originally purple, two greens, light blue and crimson) in a central zone, a scrolling stylized tree in the crown of which appears a bird's head; the whole designed to present alternatively a conventional bird (Raptores?) displayed, flanked by confronted griffons composed of a crested bird with deer (or horse?) feet, alternating with a symmetrical scroll. The border motive is a rosebud rendered as a heart in a deep calyx, and some of the multiple guard stripes are in con-tinuously graduated polychromy. The bird nesting atop a cosmological tree, and the double entendre are both west Asiatic. fantastic griffon variations are a persistent feature of Syrian design; the heart-rose is the standard border theme on later Syrian textiles, where also compound borders with variant guard stripes are frequent, while the unusual graduated polychromy appears on approximately contemporary wool tapestries at both Palmyra and Dura-Europos. Thus this tattered strip represents the same cultural linkage between the Mediterranean coast of Asia and its very heart, which accounts likewise for the Buddhist sculpture of northwest India of this same time (the so-called Gandhara style), for that is primarily of Syro-Hellenistic, rather than pure Hellenistic derivation

The wool tapestry with graded polychromy, found at Palmyra

(R Pfaster, Textiles de Palmyre, Paris, 1934, p. 36, no L 26), so onamented only with groups of square dots, but that from Dura (tdem, Rew des Aris Asataguas, vui, p. xxvi) bears stylized lines, and this figure, better drawn, appears also on wool tapestress found at Loulan which likewise may be assigned either to Syria or Persas (Stein, op et 1, pp. 241, 255, 256, nos LC v 03-06, op Pl XXXII) A closely related piece is known from south Russia Ci. Stephan, in Compte Remaid de la Commission Impériale Archéologique, St Petersburg, 1881, p. 143, Pl VI, no 3) Tapestry weaving must, then, have been common in western Asia and probably especially in Syria at the turn of the Christian era, and had climatic conditions been less unfavourable we should probably know a whole phase of the art now irretureably lost

Egypt.-The favourable conditions did exist, on the other hand, in Egypt, and consequently a mass of tapestry fragments has been recovered there, dating from the 5th to about the 10th century AD., and especially numerous from the 5th to the 7th centuries These are mostly garment trimmings, woven into or (in inferior specimens) sewed onto tunics and cloaks. Tunic trimmings (see Dalmatic) when complete consist of stripes over the shoulders (clavi) down front and back, varying in width from about 1 to 6 m., ranging in length from just below the belt to the very bottom, a neck piece, panels on the shoulders and near the knees which may be round (orbiculus) or rectangular (tabtion), and cuffs. Parts of pillows also are quite common, wall hangings far less frequent, and when in solid tapestry weave-in contrast to tapestry motives inwoven in cloth-rare and proportionately important. The last, notably a series of fragments in the Berlin museum representing dancers, in polychromy and silhouette (O Wulff and W. F Volbach, Spatantike und Koptische Stoffe, Berlin, 1926, pp 7-8, nos 9240-44, Pls 4, 5, 44), and sometimes the pillow panels, are naturalistic illustrations in a delayed Hellenistic style or subsequently in the early Byzantine style (best examples, Dumbarton Oaks, Washington, D.C.)

The garment trimmings fall into two main classes, indigenous desagns rendered either in polythromy, or more often in silhouette, most typically in some tone of purple (dyed with madder plus indigo), and designs copied, with more or less distortions, from Syrans shuttle-woven silk patterns (a distinction first established) by Straygowski, and repeatedly noted by Wulff and Volbach). In the former, constantly recurring themes are the vine, or less often ivy, the amphora, frequently with the vine growing out of it; nude women, nude youths or boys, including dancers often armed, and annuls, above all the lonn and the har—all explicable as descended from the Osiris cult and appropriate to burnal robes because of their relevance to revival in a hir after death.

In the patterns copied from Syrian models, the styles of the different great textile-producing cities there can be recognized, and subjects from the local cults, so that, analyzed in their wider relations, they throw considerable light on the history of religion, as well as of art

All types are woven with woollen wefts on linen warps, though a few with silk wefts have appeared, and cotton wefts are occasionally introduced to give a brighter white. Primarily in the 7th, and perhaps also the 8th century, the tapestry technique may be supplemented with embroidery, as in bo der margms, usually in split stitch. In a special variant which is not true tapestry the pattern, characteristically meanders or other geometric repeats, is executed with a free bobbin, "free" because it follows the design without regard to consistency of weft-direction, carrying a linea actually repply ground. The multiplicity of tones in polychrome pieces is noteworthy, especially from the 7th century on, and includes clear, delicate pastely

The Egyptian tapestry weaving deteriorated sharply to a very low level from the rth to about the rith century, when it was somewhat improved, though within a very limited range. Into white (or sometimes dyed dark green) linen garments were woven in tapestry, sometimes in wool, often in silk, occasionally with metal-thread enrichments, trimming bands in varying groups, ranging from a half-inch to a foot and more in width, with pat-

terns of geometric enlacements, frequently enclosing small quadrupeds or hards (ducks) highly stylzed, and inscriptions. Many of these merely simulate writing, but many are legible, in handsome angular ("Kufte") scripts on enlier pieces, in cursive scripts later, giving religious phrases, or the names or titles of rulers, occasionally with the place-name also (trråz) A characteristic colour combination in silk is golden yellow and scarlet

Syria.—Meanwhile from the 6th to 8th centurnes and doubtless from then on, in Syria, striking wood lapestries were being made, corresponding in style to the contemporary shuttle-woven silks, with animals or birds (commonly cocks) in energetic heraldic stylization, framed in roundels, almost always on a red ground (Pfister, in Revine des Arts Assirgiess, 3m). And later, from the 1rth to the 13th centuries, silk and gold-thread tapesries (E. Kumsch, in Zeitschrift µn bildende Kunst, n i 14) were produced in Syria, highly distinctive in style and illustrating one of the great Syrian pagan religious, which were still active in the old Pheomician cities when the Crusaders took them over, and have left a leggacy in west Asia in the so-called devil-worship of

the Yesida (q\*p\*).

Persia—Of the Persian tapestries fewer specimens have sur vived, but one notable fragment (Moore collection at Yale university) bears an bear in the impressive Sassaman style (Pope, ed, op. et.), 1, p. 708), and a single piece from the Seljuk period (rith century) establishes the maintenance of the technique (ibid., m., p. 738). This reappears in the 16th century, intermediate examples having all apparently been destroyed, as the medium for rich silk and metal-thread rugs, and for a very beautiful type of figural designs, of which only three are known still to exist of figural designs, of which only three are known still to exist 1940. The control of th

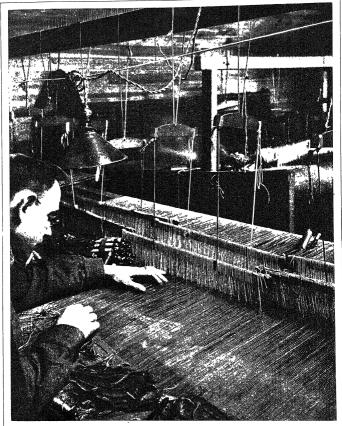
The modern descendants of these, occasionally silk but more often wool, in slit tapestry, with simpler patterns, are the familiar kulims; and the type extends, with variations in decorative style, through the Caucasus and Asia Minor into eastern Europe

Far East.—The technique had long since been in use also still further to the east in China, and there, in the original land of silk, silk was the typical material, in a fine, light texture, the wave finished perfectly on both sides so that the panels are reversible. The warps are vertical in relation to the pattern. The "metal" thread, which is quite common, is the thinnest possible gold-leaf applied to tough paper, cut in narrow strips and spirally wound on a silk core.

The earliest surviving examples, dating from the Tang and early Sung periods (8th to roth centures), show only simple repeating patterns—flowerets, vine elements, ducks, lions—but are probably not representative of the full development of the time since they come only from remote desert stations of central Asia (P. Ackeman, Tapetry, the Mirro of Cruitsation, pp. 237–238, ref. pp. 466–407) Subsequent examples, which are not numerous until the Ch'ing period (fed4–1912) when they are rey abundant, depict the same subjects as contemporary paintings, birds and flowers, landscapes, folktoristic and religious subjects, with the addition of symbolic complexes, notably selections of "Precious Things." Bepecially plentiful are squares from official robes indicating rank (Cammann, in Bull. of the Needle and Bobbin Clab. 26).

The technique travelled from China to Japan in the Ashikagaperied (15th century), where it was used for characteristic libertaritive motives, also in silk as a rule, and with vertical ways, but with a considerably coarser texture than that familiar in Chinese work. The history of the art in Korea remains obscute, but rather coarse wood tapestry-woven rugs from there, with stylized motives, are well-known in western markets (Ackerman, op.cif., pp 231– 233 and refs. p. 407).

Western Hemisphere.—How and when this, and a number of other complex Asiatic textile techniques, were transmitted to the Americas is not known. That they could have been independently re-invented there, as anthropologists have sometimes taken for granted, is hardly credible. But examples of a fully established technique and style appear, perhaps as actify as An 600-700 in

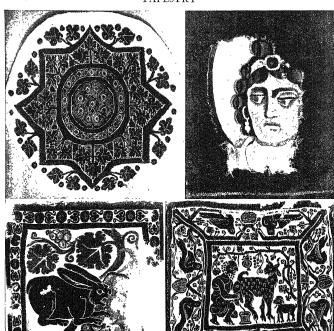


BY COURTEST OF THE EDGEWATER TAPESTRY LOOMS

# TAPESTRY WEAVING IN THE UNITED STATES

Weaver bending over herizontal or low-warp loom, and forcing the warp threads apart with his left hand so that the figure on the cartoon beneath it is seal. With his right foot he works a set of leashes attached to the even warp threads, and with his left foot those attached to the dod warp threads. The process of weaving consists in holding his warps parallel and passing the bobble to the left, atternately under orthogonal to the left and over the successive.

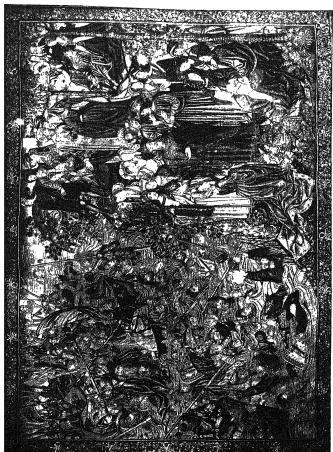
PLATE II TAPESTRY



IT COURTEST OF (1) TEXTILE MUSEUM OF THE DISTRICT OF COLUMBIA, (2) DETROIT INSTITUTE OF ARTS, (8) MUSEUM OF FINE ARTS, 803TON, (4) CITY ART MUSEUM, ST LOUIS

WOOL AND LINEN TAPESTRIES, FOUND IN EGYPTIAN GRAVES, 4TH-5TH CENTURIES, A D.

1. Violet alliseustis; star and vise meltive. Death 89,4 in 2. Polyshrome, portrait metalline, probably Syrian. Height 65,6 in 3. Viorist inhusents, polyshrome deaths, have adming profess liss about 8 in cusare 4. Violet alliseustis, shoeherd milking goat under vine. Size 13 in. square. The motives of 1 and 3, and the border of 4 (doess flanking uses of water of-life holding vine) were derived from Grystan immortality symbolism.



GURTEST OF MUSEUM OF FINE ARTS,



## GOTHIC TAPESTRY OF THE LATE 15TH CENTURY

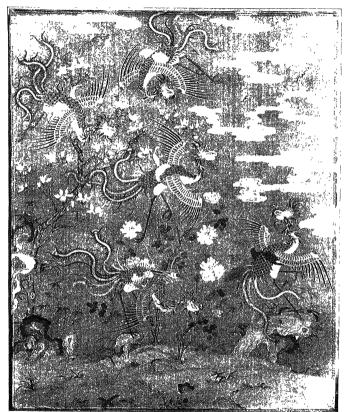
This lapacity of mills fleary design, in the M. Heavily Malapahas collection, was worse in Arras about 2.600, when that sity still occupied an eminent position as a centra of Fleenish tapstry-weeking. The subject is mystyliada, presentably a unicorn purifying the water of a spring which this bern while other animals want to dirink. The tapestry has been out down somewhat from the original value of the spring which is the s



BY COUSTESY OF THE METROPOLITAN MUSEUM OF ART, NEW YORK

## FRANCO-FLEMISH TAPESTRY

"Courtlars with Roses," the second of a set of three tapostries made towards the middle of the 15th century, perhaps at the order of Charles VII. It is wowen of wool in a censre texture of about 12 warps to the Inch. The tapostry, within results to partitings of deep Propulet, the great decorate countities. Since its exhibition at the Lowre in 1904 it has been recognized as we of the most important tapostries of its period. It was purchased in 2909 by the theoropital network of Art, New York.

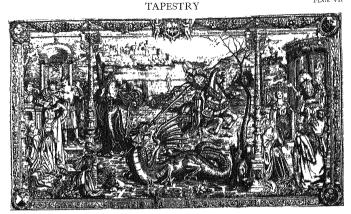


BY COURTEST OF THE METROPOLITAN MUSEUM OF ART, NEW YORK

CHINESE TAPESTRY

Slik tapestry (&'ssr.), China, Ch'en Lung period (1736-1796), with auspicious motives five (auspicious number) phoenixes (bird of the empress), amid magnolis (for spring), peonies (riches and honour), bats (happiness) and fungus (good luok).

# PLATE VII





TAPESTRIES: MODERN ENGLISH AND 18TH CENTURY FRENCH

Top: "St George and the World" (showing the call to battle, the struggle and the victory), the zecond panel of the Logend of St George series produced at Merton Abbey as part of the Eton College War Memorial. The designs were by Mrs. Ackers Douglas. Bottom. "The Quarry," a pertion of the eighth panel in the series of "The Hunter of Logis XV", exceeded at the Gobblin School yn 1744 effect a design by 1, B, D undry





TEST OF (1) THE TRUSTEES OF THE BOWES MUSEUM, BARNARD CASTLE, (2) HIS GRACE THE DUKE OF BU BEAUVAIS AND MORTLAKE TAPESTRIES

1. "Psyche Goling to the Sacrifica"; one of a series representing the story of Psyche Woven at the Beauvals factory, offer engravious attributes to Mark Antonic and from daugns of the school of Raphael 2. "Children Pisying"; one of a set weren in colourus words and sits at Mortiake, Empland, in the second half of the 27th century star a 16th-century Italian design. Height, 9 ft 6 in., length, 11 ft. 2 in

to light from the coastal sites of Peru, datable from about the 8th to the 12th centuries (thid, ch viv, P Kelemen, American Medicual Art, ch vi)

These are found on bodies, buried-characteristically in a squatting posture-fully dressed, indeed often wearing a multiplicity of garments hardly feasible in life, and padded and heavily wrapped into an approximate ovoid. The principal articles are tunics, for men, varying in length and with or without sleeves, for women, full length, or in the Incaic period, a long skiit held under the arms with a sash; for both, enveloping mantles, breechcloths for men and boys, belts, head-bands, bags, curtains and pillow covers (Excellent collections, Lima Museum, Brooklyn Museum, American Museum of Nat Hist, NY, Textile Museum, Washington, DC)

The warps of the tapestries are of undyed cotton (the cotton of the region being naturally either white or brown), the wests of wool-llama, alpaca, or vicuna-with cotton sometimes introduced for bright white The range of available colours-made with natural dyes of all three classes-is large, for the most part in saturated tones, the compositions are usually quite polychrome

and powerful contrasts are preferred

The patterns all derive from the local cults a feline divinity. in some presentations fantastically adorned; an anthropomorphic deity, or more likely several distinct personalities, ordinarily with an elaborate head-dress and trequently carrying a staff, birds, including the eagle and the conder, fish Plant motives are comparatively rare All are angularly conventionalized, with the rectangle and especially the diagonal as substructure, the style showing a marked preference for meanders and reciprocals. The latter range from the most rudimentary, the serration, with its section the Z or its magnification the chevron, to complex developments of overturned interlocking figures of naturalistic origin, notably condor heads, original in this region

In the degeneration of the art in the later middle ages, the characteristic principles appear elimination-as, omission of the mouth; fusion-as, nose and mouth merged into one spot, exaggeration-as, human profile reduced to a huge nose, part-forwhole-as, the feline represented only by its claw; but the application of these devices of deteriorating conventionalization is unusually extreme, so that these inferior phases of the art became very popular in the World War I Paris Decadent school

Though a great advantage of tapestry is its flexibility which makes unnecessary repeating patterns, these strongly predominate in the Peruvian use of the technique in all periods. The organization of the repeats follows in part basic textile forms relevant to shuttle weaving, viz : (i) stripes, (ii) bands, (iii) rectangular checks, implicit or explicit, but schemes unrelated to the fabric structure also are used, eg. (iv) diagonal stripes; (v) chevron stripes, (vi) lozenge checks Within these frameworks, the succession, whether of motives or of colour changes, is often exceptionally complex. The usual unit is three, or its double, six-the latter a peculiarity of textile design in this region throughout its pre-Columbian history-and the permutations thereon are numerous, varied, and not infrequently remarkably ingenious.

After the Spanish conquest, European designs were supplied to highly skilled Inca weavers who executed them with their own modifications, producing an effective hybrid style (good examples,

Boston Museum of Fine Arts).

Probably the technique was also current in the other highly evolved pre-Columbian cultures of Central America and Mexico; but climatic conditions there have been destructive of all textiles

Europe: "Gothic" Period.—Tapestry weaving does not appear in Europe until the middle "Gothic" period.—though the technique was probably used in classical Greece and Rome-the oldest surviving examples dating from the 12th century, of German provenance (Halberstadt cathedral). These show the "History of Abraham," "Christ and the Apostles," and "Charlemagne" amidst four classical scholars, all three in crude but vigorous drawing (B. Kurth, Deutschen Bildeppiche des Mittelalters, pp. 38-53, Pls. 3-11)

From the 14th century the history is continuous, and it is in

the Andean culture, while a vast amount of remains have come this phase, in the Paris shops, that the highest aesthetic level is attained, in a superb series-however maltreated by time and restorers-illustrating the Apocalypse, ordered in 1377 by the Duc d'Anjou from Nicolas Bataille, and based on cartoons by Jean de Bondol of Bruges (Angers Museum, impressive colour plates Demotte, La Tap Gothique, NY, 1921-24, Pls 2-14) A dignified panel shows King Arthur as one of the Seven Heroes (Sept Preux) (formerly Mackay collection, now in the Metropolitan Museum, NY), and a superb related series has been for some years in commercial hands but remains unexhibited and unpublished

From the 14th century tapestry was used not only for wall hangings in the houses of the rich, churches and secular public buildings, but also for covers for cushions, chairs, benches, tables, beds, for canopies, for horse and mule blankets, and sometimes

as rugs

In the 15th century the production centre shifts from Paris to the Low Countries, with major "schools," more or less successive yet overlapping, in Arras, Bruges, Tournai and Brussels No examples are known definitely assignable to Arras, but the town can perhaps be credited with a few damaged panels of the early 15th century, notably a series (in the Musée des Arts Decoratifs, Paris), with small-scale ladies and gentlemen amusing themselves outdoors, against a dark blue ground, strewn (rather sparsely here) with little flowering plants and bushes, a type which, with or without personages, but usually with at least animals and birds, continued for more than a century, and was known as menues verdures ("small verdures"), but is called in the modern market mille fleurs ("thousand flowers") These and scattered related pieces have a childlike charm, but are by no means great, and the same would be true of the contemporary Tournai style, known from remnants of a series illustrating the lives of St Piat and St Eleuthère made for Tournaı cathedral by Pierre Feré in 1402

Within two or three decades, however, a distinguished and energetic style had evolved there, impressively exemplified by the "Passion," of St. Mark's, Venice, which lay for generations disregarded under the basilica's roof (Dedalo, 1925) Tournai production continued important through the century, with variations in style and in divergent qualities, but characterized in general by vigorous silhouette drawing, effective narrative action and the necessary combination of carrying-power with detail-flowers, animals, architectural elements, textile designs and other costume elaborations-to provide surface enrichment and interest for closer examination. The weaving is competent, especially the deliberate exploitation of the technical peculiarity of slits in facial delineation; the colours are substantial to suit the heavy texture but clear and telling, and most of the dyes have held well, save for purples which have usually browned

The dukes of Burgundy, enthusiastic tapestry collectors, were good customers, employing especially the Greniers, but only remnants of these great sets have survived Famous existing sets include: the Beauvais cathedral "Life of St. Peter" (2460), the widely scattered "Trojan Wars" (based not on Homer but on Raoul Lefèvre's Recuyell, 1420, published in translation by Caxton, 1474, which derived from the much-discussed work of Dictys Cretensis); the Saragossa "Esther"; and numerous hunting and peasant scenes, the last very popular as part of the current vogue of pastoral romanticism. When the "school" was first defined (by Dr. Betty Kurth, Götische Bildteppiche, 1923), attributions to it were too sweeping, the then unrecognized Bruges "school," especially, becoming engulfed in it; but even as now reduced, the work of Tournai from the 15th and early 16th centuries remains of primary importance.

The identification of the cartoon painters has been generally neglected, though the possibility of deciphering their "signatures" in decorative inscriptions on the tapestries themselves has now been repeatedly demonstrated (P Ackerman, Rockefeller-McCormick Tapestries, Ap. I), and actually a critical comparative study defines in the four cities (Arras, Bruges, Tournai and Brussels, with Antwerp as a probable fifth) more than 60 masters, of unequal merit and productivity, of whom some 70% are known by name, with information on them available in guild and other documents Outstanding in Tournai are the LeOuien and LeFeire haps, with ribbons. families, and their respective pupils

But the most famous cartoon-painter whose work was executed on Tournaı looms was Beaudoum Bailleul, famous first because he was called on to design perhaps the most important series of the time, the "History of Gideon" provided by Philip the Good, duke of Burgundy, for his new Order of the Golden Fleece; and second because Bailleul had the unique honour of being mentioned by Jean Lemaire in his Couronne Margaritique. No trace of the "History of Gideon" has, as yet (1945), been found, but, contrary to the usual assumption, this does not mean that Bailleul's work has all disappeared, for it can be recognized in the two great panels from the "History of Clovis" in Reims cathedral (C. Loriquet. Tapisseries de la Cathédrale de Reims, Pls I, II), and likewise in several pieces in American collections

The most conspicuous family of weavers at the turn of the 15th century were the Poissoniers of Tournai, who produced some exotic series inspired by Vasco da Gama's trips to the Indies, and a new style of grande verdure suggested by Indian printed (or painted) cottons. An upper border treated as a bell-fringed valance is a striking recurring feature (Annual, Museum of Ait, Providence, R I

Many other Tournai tapestries have been assigned quite arbitrarily, without a shred of evidence, to a fictitious "school of Tours" or "of the Loire valley," and the uncritical repetition of this chance guess seriously impairs the value of most current histories of the art, in respect of this period. Actually, the Tours looms began producing only in the Renaissance, and were never really important.

The Bruges "school" has been completely overlooked, most of its productions being merged with those of Tournai, it displays a tonic uginess of real aesthetic force, typified by the Doria Palace (Rome) "Alexander." More elegant but still characteristic is the "Lady with the Unicorn" series, from the first decade of the 16th century, in the Cluny museum (Paris), widely familiar because various elements from it have been utilized for countless needlepoint patterns. Six allegories of the Virgin are gracefully presented, with the romantic worldliness typical of the period, against menue verdure on a light red ground

Borders are lacking on practically all the earlier tapestries (the "Passion" set in St. Mark's, Venice, is a fine exception), but rouleaux bearing descriptive texts often finish the top, or less often the bottom, while the multiple scenes are divided from each other and thus framed on the sides by slender columns, fre-

quently depicted as embossed gold and jewelled.

At the end of the 15th, and during the first quarter of the 16th centuries, the Brussels looms became very active, relying for cartoons, however, in the first instance on Antwerp painters. The type, markedly standardized, represents precisely the same taste as the funerary monument of Marguerite of Austria and Philippe de Savoie at Bourg-en-Bresse, and indeed the artist, known as Jean van Roome, who designed the tomb sculptures there, was responsible for a number of tapestry patrons. Various other nameable painters, however, used essentially the same manner. Thus a Maître Knoëst, known from a signatory inscription (M. Crick-Kuntziger, Maîts e Kuoëst, Liege, 1927), employed it in its most conventional form, while a long-discussed Maître Philippe, finally identified as Philippe de Mol (Apollo, 1931), was a more talented and finished practitioner.

The compositions in all this stylistic group are crowded with figures, often closely packed, in bouffant costumes but commonly unpatterned, so that the undifferentiated faces seem to be inset in a mass of heavily modelled stuffs. Mediocre examples abound (notably in the Spanish state collection: see Valencia de Don Juan, Tapices de la Corona . . . ; or Tormo y Monza et al., Los Tapices . . .), but a somewhat more distinctive use of the idiom is seen in the numerous, distributed series of the "Redemption," of which several large panels passed from the Hearst collection into the Metropolitan museum. An extensive "History of David" in the Cluny museum (Paris) shows a more elegant phase of the style. Throughout this class the border, only a few inches wide, follows a formula: a garland of roses, daisies, grapes, tied, per-

A modified and revitalized edition of this style, with more sensitive aesthetic imagination, was used by the well-known painter Bernard van Orley (c. 1490-1540) in the set of Hunts illustrating the months, commonly known as the "Hunts of Maximilian," though erroneously since they postdate that emperor. In a related manner, but revealing another personality, are panels illustrating the legend of Notre-Dame de Sabion, quite possibly the work of Bernard's brother, Philippe (Ackerman, Tapestry, the Muror of Civilization, p 371)

Both designers and weavers in all the Low Countries cities were organized in guilds, and especially the latter had careful regulations, carrying effective penalties for violation, to protect on the one hand the workers, and on the other, craft standards

During this period, colours are predominantly dark (20, 30 or as many as 40 shades being used in a composition); the texture tends to be coarse; silk if used at all is, as a rule, limited to highlights, and metal thread is rare

The Renaissance.-The placid quantity production which was bringing prosperity to Brussels guildsmen was suddenly disturbed in 1514 when Raphael executed a series illustrating the "Acts of the Apostles," to be woven by Pieter van Aelst of Brussels for Pope Leo X. The painter, secure in his own medium, made no concession to the unfamiliar medium for which he was working. Air, depth, light, all alien to the conventions for a flat, rough, heavy, woven hanging, envelope large, solidly modelled figures, with little respect either, on the one hand, for the silhouette needs of textile arts, or, on the other, for the detailed elaboration necessary to embellish a woven surface. But the new manner, erroneous though it largely was in this translation, succeeded so well, that it soon supplanted lingering descendants of the old local cartoon styles, and for the next 150 years Brussels turned out one set after another in stereotyped exaggerations of the Raphael innovations Whether it be Jacob from the Old Testament, or Scipio from Roman history, Charlemagne, Cyrus, Venus. or the Virtues and Vices, it is always a cluster of huge, over-dramatic figures rendered with exaggerated highlights in a perfunctory setting. Borders become wide and elaborate, with swags, scrolls, masks, trellises, urns, sculptures.

Shades are higher keyed with a preponderance of tans and yellows, gradations more gradual, strong colours like red are used chiefly for contrast (and have not infrequently faded, leaving the fabric still more weak and flat); silk is lavished on the more expensive qualities, increasing the unsubstantiality; and occasional pieces are heavily brocaded with gold, characteristically "basketwoven" for maximum ostentation.

The characteristic grande verdure of the time, a specialty of Enghien, has the field filled with huge scrolling serrated leaves reminiscent of the acanthus, sometimes with flowering plants, usually with birds and insects.

Among the outstanding Brussels families in the craft were the Pannemakers, Geubels and Leyniers, the last continuing into the 18th century. From 1528 on it was obligatory to weave the Brussels city mark-an escutcheon flanked by B's-in the selvage. and the shop mark also was usually inserted.

Scattered weavers in Paris, working in small ateliers of two or three looms during this period produced similar pieces.

The dominant influence in the Brussels industry in the 17th century was Rubens (1577-1640). His most famous set was the "Triumph of the Church" designed to the order of Archduchess Isabella of Spain (1627-28), but imitations and adaptations of his style were legion. The Renaissance qualities were pushed further: more monumentality, drama, bombast. Heavy, elaborate columns are often substituted for side borders. Additional weaving shops became important, such as those of the Hyckes, and the Raes.

Flemish Weavers Abroad .- The persecution of Flemish Protestants in the first half of the 16th century drove many craftsmen, including tapestry weavers, out of the country, while throughout that century others travelled seeking their fortunes, and such itinerant masters established more or less enduring shops, from England to Italy. Thus the Sheldon looms (E. A. B. Bannard and A J B. Wace, The Sheldon Tapestry Weavers, Oxford, 1928), while founded in the first half of the century by Richard Hyckes, who had learned the craft in Holland, was manned from 1557 on by Flemings and Englishmen, roughly half-and-half. The most individual creation was English county maps; the major output, cushion-covers in a provincial version of the Flemish Renaissance style. The enterprise expired in 1614.

Again, Flemish and French weavers collaborated in the court looms at Fontamebleau, founded by Francis I (c 1535), and carried on by Henri II. Surviving examples are few, but the best show far more delicate grace than contemporary work to the

north

When Gian Giacomo Trivulzio of Vigevano had a set of the Months made after cartoons by Bramantino (d. c. 1536) in 1509 (Sunda, in Bull Needle and Bobbin Club, 27), he employed as head weaver Benedetto da Milano, but the work shows a Flemish touch, so either Benedetto was an emigrant who had so journed in Milan, or was Flemish trained. The house of Este in Ferrara employed Flemish tapestry weavers most of the time from 1436 to 1507, often as repairers but also to execute cartoons by Italian artists (like Cosimo Tura), and the Karcher factory there from 1536 on was quite productive. Outstanding is a gay and elegant series decorated with playing button, made for Cardinal Hercules Gonzaga (1527-1563), after cartoons most likely by Battista Dossi, executed in silk and metal thread (Gulbenkian collection,

The first regular shop in Florence was established by a Brussels worker, Jan Rost, for Cosimo I de Medici (1510-1574), and production continued there, under various auspices and in fluctuating volume, to the middle of the 18th century Bronzino, Bachiacca, and Pontormo were among the noted painters who provided designs. The selvage city-mark was FF. The art never became important in Venice, and efforts elsewhere in Italy, though fairly numerous, were slight and sporadic until much later,

and that is equally true of Spain

Germany and Switzerland.-Meanwhile, from at least the middle of the 14th century, nuns in their cloisters and ladies in their castles scattered over Germany and Switzerland had been busy at their looms weaving illustrations of their legends, both religious and secular. These are for the most part rather smaller -long narrow strips, modest panels or cushion covers, coarse in texture, simple in shading, limited in palette but with clear strong colours effectively contrasted. Doll-like figures, monsters half fairy-tale and half heraldry, undulant banderolles with naive explanations in bold Gothic lettering, scrolling foliation, stiff flowerets, often combined with textile-patterned back-drops, combine to give a toyland charm (excellently presented by Kurth, Deutschen Bildteppiche . . . , with numerous admirable plates).

This domestic type continued into the 17th century, but in addition, various shops were established for longer or shorter periods by wandering Flemings, who achieved usually pseudoprimitive simplifications of their native style. An exception is the looms of Seeger Bombeck in the middle of the century, at Leipzig and Weimar (see also, H Schmitz, Buldteppiche).

Scandinavia. The Scandinavian countries likewise had a well established domestic, semi-amateur tradition of tapestry weaving, and it has proved unusually persistent. Fragments of tapestry were found, showing bits of figures and trees, in the Oseberg ship which had been used for a chieftain's tomb in the first half of the oth century. A section of a narrow horizontal strip in Oslo dating from the end of the 12th century shows two awkward but amusing figures against an arcade, illustrating April and May (see H. Dedekam, Baldesholtaeppet).

Examples assignable to the next five centuries are lacking, but from the 17th century on they are quite numerous, with four subjects often repeated: the "Adoration of the Magi," the "Mar-riage at Cana," "Salome Dancing," and the "Wise and Foolish Virgins." In the 19th century craft movement, systematic and successful efforts were made to revive the art, and serious artist craftsmen have produced sound and attractive work (see The American-Scandinavian Review, xv).

Meanwhile, in Sweden, at Kalmar, a shop was carried on for a

quarter of a century (to 1570) with Flemish weavers under ducal protection, and later Charles IX (1550-1611), as part of his planned economy for national prosperity, established a factory at Eskilstuna, which, however, hardly survived him (see J F. Bottiger, Svenska Statens Samling

French State Shops .- Henry IV of France, another king who planned his nation's economy, included in his program, which emphasized the luxury production that has ever since been industrially important in France, tapestry looms, and made his first step towards these by establishing a shop under Gérard Laurent in the Faubourg St. Antoine, which was later (1608) moved into the large gallery of the Louvre. Here, manned primarily by haute-lisseurs, it continued until 1671, producing, for example, a "History of Psyche" (which was also woven in Brussels and in the Gobelins), the "Lives of St Gervais and St. Protais," and

various other classical subjects Meanwhile at the turn of the 16th-17th centuries, two Flemish weavers had been brought over by government arrangement to establish basse-lisse looms (de la marche) in Paris: François de la Planche (or Franz van den Planken) and Marc Comans. Satisfactory working conditions were found for them in an old dve-factory on the outskirts of the city which had belonged to the Gobelin family, and so began the establishment commonly

known by that name, which has lasted ever since.

One of its first ambitious productions was an allegorical invention lauding Catherine de Medici under the guise of Artemisia (P. Ackerman, Tabestry, the Mirror of Civilization, ch x), the petits patrons chiefly by Antoine Caron (c. 1515-1593), who also collaborated with Laurent Guyot on a "History of Coriolanus" (first known weaving, 1600), and he in turn collaborated with Gaston Dumée on the long-repeated "Pastor Fido" set. Meanwhile the shop had a valuable asset in Rubens' "History of Constantine," and also they had revived a 16th century pastoral romance of enduring popularity, the "History of Gombaut and Macée," a symbolically typical peasant couple.

De la Planche died in 1627 and was succeeded by his son Raphael, who four years later broke with the Comans family and moved his share of the business to the Faubourg St. Germaindes-Près, leaving the Comans at the Gobelins Competition between the two thereafter repeatedly became bitter, but despite this, both continued to produce in considerable quantity, as well as good quality, until they were superseded in 1662 by the royal

Colbert, as usual alert to profitable possibilities, recruited skilled personnel, not only from the de la Planche and Comans shops, but also from the old Louvre enterprise, and thus established ateliers of both horizontal and vertical looms As director, he utilized Charles Le Brun (1610-1600), already experienced with tapestry in a brief-lived undertaking initiated at Maincy (1658-1663) by Colbert's ill-fated predecessor in the finance ministry, Nicolas Fouquet, and the Gobelins shops were chartered as a royal factory in 1667 (see M. Fenaille, Etat Générale . . . des Gobelins . .). Le Brun himself created the most important sets, such as

the "Elements," the "Seasons," and above all, the Louis XIV," supplemented by the "Royal Residences," 37 large panels altogether.

His rather portentous academicism dominated also the work of Antome and Charles Coypel (1661-1722, 1694-1752), and a halfdozen other designers who devoted themselves to classical and Biblical themes; but a lighter spirit was introduced by Claude Audran the Younger, with his talent for decorative inventions.

especially in the grotesque manner.

Louis XV (1710-1774), in his turn, was celebrated in a set of "Hunts" by Jean Baptiste Oudry (1686-1755). But the outstanding artist working for the factory during this reign was François Boucher (1703-1770), whose gay sophistication, presented with childlike charm yet polished elegance in delicious pastels, posed new problems for the weavers. Now indeed they must learn to paint with a bobbin, and to this end hundreds of new dyes were perfected for both wool and silk, until about 10,000 hues were available, to effect almost imperceptible tonal modulations; and interlocking of the wests was introduced to

render the transitions practically invasible, while the finest textures practical were used, from 70 to Occasionally as many as 40 warps to the inch A femmized frividous classicism imbued the "Loves of the Gods" (on which other pantiers also collaborated), the "Elements," the "Metamorphoses" Benard van Orley's "Hunts," revuevd and refutivished, proved popular.

Both Oudry and Boucher worked also for another major statesubsaduzed factory which had been carried on at Beauvas by two Flemmgs, Louis Hihart, for 20 years (1664–1654), and Philippe Behagle for 27 more (1684–1711) see J Badin, La Manufacture. de Beauvan) Oudry was attached to this factory as official painter under the next notable director, de Mérau (1722– 1734), and made for it a seuse of romantic "Hunts," "Pastordi

1734), and made for it a sense of romantic "Hunts," "Pastoral Amusements," four "Comedes of Moliter," and undet the subsequent director, Nicolas Besnier (1734-1753), his famous "Fables de La Fontaine" During this last regime, Boucher began to purvey to the looms (1756), creating the Italian fêtes, Chinese scenes, and vancius politely groomed pastoral scenes with titilating erotic overtones. The factory has always been especially noted for furniture and screen panels.

Meanwhile Charles Coypel produced the great "Don Quixote" set, brilliant decorations But by the end of the century, though technical standards were maintained, artistic deterioration had set in, and in the next 125 years it accelerated disastrously

Two new types of decorative panels appear at the height of production, the architectural composition and the grotesque. The former usually shows a complex arcade with massive balustrade on which stand urns of flowers and perhaps a for or two, as peacock with trailing tail. In the latter a nonstructural architectural tracery defines a complex of varied panels, framing a medley of festoons, scarves, vases, musical instruments, putti, masks, comedy-actors.

A third factory at Alubusson, which had been operated as a modest private undertaking for a century and a half, also was chartered as a royal factory in 1665, but practically all the output here was relatively coates maternal for the open market. The most effective pieces are pseudo-Chinese subjects. Coarse verdures, usually dull in colour, were made in quantities The Alubusson architectural panels either mittate those of the greater attelers, often with more complex elements and the addition of ammals, or depict a damasked wall hung with a painting or cluster of decorative objects, and garlands. The factory was especially successful in its production of carpets, with conventional or floral designs.

In all three shops the idea of tapestry as a woven picture was so predominant that the commonest border was a woven imitation of a carved and gilt frame

Apprentues in these factories, in order to attain the rank of master, had to produce a small specimen of their work with a difficult subject. Sometimes an elaborate vase of flowers was chosen, but often copies were made of paintings in the royal collection, and similar little pieces were made by the weavers in their own time to supplement their income.

their own time to supplement their motions.

Between World Wars I and II an effort at renewal was made in both the factories, but especially at Beauvais, by patronizing painters of the Paris Decadence school. The results were in kind

England.—The enterprise of Henry IV of France inspired James 1 of England to do likewise, and in 160-be set up the Mortlake shops. However, most Mortlake tapestries are "English" only by courtesy, for not alone the weavers, but also the cartoons were imported from Flanders, or the latter were painted by Flemings. The one notable exception as the "Battle of Soley" series in Hampton Court palace. In the 18th century, Flemish weavers in England (totably John Vanderbank in Soho) produced picturesque and distinctive grotesques in the Chinolisein

In 1872 William Morris, as part of his campaign to resuscitate handwork in order to combat the human fills resulting from machine industry, established tapestry-looms which in 1877 were moved to Merton Abbey, the name by which the shop was thereafter known. Cartoons with plant patterns were supplied by Morris himself, in his careful style, while figure pieces by Edwards.

Burne-Jones are typically pre-Raphaelesque Colours are clear but rather heavy, in the late Gothic taste, and nostalgic antiquarianism has hovered over the factory's work almost without alleviation ever since

Spain.—The Santa Barbara factory of Madrid, famous for its panels after Goya designs, was established in 1720, under a Flemmg, Jarob Vandergoten, who dued three years later, but was succeeded by his five sons, the whole family being basse-lisseurs. In the first half-century the work that issued from under their hands was all minature of current foregan syles, first Flemish or French, then Italian Later in the century, however, a local style was introduced by the painter Francesco Bayery v Sabias (1742-1795), whose cartoons present romantic illustrations of Spanish life in a hard but incluresque style

Finally Spain got a great painter who was viridly native in insight and expression, Francesco de Goya (1746-1828), and between 1776 and 1791 he supplied 45 cartonos. Intense, sharply characterized, dramatic without being theatrical, these designs, though they nake no special adjustment to the medium, are of such intrinsic interest that they are self-justifying, as they are self-existent.

The Low Countries.—Brussels continued to be the predomnant weaving centre of the Low Countries and the most characteristic cartoon painters were the two David Temers (1670-1690, 1638-1685), father and son, whose cartoons were repeated and style imitated throughout the 18th century. Their peasants, usually in small scale in a landscape setting, are entertaining, and the total effect is agreeable. Forest scenes treated as illustrative verdures were woven here and in other Flemish cities in great quantities. The industry died in Brussels in 1704.

Holland was never of pumary importance in the history of the industry, though the shop of François Spiennx hd competent work in the 16th century. The most characteristic product of the country is cushion covers with the armorial bearings of cities and city officials.

Other Countries.—Cardinal Barberini in Rome employed several Flemish weavers in 1633 or 1634, and the looms continued to produce almost to the end of the century, fluctuating between French and Flemish styles. Other looms established in 7710 in the Hospital of San Michele by the pope, which endured hinto the 19th century, alternated between woven copies of Italian paintings of the time, and imitations of Flemish verdures A factory founded in Naples in 1740, which continued into the 19th century, imitated contemporary French styles.

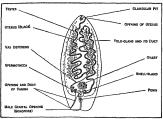
Peter the Great of Russia, as part of his program of modernizing his country in the French taste, established looms in his capital in 1716, with workers from the Gobelins The most striking productions are portraits of Catherine the Great.

In the United States, efforts were feeble In 1893 William Baumgarten, head of a decorating firm, settled Adubusson workers in New York primarily to imitate French tapestries In 1911 the painter, Albert Herter, created a shop to execute original designs and achieved some effective decorations (G. Hunter, Decorative Textlies, pp. 239-245)

Bullionaphily—No satisfactory comprehensive account is withinked and asket tipestime (or mideot textile in general). On Perevisian tappes of Asket tipestime (or mideot textile in general). On Perevisian tappes are the satisfactory and the satisfactory in green in Pereposal Textiles, Metropolitan museum (1930). All published accounts of the art during the 15th century in Europe are unsatisfactory, but for illustrations of "Godhir" pieces see. C. Louiquet, Textipisteries du Kite a Cathérdia de Reins (Partis, 1835); J. Guiffrey, Les Tajasserse du Kite a Godhira (Rustis, 1835); J. Guiffrey, Les Tajasserse du Kite a Godhira (Partis, 1835); J. B. Plains, La Tajasserse Godhirace (Partis, 2d, 1939), P. Ackerman, Catologue, Artis Cido, Chicago (1935) For a compilation, inclusive and relatively satisfactory in information on the whole of European tapestry history, with extensive references, see: H Gobel, Windlesphich, 6 vols (Lepzag, 1931–1941); All Catologue, Artis Cido, Chicago (1935) For a formation on the whole of European tapestry history, with extensive references, see: H Gobel, Windlesphich, 6 vols (Lepzag, 1931–1941); All Catologue, 1931–1941; Al

**TAPEWORMS** (cestodes or Cestoda), a class of endoparasitic Platyhelminthes (q v) in which the body is usually flattered and ribbon-like, and may be unisegmental or composed of a chain (strobila) of "segments" (proglotitides). In the latter

arthropod, but is probably to be looked upon as an adaptive device for the multiplication and dissemination of eggs. The number of segments in a complete strobila varies, in different species, from three or four to many hundreds, and the length of the chain from less than a millimetre to several metres. Each segment contains a separate set of reproductive organs, but the nervous and excre-



1-DIAGRAM ILLUSTRATING REPRODUCTIVE SYSTEM OF AMPHI LINA FOLIACEA. A CESTODE WORM, INFESTING THE BODY OF STURGEONS

tory systems are continuous throughout the chain Tapeworms have no mouth or alimentary canal, liquid food being presumably taken in by absorption through the body-wall. The adult worms are, with few exceptions, intestinal parasites of vertebrates. In almost all known cases the life-history involves an intermediate host and a somewhat complex metamorphosis.

General Morphology.-The body of the adult is covered externally by a cuticle, below which there is a cellular subcuticular layer All the internal organs are embedded in loose parenchymatous tissue. In most forms the parenchyma contains numerous "calcareous corpuscles"-small refringent nodules composed mainly of carbonate of lime The function of these is unknown Possibly they are merely stored-up excretory products The musculature consists mainly of longitudinal fibres, often in definite bundles and situated, for the most part, rather deeply in the parenchyma

In the segmented forms there is, at what is usually called the anterior end, a specialized "head" or scolex, serving as an organ of fixation This is generally provided with muscular suckers or variously modified sucker-like organs known as bothria or bothridia, and may, in addition, bear a central proboscis-like structure. the rostellum, which is commonly armed with cuticularized hooks The region nearest to the scolex is the zone of proliferation of new segments, which are, as a rule, continually being formed throughout the life of the worm. As they pass back along the strobila the segments become successively sexually mature and finally gravid, the most posterior usually containing little but a uterus crowded with eggs.

The nervous system consists of an intercrossing system of nerve-fibres and ganglionic cells at the anterior end (in the scolex in strobilate forms), and usually a single pair of main lateral nerve cords which are continuous throughout the body and without segmental ganglia. The excretory or "water-vascular" system is composed typically of two pairs (dorsal and ventral) of main longitudinal canals, continuous throughout the strobila and connected together anteriorly.

The animals are, with rare exceptions, hermaphrodite, each individual, or each segment in strobilate forms, being potentially male and female The male duct and the vagina may have separate apertures or may open side by side into a common atrium. There is considerable variation in the position of these openings In unsegmented forms they may be terminal, subterminal or ventral, while in segmented forms they may be on the ventral surface

case the segmentation is not comparable with that of an annelid or on one of the lateral margins of the segment. The essential organs of the genital apparatus do not differ greatly from those of other groups of Platyhelminthes The oviduct connected with the ovary and its associated glands, and with the inner end of the vagina, leads into a uterus in which the fertilized eggs are accumulated

Classification .- There have been considerable changes during recent years in the systematic arrangement of this group. The older division into unsegmented forms (Monozoa) and segmented forms (Merozoa) has been generally abandoned, since it does not correspond with an arrangement based on internal anatomy It is now customary to divide the Cestoda into two main subclasses, the Cestodana and the Eucestoda or cestodes proper The former group contains two families of unsegmented forms, parasitic in fishes.

- (1) Amphilimdae, with a protiusible proboscis at the anterior end and a very long uterus traversing the body length three times and opening near the anterior end, whereas male and vaginal pores are posterior.
- (2) Gyrocotylidae, with a frilled margin, posterior ruffled rosette, and uterine, male and vaginal pores in the anterior body

The Eucestoda include a large number of the more typical tapeworms, sometimes unsegmented but usually with a long ribbonlike body divided into a few to many segments and with a scolex There are five main orders although others may be necessitated by recent findings of unusual species

I Phyllobothrioidea These are intestinal parasites of elasmobranch fishes and are characterized by the four mobile, often large and leaflike bothridia which may be armed with hooks or subdivided by senta

II. Diphyllidea This order includes only the genus Echino-bothrium, parasitic in elasmobranch fishes These are segmented tapeworms of not more than 20 segments with a scolex having

two bothridia and with a spiny "neck" region behind the scolex III Tetrarhynchoidea These tapeworms, also parasitic in the intestine of elasmobranch fishes, are distinguished by the four protrusible proboscides covered with hooks or spines that can be everted through four openings on the scolex. The scolex in addition has four bothridia or bothria

IV Dibothriocephaloidea This order, inhabiting the intestine of various vertebrates, includes a number of unsegmented tapeworms such as Caryophyllaeus and Archigetus and also many segmented types. The scolex is usually provided with two shallow bothridia Heie belongs Diphyllobothrium latum, a human parasite whose complicated life history is discussed below.

V Taenioidea This is the largest and most important order, including all the more common tapeworms of higher vertebrates The body is always segmented and the scolex bears four true suckers or acetabula, often with the addition of a rostrellum armed with hooks. The life cycle includes a bladder-worm stage (see below).

## LIFE HISTORY

Development.-The eggs of Cestodes are usually enclosed in two membranes, one of which may show cuticularized thickening, forming a hard "shell." In the Bothriocephalidea the shell is provided with an operculum at one pole, like that of a digenetic Trematode The embryo, at the stage when it is ready to hatch. is a spherical or oval mass of cells (called an "onchosphere"), provided at one pole with cuticularized hooks, of which in most species there are three pairs-hence the name "hexacanth embryo." In certain Amphilinoinei, however, the embryo has ten hooks. The embryonic hooks are used as levers, chiefly in burrowing among the tissues of the intermediate host.

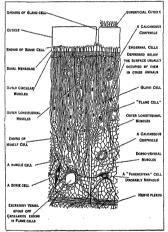
In some of the Dibothriocephaloidea the embryo is provided with an external ciliated envelope and hatches in water, where it swims about by means of its cilia. In the human parasite Diphyllobothrium latum, for example, the ciliated embryo is at first free in fresh water and is then swallowed by a small copepod (Cyclops or Diaptomus). Shedding its ciliated coat, the embryo penetrates into the body-cavity of the copepod, and develops into a more elongate form called the procercoid If the copepod is swallowed by a suitable fish, such as a pike, perch or trout, the procercoid, develops further among its tissues into a pherocercoid, and is then infective for the final host, infection being acquired by eating the fish in a raw or impetfectly cooked state

For the development of this species, therefore, and of others related to it, two successive changes of host are required. The larval forms known as Sparganum, which occur in many land vertebrates, including man, have been shown to be the plerocer-

coids of Diphyllobothrum.

The larval forms of Tetrarhynchoidea, resembling the scolex of the adult, without the strobila, or with only an unsegmented appendage, occur encysted among the ussues of various marine

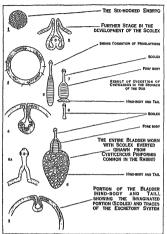
animals, chiefly teleostean fishes
Among the best known of the Taeniidea the developmental Instory is quite different. The human parasite Teema solutum may be taken as typical. If an egg of this worm be swallowed by the proper intermediate host (in this case the pig) the beacanth empty is liberated in the intestine and proceeds to pierce the intestinal wall, wandering about among the tissues and usually coming orest among the muscles. Here it grows into a small bladder, in opposite to the embryonic hooks. At the bottom of this invagination five thickenings appear, destined to become the four sucknown and the median rostellum. Finally the hooks are developed on the rostellum, and the bladder worm, or cystizeress, is fully formed



TROW LANKESTER, "TREATHER OR ZOOLOGY" (BLACK)
Fig. 2.—MICROSCÓPIC STRUCTURE OF A TAPEWORM. A PORTION OF A
TRANSVERSE SECTION THROUGH THE BODY-WALL OF LIGULA INTESTINALIS

Should this be ingested by a human being with raw or imagefactly concept pox; five "beat" is every animated and attaches itself to the limit of the littesthie, and the "neck" joining it to the bladder beignt to from its series of progletides. Another human parasite, Tomis signate, has a similar development, but is without hooks, and makes use of the ora si memerical the lost.

Many modifications occur in the form of the bladder worm, but the essential features of the development are the same throughout the order. In some forms the ougunal bladder worm gives rate to several or many scolices instead of the usual single scoley, a phase of asevual multiplication thus being introduced in the aud-onastic of the sheer (Teamus on Multicest multices).



FROM LANGESTER, "THEATHER ON EGOAGET (BLACE)

TEG. 3.—DEVELOPMENT OF A TAENIID TAPEWORM (TAENIA PISIFORMIS)

1-5, development of the six-hooked embrys, within the intermediate host, and successive stages in the formation of the head, 6-5, weighted the complete of the co

the bladder worm, which occurs in the brain and is often called a Coenurus, gives rise to numerous scolices, each capable of developing into an adult worm if ingested by a dog or other suitable carnivorous host.

In Echmococcus granulosus this phase of multiplication is elaborated still further, the original embryo developing in the intermediate host into a large and relatively thin-walled bladder or cyst ("hydauta"), from the inner surface of which there are budded off a large number of "brood-capsules," each containing from 10 to 30 scolices. Daughter cysts may also be budded off, and these may give rise to further scolices, so that altogether a very large number of potential adult worms may be formed from the original embryo.

This worm occurs, in the hydatid stage, in the liver and other organs of a large number of hosts, including man, sheep, ox and pig The adult is a very small worm with only three or four segments, and occurs in the intestine of the dog, wolf and fox,

As may be noted from the examples already given, the intermediate host is usually an animal likely to be devoured by the final host. Thus the dog harbours severat Taenioid tapeworms whose intermediate hosts are rabbits and sheep. The cysticerus of Taenia taeniaeformis of the cat occurs in rats and mice A number of species of Hymenolepis parasitic, as adults, in ducks and geese make use of small fresh-water Entomostrace such as Cyclops and Cybris as intermediate hosts Houseflies and earthworms are the vehicles of infection for several of the tapeworms of fowls Dipybdum caunum, a common parasite of the dog and cat, passes its cysticercus stage in fleas and in the louse, Trichodectes The louse is capable of swallowing the eggs of the worm, but the adult fles cannot do so Fleas become infected during their larval period, the eggs, when swallowed, hatching in the hinder part of the intesting and the embryo boring through its wall into the bodycavity Here they do not continue their development until the pupal stage has been passed, the cysticerci becoming fully formed only in the adult flea Infection is acquired by dogs and cats, and accidentally by man, through swallowing fleas containing them

The larvae of many of the Phyllobothrioidea, whose adult forms are found in the spiral valve region of the intestine of sharks and rays occur among the tissues of other marine animals. One such larval form (apparently belonging to a species of Tylocephalum) occurs in the pearl-oyster, and is believed to be one of the princinal causes of the production of pearls This, apparently, takes place only in the event of the death of the parasite from some unknown cause

Economic Importance.-From the fact that taneworms often occur in enormous numbers in the intestine of an apparently perfectly healthy animal, it is clear that they are not always definitely injurious to their hosts. As parasites of man and of domestic animals, however, they have considerable importance. As a rule their ill effects are most manifest in young animals, and they are sometimes responsible for serious digestive and nervous disturbances, and even for severe losses among stock and poultry. The adult worms, besides depriving the host of a certain amount of nutrient material, secrete substances which have been shown to be definitely toxic in many instances, when injected into the blood or body-cavity of experimental animals. The same is true of the larval forms, and certain changes take place in the blood cells of infested animals which indicate that some of these poisons are normally absorbed into the system. It is probable, however, by the migrations of the laivae within the body, and the secondary invasions by pathogenic organisms for which they prepare the way, that the most serious harm is

Only in exceptional cases, such as the invasion of the brain by the hydatid of Echinococcus, are tapeworms really dangerous (H A B.: L H H)

TAPIOCA (a native Brazilian word), a farinaceous food substance prepared from cassava starch, the product of the large tuberous roots of the cassava or manioc plant, (See Cassava) Cassava starch, separated from the fibrous and nitrogenous constituents of the roots, is spread, while in a moist condition, upon iron plates, and with constant stirring exposed to such heat as causes a partial rupture of the starch granules, which agglomerate into irregular pellets, becoming hard and translucent when cooled. In this condition the starch forms the tapioca of commerce, a light, pleasant and digestible food, much used in puddings and as a thickener for soups.

TAPIR, the name for large woodland mammals, forming the family Tapiridae of the order Perissodactyla (q.v), with four front and three hind toes, massively built and with the nose and upper lip produced to form a short flexible trunk. Four species

inhabit South and Central America, and one, Tapirus indicus, the Malay region. The latter is the largest, and is readily recognized by its black fore- and hindquarters and white body. It may stand 3 ft. 6 in at the shoulder and is solitary, shy, nocturnal and inoffensive, frequenting deep forests in the neighbourhood of THE BRAZILIAN TAPIR (TAPIRUS water. Its diet is exclusively vegetarian. The American spe- TRAL AND SOUTH AMERICA cies are all nearly uniform dark brown when adult, but the young,



TERRESTRIS) FOUND ONLY IN CEN-

like those of T. indicus, are spotted and striped with white. The best-known new world form is T, terrestris of Brazil and Para-

guay. In habits it and the other three species resemble the Asiatic The peculial distribution of the tapirs is explained by the form presence of fossil forms in Europe, China and the U.S.A. in Miocene, Phocene and, in the two latter localities, Pleistocene forma-

TAPPAN, ARTHUR (1786-1865), U.S. philanthropist and abolitionist, was born on May 22, 1786, at Northampton, Mass He was of a stem and pious nature and often championed humanitarian and religious causes Among those organizations to which he contributed were the American Bible society, the American Missionary society and the American Tract society. He donated money to establish Kenyon college, Gambier, O, and Oberlin college, Oberlin, O

Tappan was an active supporter of various antislave movements. He joined the American Colonization society, later withdrawing in order to work for the abolition of slavery in the U.S. In 1840 he became president of the American and Foreign Anti-Slavery society and founded the American and Foreign Anti-Slavery Reporter He advocated the abolition of slavery through political means within the constitution, and in 1840 and 1844 he supported the Liberty party's candidate for president, James G Birney. He died in New Haven, Conn , on July 23, 1865.

TAPPAN, EVA MARCH (1854-1930), U.S. teacher and author, was born on Dec 26 in Blackstone, Mass She was only six years old when her father, Rev Edmund March Tappan, died. From that time she received her early education in several seminaries where her mother was a member of the faculty. After graduation from Vassar college, Poughkeepsie, NY, in 1875 Miss Tappan went to Wheaton seminary, Norton, Mass, where she taught from 1875 to 1880 Between 1884 and 1894 she was associate principal of Raymond academy, Camden, N J The University of Pennsylvania awarded her an AM, degree in 1895 and a Ph D the following year From 1897 to 1904 she taught English at the English high school, Worcester, Mass In 1904 she retired from active teaching and, until her death, devoted herself exclusively to writing

Miss Tappan's dedication to the education of young people can be seen reflected in the nature and scope of her writing book, published in 1896, was entitled Charles Lamb, the Man and the Author. In 1900 and 1901 she published In the Days of Alfred the Great. In the Days of William the Conqueror, Old Ballads an Prose and England's Story Among her books on history, many of which were used as textbooks in grade schools and high schools, may be recounted Our Country's Story (1902). In the Days of Queen Victoria (1903), The Story of the Greek People (1908). Our European Ancestors (1918) and The Story of Our Constitution (1922). The story of her own early life was recorded in Ella. a Little Schoolgerl of the Sixties (1923). Her stories were written and organized so that children could

easily understand them; her style was clear and concise.

After 1911, when her mother died, she seldom left her home and continued writing until her death on Jan. 29, 1930, at Worcester, Mass.

TAPPET is an intermediary fitment which converts the action of a rotary cam or lifter into a linear motion, with a return movement by gravity or spring pressure. The largest tapnets are those in the one stamp batteries, which raise a weight of sometimes as much as a ton. The tappets in internal-combustion engines require nice regulation to ensure obtaining the full power of the engine and to maintain silence in the valve operation. (See INTERNAL COMBUSTION ENGINES: MOTOR CAR.)

TAPS AND DIES: see Machine Tools

TAPTI, a river of western India. It rises in Betul district of Madhya Pradesh, flows westward between two spurs of the Satpura hills, across the plateau of Khandesh, and thence through the plain of Surat to the Arabian sea. It has a total length of 450 mi. and drains an area of 30,000 sq mi For the last 32 mi. it is tidal, but is only navigable by small vessels; the port of Swally at its mouth, famous in Angle-Portuguese history, is now deserted because of silting.

TAR: see CAMPHOR; COAL TAR; GAS MANUFACTURE; NAVAL STORES; TARS, LOW-TEMPERATURE,

TARA, a village of Co Meath, Ireland It is celebrated for the hill of Tara, which was for many centuries a royal residence and the scene of great meetings of the people. The soliated hill, upon which five highroads converged, is about 510 ft. in height. On it are ax raths or incular earthworks, the largest of which, the king's 18th (rath-na-riogh), encloses other works, including the formath or meeting place, a flat-topped mound. On this (but not in its original position) stands a pillar stone, said to be the stone of destury on which the Irish kings were crowned. An oblong enclosure, 750 ft. in length by 46 ft in breadth, formed of earthworks, with entrances at intervals on each side, represents the banqueting hall. Extensive excavations were begun in 1953 with the assistance of the Irish woverment.

In the middle of the 3rd century AD King Cormac Mac Art is said to have founded there schools of military science, law and literature In the time of St Patrick, Tara was a great centre of pre-Christian religious rites, and about 560 it was abandoned as a roval residence.

There the Danes were defeated in 980, and in 1843 the hill of Tara was the scene of one of Daniel O'Connell's mass meetings to demand repeal of the legislative union (Aug 15)

TARAFA ('Amr shu ul- 'Ahd ul-Bakrī), 'Arahan poet of the dift century, who, after a wall dan dissapated youth spent in Barran, left his native land after peace had been established between the tribes of Bakr and Taghib and went with his uncle Matlamis, who was also a poet, to the court of the king of Hira, 'Amr ibn Hind (d. 568-569), and there became companion to the king's brother Haiving reduciled the king in some verses, he was sent with a letter to the rule of 8 hären; and in accordance with instructions contained in the letter was buried alive. One of his neems is contained in the Modelbat.

His collected works were published in W. Ahlwardt's The Diwans of the Six Ancient Arabic Poets (London, 1870) Some of his poems were translated into Latin by B Vandenhoff

(Berlin, 1895).

TARAI (TERAI) (i.e., "moist land"), the name of the submontane stip of marshy jungle stretching beneath the lower ranges of the Humalayas in northern India. This strip may be said to extend roughly from the Juman raver on the west to the Brahmaputra on the east, and a large portion of it lies within Nepal. The term, however, is now officially confined to a subdivision of Naim Tal district in Uttar Fradesh. At its northern edge, where the waterless forest tract of the binder (coarse graved deposits) ends, a least of the coarse of the coarse of the coarse of the coarse such as the coarse of the coarse of the coarse of the coarse set the Tain. The Gogra is the great traver of the Taia proper and is novigable from the Himalayan foothills. Elephants, tigers, bears, loopards and other wild animals are found

Everywhere it is most unhealthful, inhabited only by tribes who seem immune to malaria, though large tracts were drained for cultivation and settled with agriculturists from the plains.

TARANCHI. The Taranchi or Ili-Tatars, numbering about too, ooo are a branch of the Iranna Turks, and hve in Semirechie and in Transcaspia, whither they migrated when Kulja passed under Chinese rule. They are closely related to the Sart is religion, culture and language, differing from them principally in allowing their women more freedom.

anowing inter women more freecom.

TARANTELLA, Italian dame of a rapid whirling character, popularly believed to be a cure for the supposed posonous sting of the threat and the properties of the words and the properties of the control of the cont

TARANTO (anc. Tarentum, q.v.), a seaport of Apulla, Italy, and the capital of the province of Taranto 50 mi. from Lecce W. by N. by road, and 68 mi. by rail (44 mi. W. by S. from Brindis)

Pop (1951) 167,166 (commune) The city propes is situated on a rocky sidead 5f ft above sea level, which, in ancient thick, in accent they was a pennsula, the isthmus on the west having been cut through by Ferdmand I of Aragon. This island separates the Gulf of Taranto (Mar Grande) from the deep inlet of the Mar Piccolo, and is sheltered by two other flat islands, San Pietro and

The Strada Garibaldi along the Mar Piccolo is inhabited by fishermen whose language retains traces of Greek The cathedral dedicated to San Cataldo, an Irish bishop, has externally some remains of Saraceauc Gothic, internally it has been completely modernized (retaining however 16 ancient columns in the nave) and the shrine of the patron saint has been termed "an orgy of coccoo" (1657). It has a crypt of the 6th or 7th century There is a museum in the former convent of San Pasquale, with an especially fine collection of vases, terra cottas, and silverware, jewellery, Greek statuary, mosaics, etc., from Taranto and other sites in Anolias.

Adjacent is the Palazzo degli Uffizi, containing various public offices To the east, across the swing bridge over the channel connecting the Mar Grande with the Mar Piccolo is the new part of the town, on the site of the main part of the ancient city, extending as far as the arsenal and even beyond while the Boyo, with the railway station, lies to the west of the island There, too. is the commercial harbour. The chief industry is the cultivation of oysters in the Mar Piccolo, besides oysters Taranto carries on a large trade in cozze, a species of large black mussel, which is packed in barrels with a special sauce. Excellent fish abound in the Mar Piccolo, 93 different species being found. The ebb and flow of the tide is distinctly visible there. Taranto being one of the few places in the Mediterranean where it is perceptible. In 1861 the strategic importance of Taranto was recognized, and the arsenal is the most important in Italy after Spezia. It extends for a mile and a half along the southern coast of the Mar Piccolo, its chief basin

At Taranto the Italians suffered their first major naval losses of World War II. On the night of Nov. 11—12, 1940, British torpedo planes attacked a group of ships there, damaging two crusers, two or three battleships and two fleet auxiliary vessels In the fall of 1943 the city was occupied by British troops

In the rate of 1933 use 15 west complete of printial toppe 1 no 1972. Taranto was entirely destroyed by the Saraces, of the 1972 of the 19

1577. The tarantula (see below), inhabits the neighbourhood of Taranto. The wild dance, called tarantella~(q~v.), was supposed, by causing perspiration, to drive out the poison of the bite.

TARANTULA, strictly speaking, a large spader (Locosa treartula), which takes its name from the town of Taranto (Tarentum) in Apulia, near which it occurs and where it was formerly believed to be the cause of the malady known as "tarantism." This spider belongs to the family Lycosidae, and has numerous allies in various parts of the world. The tarantula, hike all its allies, spins no web as a snare but catches its prey by speed of foot. It lives on dry, well-drained ground, and digs a deep burrow lined with slik to prevent its falling in. In the winter it covers the orfice with slik, and hiberantes in a dormant condition It also guards its occoon and young in the burrow. It lives for several years.

The sexes are approximately the same size but do not surpass I in. in length of body. Like all spiders, the tarantula possesses poison glands in its jaws, but a particle of the secretion of these

Tarantula is often applied indiscriminately to many large spiders not related to Lycosa tarantula, and to at least one Arachmid belonging to a distinct order, Galeodes luscasu of the Egyptian desert In English-speaking parts of the American continent, the Avicularidae, oi "bird-eating" spiders, much larger than any Lycosidae, are called tarantulas Most of them are not poisonous to man

TARAPACÁ, the northernmost province of Chile, bounded N. by Peru, E by Bolivia, S by Antofagasta and W by the Pacific Area 21,346 sq mi. Pop. (1952) 102,789 It is part of the rainless desert region of the Pacific coast of South America and is without water except at the base of the Andes, where streams flow down into the sands and are lost. In some of these places there is vegetation and water enough to support small settlemente

The wealth of Tarapacá is in its immense deposits of nitrate of soda (found on the Pampa de Tamarugal, a broad desert plateau between the coast range and the Andes, which has an elevation of about 3,000 ft ) The mining and preparation of nitrate of soda for export has provided an uncertain livelihood for the population of this province Silver is mined near Iquique, the capital Unfavourable world markets for nitrate caused a decline in population The principal ports of the province are Pisagua, Iquique and Arica, from the first two of which "nitrate railways' tun inland to the deposits.

Tarapacá was ceded to Chile by Peru after the war of 1879-83 and was organized as a province in 1884

TARARE, a town of east-central France, in the department of Rhône, on the Turdine, 28 mi W N W, of Lyons by rail Pop. (1946) 10,142. It is the centre of a region engaged in the production of muslins, tarletans, embroidery and silk plush, and in printing, bleaching and other subsidiary processes The manufacture of muslins was introduced from Switzerland in 1756 The manufacture of Swiss cotton varns and crochet embroidenes was introduced at the end of the 18th century; at the beginning of the 10th figured stuffs, openworks and zephyrs were first produced

The manufacture of silk plush for hats and machine-made velvets was set up toward the end of the 19th century.

TARASCANS, the principal native people of the southwest Mexican state of Michoacan, who term themselves and their language Purépecha. An expanding independent nation at the time of the Spanish conquest, most of the Tarascans by the 20th century were confined to the pine and oak clad highlands dotted with volcanic cones and lakes west from Morelia and Lake Pátzcuaro and north from Uruapan and Paricutin volcano Despite a culture that is more old world than native, there is a marked retention of racial identity; and as of 1050 there were approximately 60,000 persons of Purépecha speech, of which perhaps one-quarter were monolingual This language constitutes a linguistic family with no known relatives Tarascan archaeology and history have been little studied, but artifacts and colonial accounts indicate that this group was the equal or superior of their Mexican contemporaries m the working of feathers, shell, wood, metal and stone, and in military prowess, and only in architectonics were they greatly inferior.

The Tarascans have no special tribal organization, but participate in much the same political, economic and religious organizations as do their mestizo neighbours. Agriculture is dominant: maize and wheat occupy most of the acreage, followed by pulses, cucurbits, barley, cabbage and chile pepper. Livestock includes chickens, oxen, pigs, sheep, beehives, burros and turkeys. Probably the turkey was domesticated by the Tarascans. In the mountain or sierra region forest products are quite important, and there . the wooden house or troje prevails. Among the leading cottage handicrafts are woodworking, pottery making, and weaving. Many Tarascans go as braceros to the United States, and most of the nearly 120 communities have at least one man who has lived in the United States.

Among the leading communities are the Sierra "capital"

glands is not more virulent than that of other spiders of the same Paracho, strongly Indian Cherán and Santa Fe, and the sentimentally important former capitals Tzintzuntzan, Ihuatzio and Patzcuaro

TRIEUZIAO

BIRLIOGARTIY — J. A. Mason, "The Native Languages of Middle America," in The Mays and Their Neighbor, (1904), and endete at Miller et al., Lot Tarascoi (Mascon, 1904), in Transaci Region, New Sketch of Geography and pp. 197-108. (June 1944); Smithsonian Institution, Publications of the Institute of Social Astropology, no. 1, 3, 6, 7, 11 (1944-1951), M. Sterm, Englying Uraspare (Marcio, 1945), and D. Goldon, Our Son Miller (1946), and D. Goldon, Our Son Miller (1947), and D. Goldon, catebec (Mexico, 1952).

TARASCON, a town of southeastern France, in the department of Bouches-du-Rhône, 62 mi. N.W. of Marseilles by rail. Pop (1946) 5,813 Tarascon stands on the left bank of the Rhône opposite Beaucaire, with which it is connected by a railway bridge and a suspension bridge The church of St Martha, built in 1187-97 on the ruins of a Roman temple and rebuilt in 1379-1449, has a Gothic spire and interesting tombs in the crypt. Of the original building there remain a porch and a side portal flanked by marble columns with capitals like those of St Trophimus at Arles. The former leads to the crypt, where are the tombs of St. Martha (1658), Jean de Gossa, governor of Provence under King René, and Louis II, king of Provence. The castle, built on a rock, was begun by Count Louis II in the 14th century and finished by King René in the 15th. It contains a turret stair and a chapel entrance, both 15th-century, and fine wooden ceilings The building is now used as a prison. The hôtel de ville dates from the 17th century.

The civil court of the arrondissement of Arles is situated at Tarascon, which also possesses a commercial court, and fine cavalry barracks. The so-called Arles sausages are made here, and there is trade in fruit and early vegetables. In Tartarin de Tarascon Alphonse Daudet has satirized the provincial life of Tarascon, which has a tribunal of commerce and the fair of Beaucaire. It formerly had the two fêtes of La Tarasque, the latter in celebration of St. Martha's deliverance of the town from a legendary monster of that name King René presided in 1469, and grand exhibitions of costume and strange ceremonies take place during the two days of the festival. Tarascon was originally a settlement of the Massahots, built on an island of the Rhône The mediaeval castle, where Pope Urban II lived in 1096, was built on the ruins of a Roman camp Tarascon preserved the municipal institutions granted it by the Romans, and of the absolute power claimed by the counts of Provence only recognized the rights of sovereignty.

TARASP-SCHULS, a Swiss railway station in the lower Engadine, giving its name to a group of villages of which Schuls, the capital of the lower Engadine, situated about 160 ft, above the Inn river, is the chief. Tarasp is famed for its springs, which have been known since the middle ages, but it lies low in the valley and many visitors live at Vulpera, above the south bank of the Inn river.

Above the village of Taiasp is the early mediaeval castle of that name, heavily restored as in 17th century style in recent years. The neighbourhood is famed for its beauty, TARAXACUM: see DANDELION.

TARBELL, EDMUND C. (1862-1938), American artist, was born at West Groton, Mass., on April 26, 1862. He was a pupil of the schools of the Boston Museum of Fine Arts and of Boulanger and Lefebvre, Paris, and became a distinguished painter of the landscape, of the figure, and of portrait. He won the gold medal of the National Academy of Design in 1908, the bronze, silver and gold medals of the Carnegie International exhibition at Pittsburgh, Pa., and various other important prizes and medals. He is represented in the museums of many American cities. In 1906 he was elected a National Academician, besides being a member of the Ten American Painters. He was instructor of painting in the Boston Museum of Fine Arts, and was later principal of the Corcoran School of Art, Washington, D.C., and chairman of the council of the school of the Museum of Fine Arts. Boston, Massachusetts.

See F W Coburn, "Edmund C. Tarbell," International Studio, vol xxxii, pp 75-77 (1907), and J. E D Trask, "About Tarbell," Amer. Mag of Art, vol 1x, pp 217-228 (1918).

TARBERT, fishing village at the head of East Loch Tarbert, an arm of the sea on the west show of the mouth of Lock Fync. Argyllshire, Scotland. Pop. (1931) 1,184. The harbour, though it has a narrow entrance, so shoulted yafe and can shelter the whole Loch Fyne fishing fleet. The pier for the passenger steamers that call there is about 4 m from the village. The herring fishery—including a large tade in curing—forms the only industry Overlooking the harbour are the uilus of a castle built by Robert Bruce in 1326. The ishtmus connecting the districts of Knapdale and Knityre is little more than one mile wide, and boats used to be dragged across to the head of West Loch Tarbert, a narrow sea loch hearly ten miles long.

TARBES, a town of southwestern France, capital of the department of Hautes-Pyrénées, 98 mi WSW of Toulouse on the Southern railway. Pop (1936) 34,749. Under the Roman dominion Turba, which was about 11 mi SE of the present town of Tarbes, was the capital of the Bigerriones, one of the states of Novempopulania The bishopric of Tarbes dates from the 5th century, and in feudal times its bishops held the chief temporal authority, that of the counts of Bigorre, of which Tarbes was the capital, being limited to the quarter of the town where their castle was built. The English held the town from 1360 to 1406. In 1569-70 Tarbes was twice taken by Gabriel, count of Montgomery, and the inhabitants driven out, but in August 1570 the peace of St. Germain allowed them to return. Subsequently Tarbes was several times taken and retaken, and a number of the inhabitants of Bigorre were forced to take refuge in Spain, but in 1504 the members of the League were finally expelled. The English, under Wellington, gained a victory over the French near Tarbes in 1814. Tarbes stands in a fertile plain, stretching to the Pyrenees, on the left bank of the Adour, streams from which are conducted through the town. The lines of the Southern railway from Morcenx to Bagnères-de-Bigorre and Lourdes and from Toulouse to Bayonne cross there. Chief among the many open spaces is the Jardin Massey (35 acres), given to his native town by a director of the gardens of Versailles and containing a museum of paintings and antiquities. Near a small lake stands a cloister (15th century) brought from the abbey of St Sever-de-Rustan, 14 mi. N.E. of Tarbes. The architecture of the cathedral, Notre-Dame-de-la-Sède, is heavy, but the cupola of the transept (14th century), and a rose window of the 13th century, in the north transept, are interesting. There is also a modernized Carmelite church of the 13th century.

Tarbes is the seat of a bishoptic under the archbishop of Auch, of a prefecture, tribunals of first instance and of commerce, a chamber of commerce and a board of trade-arbitrators. Tarbes has an important stud for the breeding of Anglo-Arabian hospis, much used by light cavalry. The industrial establishments include transners, potteries, saw-mills and turners' shops. There are immediately and the statements are included that the statements and the statements are included that the statements are included to the statement of the

portant fairs and markets.

TARBUSH, the close-fitting, flat-topped and brimless cap, in shape like a truncated cone, made of felt or cloth, worn by Mohammedan men throughout the east either as separate headgear of forming the inner part of the turban. It used to be worn as the badge of a Turkish subject in Turkey and Egypt, where it was red in colour with a black or blue silk tassel. It is the same as the "fee." In September 1928, Turkish citizens were forbidden to wear the fee, under severe re-natites. by President Kemal Pashs

the "Res." In September 1925, 1ursish cutzens were romoned of wear the feet, under severe penalties, by President Kernal Pashs TARDE, GABRIEL (1843-1094), French sociologist. He was professor of modern philosophy at the College de France, Paris, and an official of the ministry of justice. For a bibliography of his many important works see M. M. Davis, Psychological Interpretations of Society (1909). His Psychologic économique (1909) was remained in the English as Social Large.

TARDIEU, ANDRÉ PIERRE GABRIEL AMÉDÉE (1876-1945), French politician and writer, was born in Paris on Sept. 22, 2876. Educated at the École Normale Supérieure, he was châf de cabinet to Waldeck-Rousseau from 1899 to 1902. From 1902 to 1014 he Jectured at the École des Sciences Politiques and

the École Supérieure de la Guerre, and was foreign news editro Le Tembe. Entering the chamber of deputies in 194 he acted as special commissioner in the United States (1947–18), member of the Peace conference (1958–19), and minister of the liberated regions (1919–20). As captain of Chasseuris between 1944 and 1916, he was wounded and three times mentioned in dispatches. At the Peace conference (1949) he had a considerable share in darfring the political and territorial clauses. He presided over the Committee of Five which drafted the Allied reply to the German observations on the draft terms of the peace treaty Tardieu also presided over the Alsace-Lorraine committee, the Committee tee of the Saar and that of the execution of the treaty

Tardicu's political attitude was characterized by his inflexible attachment to the policy of Clemenceau, with whom he was associated in the closest collaboration for war and for peace. Three times in succession, between 1919 and 1924, he refused to enter the government, in order to maintain his independent defense of this policy. As director of the Echo National, the dialy paper founded by Clemenceau and himself, he waged a facree war, in foreign affairs, against the steps which paved the way for the victory of the cartel des gauches. Between 1924 and 1926 he had no seat in the chamber, but was again a member from 1926 to 1936. He was premier, 1929–30, and again in 1932 Tardieu died Sept. 17, 1945, 44 Menton, France.

Taroneu men Sept. 17, 1943, sit zermon, France.
Tardeu was the author of the following hastorical works. Questions
Diplomatiques (1965), France and its deliances (1968), La conference
(1970); La France et les eliances (1970); Le mylère d'étadir (1912),
Notes sur les Bists-Unis (1917); L'Amérique en armes (1919); La
Pais (1921); La Elexuy et le Pais (1921); El Pais (1921); El Elexuy et le Pais (1921); El Pais (1921); El Elexuy et le Pais (1921); El Pais (1921); El Elexuy et le Pais (1921); El Pais (1921); El Pais (1921); El Elexuy et le Pais (1921); El

TARDIGRADA, a class of animals of uncertain affiliation. The Bear-animalucies, as these animals were formetly called, are all of small size, the largest being not much more than r mm, in length, while most of them are very much smaller. They are not parasitic but are found in variable habitats, in damp moss, on flowering plants, in sand, fresh water and even in the sea; and in adaptation to this wide range of external conditions a very large number of genera and species have been evolved.

The organism consists of a well-developed head region in front and of a short body composed of four fused segments, each represented externally by a pair of short, stout, unjointed limbs generally terminated by sharp claws, which seem to range in number from four to mne, but sometimes, as in Batillipea, ending in three pairs of racquet-shaped, digitform outgrowths. The limbs of the last pair project backward from the posterior end of the body on each side of the amus. The cutticle, which is not chithrized, may be smooth or sculptured in various ways and is sometimes strengthened with segmentally arranged plates (Echimizeau) and

sometimes provided with long paired hair-like cirri.

No special organs of circulation or respiration are known The alimentary canal traverses the body from end to end. Within

Style the country of

PERMISSION OF THE MACHILLAN COMPANY, PUBLISHERS ECHINISCUS SPINULOSUS, AFTER

the mouth is a pair of protrusible stylets, large glands open into the oesophagus, there is a muscular pharynx and large median and lateral glands open into the intestine posteriorly. The nervous system, which is remarkably well-developed, consists of a bridblobed cerebral ganglion, frequently provided with a pair of eye-spots, and of a ventral chain

of five large gangha connected by lateral commissures. The sexes are not distinct and the generative products are discharged either into the posterior end of the alimentary canal or directly to the exterior through a median pore in front of the anus. The eggs are large and in some cases at least are enclosed, when laid, in the cuticle of the parent which is cast to form a case for them. The young when hatched are about one-third the size of the parent which they closely resemble apart from the occasional absence of one pair of limbs which is subsequently developed

The Tardigrada are divided into two orders (1) The Hetero-

Batilispes, etc.) in which the head is provided with two pairs of cirri in front, a pair of lateral cirri, and a so-called clava or spatulate process, one on each side, and (2) the Eutardigrada containing two families and three genera (Macrobiotus, Hypsibius and Milnessum) in which cephalic cirri are wanting Macrobiotus is the oldest known tardigrade, first observed in the last quarter of the 18th century The most remarkable feature of the tardigrades is their ability to withstand desiccation and low temperature, a phenomenon known as anabiosis Specimens kept for eight days in a vacuum, transferred for three days into helium gas at room temperature, then exposed for several hours to a temperature of -272° C. came to life again with the raising of the temperature to normal room temperature, 60% of specimens kept for 21 months in liquid air at a temperature of -190° C came to life Specimens allowed to dry at room temperature and kept dry for 18 months returned to life in about two hours after having been transferred into water An interesting feature of the structure of Tardigrada is the more or less fixed number of cells of which their body is composed Thus the median dorsal strip of epidermis is composed of only 24 pairs of cells.

The Tardigrada cannot be assigned with complete confidence to the Arthropoda, or Gnathopoda, until it be proved that their oral stylets are modified appendages. Assuming that they belong to the Arthropoda, they must rank as a class by themselves They have been generally relegated to the Arachnida on the supposition of their kinship with the Acari, but their internal and external anatomy make such an affiliation unlikely. They have also been compared to Perspatus mainly on account of the structure of their limbs; but there seem to be no good reasons for regarding the

two types as related

(The best treatise on Tardigrada is Ernst Marcus, "Tardigrada," published in Bronn's Klassen und Ordnungen, 1929)

TARDIVEAU, RENÉ: see Boylesve, René

TARENTUM, a Greek city of southern Italy (Gr Τάρας), (mod Taranto, q.v), situated on the north coast of the gulf of the same name, on a rocky peninsula at the entrance to the only secure harbour in it. The entrance was defended by the two islands called the Choerades (now S Pietro and S. Paolo) It was a Spartan colony, founded by Phalanthus about 708 B.C. (See SPARTA.) Taras was a mythical hero, son of Neptune. Situated in a fertile district, especially famous for olives and sheep, with an admirable harbour, great fisheries and prosperous manufactures of wool, purple and pottery, Tarentum grew in power and wealth and extended its domain inland. A great defeat by the natives in 473 BC., led to a change of government from aristocracy to democracy. A feud with the Thurians about the district of the Siris was settled in 432 by the joint foundation of Heraclea

In the 4th century Tarentum was the first city of Magna Graecia, and its wealth and artistic culture at that time are amply attested by its coins. (See NUMISMATICS.) In the second half of the century Tarentum was at constant war with the Lucanians, and did not hold its ground without the aid of Spartan and Epirote condottieri Then followed war with Rome (281), the expedition of Pyrrhus, whom Tarentum summoned to its aid, and at length, in 272, the surrender of the city by its Epirote garrison. Tarentum retained nominal liberty as an ally of Rome. In the Second Punic War it went over to Hannibal in 212, and suffered severely when it was retaken and plundered by Fabius (209), who sold 30,000 citizens as slaves. It revived after receiving a colony in 123 B.C., which received the name of Neptunia. In the time of Augustus it was essentially Greek and a favourite place of resort (Horace, Od., iii, 5, 53). Belisarius ordered it to be refortified, but it was soon taken by Totila, who made it his treasure store. After his defeat by Narses, it was sold to the Byzantine empire by its Gothic governor.

One of the most interesting discoveries of recent years has been that of a terramara on the so-called Scoglio del Tonno on the northwest of the town, which in its type and in the character of the objects found there, is exactly identical with the terremare of the Po valley. It seems, however, to be an isolated colony, and not to prove a parallel development in north and south Italy. The

tardigrada containing two families with nine genera (Eclusiscus, only relic of any building of the Greek city is a part of a Doric temple on the island-two fluted columns, with a lower diameter of 61 ft, and a height of 28 ft, and some fragments of the entablature, belonging probably to the beginning of the 6th century BC The rock occupied by the modern town was the citadel, but was connected with the land to the west by an isthmus, which was only cut through by Ferdinand I of Aragon. The line of the walls which defended the city on the east (land) side has been traced, and a few remains of well cut blocks, with Greek masons' marks, have been found. In the centre of the Agora was the huge bronze Zeus by Lysippus, and facing on to it the Ποικιλή, or painted portico, with pictorial representations of the life of Phalanthus, and the foundation of the city, and the museum There was also a fine gymnasium and other buildings mentioned by classical writers. Strabo's description of the site (vi, 3, 1) is a good one. The Roman amphitheatre, on the other hand, and remains of Roman baths by the seashore, have been found; the former perhaps occupies the site of the ancient theatre, in which the Roman ambassador was received in 281 B.C. Tarentum was the birthplace of Archytas and Aristoxenus (qq.v.).

TARENTUM, a borough of Allegheny county, Pennsylvania, USA, 17 mi. NE of Pittsburgh, on the Allegheny river and the Pennsylvania railroad Pop (1950) 9,540; (1940) 9,846 It has large industrial plants (glass, stainless steel, aluminum, paper, castings, etc.) and there are several coal mines in the vicinity. Tarentum was settled in 1796, laid out in 1829 and incorporated as a borough in 1842. The first glass factory was established in

TÂRGOVISTE, the capital of the department of Dimbovita, Rumania; situated at the foot of the Carpathians. on the right bank of the river Jalomita, 48 mi. N N.W of Bucharest. Pop. (1948) 26,038 A branch line connects Târgoviște with the main Walachian system, and is prolonged northwards into the hills, where there are rich deposits of petroleum, salt and lignite. Coal is also found but not worked Apart from the scanty runs of a 14th-century palace, the most interesting building in the town is the Metropolitan church, still one of the finest in the country, with its nine towers and monuments of the princely house of Cantacuzino. It was founded in 1515 by Neagoe Basarab, builder of the famous cathedral of Curtea de Arges. Târgoviște is a garrison town, with a cavalry training school and an artillery depot and repairing arsenal

Târgoviște was the capital of Walachia from 1383-1698 In the 15th century it was sacked by the Szeklers Michael the Brave defeated the Turks under its walls in 1507 In the 16th century it had a population of 60,000 and contained 70 churches and 40 convents. Its importance and population decreased when

the capital was moved to Bucharest.

TÂRGU-JIU, a large garrison town and capital of the department of Gorj, Rumania; situated among the lower slopes of the Carpathians, on the left bank of the river Jiu, and at the terminus of a branch railway which joins the main Walachian line between Turnu Severin and Craiova. Pop (1948) 17,698. The town has a considerable trade in timber, petroleum and farm produce. Anthracite coal is found in the neighbourhood. In the neighbouring hills are the monasteries of Tismana, Lairnici and Polovraci, much frequented as summer resorts.

TARGUM. The Targums are the Aramaic translations-or rather paraphrases-of the books of the Old Testament, and, in their earliest form, date from the time when Aramaic superseded Hebrew as the spoken language of the Jews. (See HEBREW LANGUAGE ) In their origin they were designed to meet the needs of the unlearned among the people who had ceased to understand the Hebrew of the Old Testament. In the absence of any precise evidence on the point it is impossible to give more than a rough estimate as to the period at which Hebrew, as a spoken language, was finally displaced by Aramaic. It is, however, certain that the latter language was firmly established in Palestine in the 1st century A.D. By that time, as we know from many sources, Aramaic was not only the language in common use, but had also received official recognition despite the fact that Hebrew still remained the learned and sacred tongue. Hence we may reasonably infer that the mass of the people had adopted Aramaic at a considerably earlier period, probably, as early as the 2nd century BC, and that the need of Aiamaic translations of the sacred text made itself felt but little later.

The Talmudic tradition, however, is, doubtless, correct in connecting the origin of Targums with the custom of reading sections from the Law at the weekly services in the synagogues, since the need for a translation into the vernacular must first have arisen on such occasions. As we know from the New Testament, the custom of reading in the synagogues both from the Law (Acts xv, 21) and from the Prophets (Luke IV, 16 f , Acts XIII, 14, 27) was well established in the 1st century AD 1ts introduction therefore, will date from a much earlier period. The practice of accompanying these readings with a translation into Aramaic 18, further, so generally recognized by the 2nd century AD. that the Mishna takes it for granted, and merely inculcates certain regulations to be observed by the Meturgeman (translator), who had by this time acquired a definite status. From it we learn that the Meturgeman, who was distinct from the reader, translated each verse of the Law into Aramaic as soon as it had been read in Hebrew: in the readings from "the Prophets" three verses

might be read at a time. Judging by the contents of our existing Targums, and the Targumic renderings given in Tewish literature, it is improbable that any definite system of interpretation was ever formally adopted, the rendering into the vernacular being left to the discretion of the individual Meturgeman. At first, no doubt, the translator endeavoured to reproduce the original as closely as possible, but, masmuch as his object was to give an intelligible rendering, a merely literal rendering would soon be found to be insufficient, and he would be forced, especially in the more difficult passages, to take a more elastic view of his obligations. To prevent misconception he must expand and explain what was obscure, adjust the incidents of the past to the ideas of later times, emphasize the moral lessons to be learned from the national history, and, finally, adapt the rules and regulations of the Old Covenant to the conditions and requirements of his own age. As time went on the practice of introducing additional matter of an edifying character grew in popular favour, and was gradually extended Thus, by degrees, the reproduction of the original text became of secondary importance, and merely served as a pretext for the discussion of topics that had little or no bearing on the context. The method, by which the text was thus utilized as a vehicle for conveying homiletic discourses, traditional sayings, legends and allegories, is abundantly illustrated by the Palestinian and later Targums, as opposed to the more sober translations of Onkelos and the Targum to the Prophets.

It would, however, he incorrect to suppose that the translation of the text was left entrety to the individual taste of the translator. The latter is rather to be regarded as the representative of the age in which he lived, and his interpretation is to be taken as reflecting the exegess of that period. That there were certain limits beyond which the translator might not venture, without incurring the censure of the authorities, may be inferred from the few instances of irranslation which are mentioned with disapproval in the Mishna and elsewhere. A definite rule for guidance in translating is apparently preserved in the Tosefta where it is stated that "the who translates quite literally is a lar, while lar

who adds anything is a blasphemer."

There can be little doubt that the Targums existed for a long time in oral form. They belonged' to the class of traditional literature which it was forbidden to write down, and, so long at least as the Targum tradition remained active, there would be little temptation to commit it to writing. But it is lightly probable that this problibition, in the case of the Targums, was mainly enforced with respect to those parts of the Old Testament which were treatful this synangous servers; g.g., the Law and the Prophets, and that it was jess fragilly observed in relard to the other portions of Sciphuter; a written frimbation of the latter would be of special value for the purpose of givrate study. Hence there is no need to reject the tradition is to the extencte of a written Targum on Job in the time of Canadite I (1st century A.D.).

especially as references to Targum mss occur in the Mishna and elsewhere But, as Dalman has pointed out, it was not these manuscripts, but the living tradition of the learned which was recognized as authoritative throughout the period which closes with the compilation of the Talmud . The official recognition of a written Targum, and therefore the final fixing of its text, belongs to the post-Talmudic period, and is not to be placed earlier than the official results.

I. Targums on the Pentateuch.-(1) The so-called Targum of Onkelos admittedly owes its name to a mistaken reference in the Babylonian Talmud In its original context, that of the Jerusalem Talmud, the passage refers to the Greek translation of Aquila With the exception of this one reference, the Targum is always introduced in the Babylonian Talmud by the phrase "as we translate" or "our Targum" it is probable, therefore, that the name of the author, or authors, was unknown to the Babylonian Jews It is first quoted under the title of the Targum of Onkelos by Gaon Sar Shalom (d AD 859). On the linguistic side we may regard Onkelos "as a faithful representative of a Taigum which had its rise in Judaea, the old seat of Palestinian literary activity " (Grammatik des judisch-palastinischen Aramatsch, p 12 f) It is to be regarded as an official translation of the Law, in the Judaean dialect, which was carried out in Babylon, probably about the 4th century AD. in its final form it cannot be earlier than the 5th century The translation, as a whole, is good, and adheres very closely to the Hebrew text, which has not been

without its influence on the Aramaic idiom

Of all the extant Targums that of Onkelos affords perhaps the most characteristic and consistent example of the exercical methods employed in these works. Two principles may be said to have guided the translators. On the one hand, they had, as their primary object, to produce a faithful rendering of the original which at the same time would be intelligible to the people, for this purpose a purely literal translation would be insufficient. On the other hand, they regarded it as necessary to present the sacred text in such a manner as best to convey the particular form of interpretation then current But later Jewish exegesis was especially concerned to eliminate everything in the sacred writings that might give rise to misconception with respect to God on the part of the unlearned Hence we find various expedients adopted in the Targums for avoiding any reference to the Deity which might be misunderstood by the people, or which involved apparent irreverence Examples of this peculiarly Targumic method are: (1) the insertion of "word," "glory," "presence" before the divine name, when God is referred to in his dealings with men, (2) the insertion of the preposition "before" when God is the object of any action; (3) the use of the passive for the active voice; (4) the use of periphrasis for the more pronounced anthropomorphisms, such as "to smell," "to taste"; (5) the use of different expressions, or the insertion of a preposition before the divine name, when God is compared to man, or the same action is predicated of God and man; (6) the use of " for mm and and the rendering מעוא or אלחים when אלחים denotes heathen gods. Instances of this endeavour to maintain, as it were, a respectful distance in speaking of God occur on every page of the Targums, but cases also occur, by no means infrequently, where human actions and passions are ascribed to God.

(2) In addition to the Targum of Onkelos two other Targums to the Pentatech are cited by Jewish authorities, under the titles of the Targum Jerushalmi and the Targum of Jonathan ben Uzsiel. Of these the former contains only portions of the Pentatuch and is therefore usually designated the Fragmentary (Jerusalem) Targum. Its fragmentary character arises from the fact that it is simply a collection of variae lectiones and additions to the version of Onkelos, intended possibly for use at public services.

The second Jerusalem Targum admittedly owes its ascription to Jonathan ben Juzziel to the incorrect solution of the abbreviated form by which it was frequently cited, viz., "no Targian Jerushalmi. This Targum represents a later and more successful attempt to correct and supplement the Targum of Onkelos by the aid of varients derived from another source. It is not, 'however, a revision of the Fragmentary Targum—for it is clearly independent of that version—but is rather a parallel, if some what later, production, in which the text of Onkelos is already combined with a number of variants and additions. It exhibits, to a marked deeper, that tendency to expand the text by additions of every land, which has been already noted as charactersiste of the later stages of Targumic composition. Homiles, legends, tadditional sayings and explanations, in fact every form of Haggadic expansion, are utilized by the Targumist, so that at times his works convey the impression more of a late Midrash than of a translation

In regard to the source of the two Palestinian Taigums to the Pentateuch, we must accept the conclusion of Bassfreund (MGWJ, xl) that they both derived their variants from a complete Targum Jerushalms But though the existence of an older Targum Jerushalmi cannot be denied it cannot be of an early date, for many of the latest elements in the Fragmentary and pseudo-Jonathan Targums were undoubtedly derived from their common source Moreover, the existence of a written Palestinian Targum at an early date is expressly excluded by the evidence at our disposal In the middle of the 2nd century AD R Simon ben Gamaliel forbade the translation of the Pentateuch in any language but Greek, and this command was upheld by R. Johanan in the 3rd century Even in the time of the later Amoraim there is no mention of a written Palestinian Targum, though the official Babylonian Targum is repeatedly referred to in the Babylonian Talmud, in the Midrashim, and at times also by Palestımıan Amoraim

Yet it is impossible to hold that the Targum of Onkelos was the only representative of Targum tradition that existed among the Jews down to the 7th century AD., the period to which the internal evidence compels us to assign the Targum Jerushalms as used by the Fragmentary Targum and the pseudo-Jonathan We must rather assume that a tolerably fixed Targum tradition existed in Palestine from quite early times. The language employed in the Targum of Onkelos is, admittedly, Palestinian or Judaean, and we may conjecture that the current Judaean exegesis, which, in part at least, must go back to the 2nd century AD., was not without its influence on the Babylonian translation. This old Targum tradition, however, never received official recogmtion in Palestine, and was unable, therefore, to hold its own when the new Babylonian version was introduced. We may infer that, as time went on, a reaction in favour of the older renderings made itself felt, with the result that these were collected in the form of variants and appended to Onkelos. But the authority enjoyed by the latter rendered it secure against anv encroachments, hence any later expansions, especially those of a popular Haggadic character, naturally found their way into the less stereotyped Targum Jerushalmi

II. Targums on the Prophets.—The official Targum on the Prophets is stated by the Babylonian Talmud to have been "said" by Ionathan ben Uzziel, the disciple of Hillel, and is usually known, therefore, as the Targum Jonathan. Elsewhere in the Talmud, however, the quotations from this Targum are given under the name of Joseph bar Chijah, head of the school at Pumbeditha in the 4th century AD. Both in language and style it closely resembles the Targum of Onkelos, and appears to have been modelled on that translation m certain passages, indeed, it appears to have made use of it Probably, like Onkelos, it did not assume its final form in Babylon before the 5th century AD. It naturally follows from the character of the original that the rendering of this Targum is less literal than that of Onkelos, especially in the prophetic books, but, when due allowance is made for the difficulty of the Hebrew, it may be described on the whole as a faithful reproduction of the original text. Its peculiarities of rendering are due to the same principles which were noted as underlying the translation of the Pentateuch. Anthropomorphisms, as a rule, are avoided by means of the same expedients as those employed by Onkelos, expressions derogatory to the dignity of God, or of the heroes of the nation, are softened down, while figurative language is either boldly transposed, or its character clearly shown by the introduction of the particle "as" or

"like." There is, further, a tendency to narrow down the scope of the prophetic utterances, and to limit their application to Israel and its immediate enemies Lastly, in the obscurer passages the Haggadic method of interpretation is employed to its fullest extent, while the translation throughout shows a marked tendency to explanatory additions.

Of a Targum Jerushalm to the Prophets but little is known, though 1 is hardly dubtful that such a Targum eisted, if only m oral form Traces of this versus have been discovered by Bacher in the variants attached to be margin of the Codes Reudinemum, and printed by Jagarde in his edition of Propheta Cheldines (1871). The quotations in Artik from Engs, Exchange Proverbs and Lamentations point to the existence of a Targum

III Targums to the Hagiographa.—These Targums possess but little interest for the student of Jewish literature as they are almost entirely the work of individuals, made in imitation of the older Targums

(1) Targums to the Psalms and Job—These Targums present certain features in common and may therefore be treated under the same heading. Like all the later Targums they exhibit a large amount of explanatory addition, chiefly Haggadic in character At the same time the tanslation of the original is not neglected, and, when separated from the later accretions, this is found to follow the Hebrew tolerably closely. Peculiar to these Targums are the double translations, which they give to many verses, one of which is usually Haggadic in character, while the other is more literal They cannot be earlier than the 7th century AD, and possibly are of a considerably later date.

(a) The Tangum to the Proverbs stands apart owing to the peculiarity of the language in which it is written The influence of the Peshitta version is so clearly marked, that Dalman describes it as a Jewish revision of that version. But setting aside the Syrisams due to the use of the Peshitta, the Targum shows affinity to the Targums to the Psalms and Job. The translation is literal and almost entirely free from Hagagadac additions.

(3) The Targums to the Megulloth -The chief characteristic of these Targums is their exaggerated use of paraphrase. They mark the final stage in the development of Haggadic interpretation, in which the translation of the text has practically disappeared in a mass of fantastic and irrelevant matter The Targum of Esther is known to us in three recensions (1) that of the Antwerp Polyglot, almost a literal translation, (2) that of the London Polyglot, which gives practically the same text with many additions of a Haggadic character; (3) the so-called second (shem) Targum, a much larger work, containing a collection of later Midrashim to this book, According to Zunz this "second" Targum is quoted by Rashi (to Deut 111, 4) as a Jerusalem Targum, and also (I Kings x, 10) as the "Haggada" of the Megilloth Esther The Targum to Canticles is of a similar character to that of the "second" Esther Dalman assigns these Targums to a date halfway between the Babylonian Taigums (Onkelos and that to the Prophets) and the Jerusalem Targums to the Pentateuch and those to the greater Hagiographa. The British museum possesses three important Yemen manuscripts for the five Megilloth and the "second" Esther Targum in mss. Or. 1302, 1476 and 2375.

(a) The Targum to the Chronicles was first edited from an Erintr manuscript by M. F. Bock, 1680-3; A more complete and accurate edition from a Cambridge manuscript was edited by D. Wilkins in 2715. In the translation, which at times is fairly literal, use appears to have been made of the Jerusalem Targums to the Pentateuch, and of the Targums to the books of Samuel and Kings. The text represented by the Eritur manuscript is assigned to the 8th, that of the Cambridge manuscript to the 9th century AD.

No Targums have so far been discovered to Daniel and Ezra and Nehemiah.

(J. F. S.)

See bibliog. on p 39 of W. O. E. Oesterley and G. H. Box. Short-

See bibliog. on p 39 of W. O. E. Oesterley and G. H. Box, Short-Survey of Lit of . Judausm (1920). See also P. Churgin, Targum Jonathan (Yale, 1927).

TÂRGU-MURES, a town of Transylvania, ceded in 1940 by Rumania to Hungary, 79 mi. E. of Cluj by rail. Population (1948) 47,043. It is situated on the left bank of the Mures, and is a well-bunk town, once the capital of the territory of the Szeklers On a hill dommating the town stands the old fortress, which contains a beautiful clurch in Gother style bult about 14,46, where in 1571 the diet was held which proclaimed the equality of the Unitarian Church with the Roman Catholic, the Lutheran and Calvinistic Churches. The Teleki palace contains and several valuable manuscripts (e.g., the Teleki codes), as collection of old Hungarian pomes, and a manuscript of Tactius. Target Murey has site on interesting Szekler Industrial miseum. The trade is cheep in timber, gran, was, tobacco, fruit and other products of the neighboushood. There are manufactures of sugar, spirits and beer.

TÂRGU-NEAMTU, a town in the department of Neamtu, Rumanna, situated among the lower slopes of the Carpsthians, and on the left bank of the Neamtu, an affluent of the Moldova. Pop. (1943) 8,948, 737 beng Jews. A branch railway runs to Jassy Near by is the ruined fortress of Neamtu, constructed early in the 13th century by the Teutonic Knights against the Cumans (q v), and the monastery of Neamtu, founded in the 14th century and containing two churches and many ancent and interesting relies. Before the seculiarisation of the monastic lands in 1864 at was one of the nchest and most important of the Rumanan monasteries.

Baltatesti, 10 mi. W by S. of Neamtu, is locally famous for its mineral springs and baths.

TÂRGU-OCNA, a town of Rumania, on the left bank of the river Trotos, an affluent of the Sereth, and on a branch railway which crosses the Ghimes pass into Transylvania Pop (1948) 9,796

9,796
Tärgue-Ocas is built among the Carpathian mountams, on bare hills formed of rock salt Outside the town stands the largest pisson in Rumanus; beyond this are the mmes, worked, since 1870, by converts, who receive a small wage. The estimated total of the salt deposits is 264,000,000 tons, about 11,000 tons being extracted annually.

TARIFA, a seaport of Spain, in the province of Caida, at the extreme south point of the pennasula, 2 mi, by rail W.S.W. of Gibraltar Pop. (1940) 6,959 (mum, 14,815). Tarifa is the Haula tone of Strabo, between Gades and Belon. According to that writer, it was colonized by Romans and the removed inhabitants of Zelis in Mauretaina Tingitian. The Intel Transductor or Traductor of coins and of Polemy appears to be the same place. Its present name, daing from early in the 8th century, is derived from Tarif. (See Spain History.) In 1292 Tarifa was taken by Sancho IV of Castile from the Moors. In the defense of Tarifa Alphonso XI gained the battle of Salado, a short distance to the westward, in 1340. In 1812 a French force under Claude Victor-Perrin and Laval vainly endeavoured to capture Tarifa, then held by Gen. Hugh Gough.

The town is nearly quadrangular, with narrow, crooked streets, and is still surrounded by its old Moorish walls The rocky island in front of the town, connected with the mainland by a causeway, is for field.

TARIPFS. From the middle of the 19th century to the period of the great depression of the 1930s, tainfis, in the sense of lists of the taxes required to be paid upon various classes of goods when mowing across national frontiers, constituted the principal official condition upon the conduct of commercial transactions between persons in different countries. With the 1930s, other forms of control over foreign trade came into wide use. In some countries, the right of the duties prescribed by the tariff schedule to munor importance. This had been the situation even before the exigencies of World War II and of the unsettled early post-war years made official licences and other dracet governmental decisions the prime determinants of the movements of goods between countries for the time being. The above applies to controls of exports as well as of imports, although not as markedly or as extensively. Controls upon imports are by far the more imports are the first me or the more imports are by far the more imports are the price the more imports.

tant, and this discussion deals principally with them.

Customs Duties and Their Functions.—Tariffs may be distinguished from customs, although the two are often used interchangeably Tariffs, a term found in many languages, denotes the lists or schedules of commodities with the particular duties or charges upon each noted, whereas customs is the English term which originally denoted all "customary" tolls or dues paid by merchants upon commodities on their way to or from market, not necessarily differentiated by the class of goods, for the benefit of the king, lord, local government or other authority. In the course of time, as the national state became the dominant economic as well as political unit, the complex structure of multiple local and provincial tolls on trade was substantially replaced by those levied only upon crossing the frontier of the country The term then came to be restricted, in most countries by the late 18th or early 10th century, to taxes on the importation or exportation of commodities across national boundaries By the middle of the 19th century, most industrial countries had curtailed or abolished their taxes on exports Internal taxes, where now levied on production

or trade, are most commonly termed excise duties or sales taxes. In their original character, as internal levies or tolls, customs sometimes had the character of fees for services sendered to traders, such as the use of market places, roads, bridges, habbours, etc, or assurance of protection for persons and goods. By the time they became purely frontier taxes, then primary function was to raise revenue, to help cover the costs of the national government or the personal expenditures of the king. In time, as international trade in competitive products expanded, customs duties, especially on imports, came to serve also in a protective way. In fact, many governments have from time to time revised their schedules of customs duties for that very purpose, in accordance with the current concept as to how far foreign commerce should be regulated in favour of domorties for the production or trade in particular lines. (See Free Trade; Pro-TECTION.)

The revenue and protective functions of import duties shifted in relative importance from time to time after the middle of the 10th century and varied considerably with the different countries. as will appear from the historical discussions which follow When duties are levied almost entirely for revenue, as they were in Great Britain for a great many years until after World War I, the regime is referred to as free trade The two principal functions of customs duties are, however, seldom mutually exclusive. Revenue duties may be with or without incidental protection, while protective duties, unless they prove entirely prohibitive of imports, usually yield revenue incidentally and often in substantial amounts. In most industrialized and economically diversified countries, the protective function became predominant Among the countries pumarily producers of natural products, notably those of Latin America, the import duties continued to serve almost exclusively as yielders of revenue. As local manufacturing developed in particular lines, however, especially under the stimulus of import shortages during wars, some of the import duties of traditionally raw-material producing countries also assumed a protective character and indeed were often selectively revised for that purpose.

Customs duties have long been employed also as preferential deveces, to divert trade to particular sources or directions. This use has been found mainly, but not exclusively, in the trade relations between certain countries and their dependencies Differential scales of import duties have frequently been employed also for bargaming purposes, to obtain improved conditions of admission for a country's export products into foreign markets, or to penalize the trade of countries whose tariff practices were regarded as unfair. Duties were most actively used for trade barganning after the 1860s by the countries of continental Europe and since 1934 also by the United States.

(H. CHA.)

## TARIFF HISTORY OF THE PRINCIPAL TRADING COUNTRIES UP TO 1930

The United States.—The tariff history of the United States, like that of European countries, divides itself into two great

periods, before and after the year 1860. The period before 1860 may again be divided into three sub-periods, the first extending from 1789 to 1816, the second from 1816 to about 1846, the third from 1846 to 1860.

- If (a) The Tariff Act of 1.780 was the first legislative measure passed by the United States The protectionsts have pointed to it as showing the disposition of the first congress to adopt at once a policy of protection, the free traders have pointed to a similarly as showing a predilection for their policy Each has some ground for the claim The duties of the act of 1.789 were very modestate, and, as compared with those which the United States has had under any subsequent legislation, may be described as free trade duties On the other hand, the spirit of the act of 1.789 was protective Such in the main remained the situation until 1816, duties being indeed raised from time to time norde to secure more revenue, but the spirit and the general rate of the duties not being sensibly modified
- (b) After the close of the War of 1812, however, a new spirit and a new policy developed. A demand arose for two closely connected measures protection to domestic manufactures and internal improvements. Protection was demanded as a means both of aiding young industries and of fostering a home market for agricultural products; it was a part of the "American system." Some movement in the direction of higher duties was manifested as early as 1816 Still greater changes were made in 1824. 1828 and 1832. The tariff of 1828 was affected by some political manipulation, which caused it to contain objectionable provisions, and to be dubbed "the tariff of abominations" The so-called abominations were removed in 1832, when the protective system was deliberately and carefully rearranged By this time, however, the opposition to it in the south had reached a pitch so intense that concessions had to be made. The nullification movement led in 1833 to the well known compromise, by which the rates of duty as established by the act of 1832 were to be gradually reduced, reaching in 1842 a general level of 20%. But the reductions of duty made under it proved ephemeral In 1842, when the final 20% rate was to have gone into effect, the protectionists again had control of congress, and after a brief period of two months. during which this 20% rate was in force, passed the Tariff act of 1842, which once more restored the protective system in a form not much less extreme than that of 1832.
- (c) Four years later, however, 1846, a very considerable change was secured by the south, and a new era was entered on. The Democratic party now was in control of legislation, and in the Tariff act of 1846 established a system of moderate and purely ad valorem duties, in which the protected articles were subjected, as rule, to a rate of 3.0%, is some cases to rates of 3.5 and 2.0%. The system, often spoken of as one of free trade, was in reality only one of moderated protection. In 1847, duties were all further reduced, the rate on most protected commodities going down to 3.4%.
- II The second great period in the tariff history of the United States opens with the Civil War. In the session of 1860-61, immediately preceding the outbreak of the conflict, the Morrill Tariff act was passed by the Republican party, then in control because the defection of southern members of congress had already begun. The advances then made were of little importance as compared with the far-reaching increases of duty during the Civil War. Duties were steadly raised, partly by way of offset to the internal taxes, partly to get additional revenue and largely because of a disposition to protect domestic industries. The close of the war thus left the United States with a complicated system of very high taxes both on imported and on domestic products.

The main features of the tariff history of the United States in the years after the Civil War were that the internal taxes were almost entirely swept away and the import duties on purely revenue articles similarly abolished, while those import duties that operated to protect domestic industries were mulntained, and in many cases increased. Efforts were indeed made to reduce the tariff duties, but met with strong opposition, and in the end were almost completely frustrated. The decade immediately following the war brought about the gradual transformation of the high war brought about the gradual transformation of the taxes levied on all commodities for revenue purposes into a system of high dutues almost wholly on protected commodities. This transformation met with much opposition, not less in the Republican party than in the Democratic pairy. The opposition led to a general revision in 1883, which, on the whole, served rather to put things in order than to make any change of policy

The tariff system as revised and codified in 1883 would probably have remained unchanged for many years had it not been for an unexpected turn taken by political and financial history In the second half of the decade 1880-00, a continuous large surplus in the treasury directed attention to the state of the revenue, and gave strength to the protests against excessive taxation. In addition, the Democratic party, which had long been committed, though in a half-hearted way, against the policy of high protection, was brought to a vigorous and uncompromising attack on it through the leadership of President Cleveland In his presidential message of Dec 1887 he attacked the system in unqualified terms. The Republicans, as is almost inevitable under a party system, championed the policy opposed by the other side, and declared themselves in favour of the consistent and unqualified further application of protection. The protective question thus became the main issue in the presidential election of 1888, which resulted in the defeat of the Democrats In the next ensuing session of congress, the Republicans passed the McKinley Tariff act It advanced duties materially on a considerable number of commodities, both raw materials and manufactured articles. A further step towards consolidating the protective system was taken by abolishing the duty on sugar, mainly a revenue duty For consistency in maintaining the protective principle a direct bounty was given to the domestic producers of sugar in Louisiana Another turn in the political wheel brought an abrupt change four years later, in 1804. President Cleveland. defeated four years before, was now again elected, and the Democratic party came into power, pledged to change the tariff system Accordingly the tariff act of 1804 was passed, known as the Wilson Tariff, bringing about considerable reductions of duty The measure, however, was less incisive than its chief sponsors had planned, because of the narrow majority commanded by the Democrats in the senate. The most radical change was that the duty on wool, typical among the duties on raw materials, was completely abolished, and with this came a great reduction in the duties upon woollen goods. A duty was reimposed on sugar, chiefly as a means of securing needed revenue, but at a less rate than had existed before 1800; the bounty of 1800 was abolished. The next election in 1896 brought still another turn, the Republicans being once more brought into power under the leadership of President McKinley. At the extra session which President Mc-Kinley called in 1897, almost the sole measure considered was the tariff act, known as the Dingley act. This reimposed the duties upon wool, on most qualities at the precise rates of 1800. on some qualities at even higher rates. Necessarily the duties on woollens were correspondingly raised, and here again made even higher than they had been in 1890. The tariff act of 1900, amending that of 1897, did not appreciably change the situation. It made certain reductions in duties, such as the rates on hides, wool tops and various iron and steel products; but except in the case of hides, the reductions were in most cases more nominal than real. The net result was to leave the general height of the tariff at much the same level as had previously ruled. At the next presidential election in 1912 the Democrats, for the first time since 1802-04, gained control of both the executive and legislative branches of the government Immediately the Democratic leaders began the revision of the tariff law. In the act of 1913 most raw materials, including raw wool, were placed upon the free list; the complicated schedules that had grown up in the Republican tariffs were largely scrapped; and the effective protection upon semi-manufactured and wholly manufactured articles was markedly decreased. Sugar was to be admitted free. But the abolition of the sugar duty was not to take effect till 1917; by that time World War I had set in; and under the war conditions, the duty was retained, though at a lower rate than that of 1900. The act of 1913, however, proved to be of little practical significance. The outbreak of World War I in 1014 made impossible all competition from abroad with United States industries. This situation endured for a year or two after the close of the war, and it was not until the collapse of 1920-21 that serious consideration was again given to the tariff problem. By that time the Republicans were again in power, and were so firmly entrenched, after their decisive victory at the polls in 1920, that they did not hesitate to restore the protection of prewar days and even increase it. The agricultural regions of the central west were hardest hit by the great decline in prices, and clamoured for some remedy The Republicans followed their traditional policy of holding forth a high tariff as the remedy for all ills, and at once enacted the Emergency Tariff act of 1921, which provisionally reimposed the duty on wool, and raised those on sugar, wheat, corn, meat. In 1922 a general revision was made, and a new complete tariff act was passed. The duties on agricultural products were still further increased, and those on manufactured goods, such as woollens, cottons, silks, pottery, hardware, were either put at the level of the tariff act of 1900 (the last preceding high tariff act) or raised above that level. Some articles previously admitted at low rates were now subjected to high ones, such as dvestuffs and chemicals. All in all, the protective policy was carried higher than ever before. At the same time a new administrative policy was introduced, by giving the tariff commission certain powers as regards modification and adjustment of

Great Britain .- England emerged from the mercantilist policies of the 17th and 18th centuries with a tariff system that not only imposed high rates but was extraordinarily complicated and confused The first steps toward the radical change which was to come in the 19th century were taken by Pitt. In 1787 he caused the Consolidation act to be passed, which codified the previous intricate mass of scattered, inconsistent and cumulative duties. In 1786 he also arranged a commercial treaty with France providing for substantial reciprocal reductions of duties; but this measure, unlike that for consolidation, was swept away by the French Revolution. After 1815 English tariff history is marked by two great changes: on the one hand the modification and finally the repeal of the "corn laws", on the other, the steady succession of acts which gradually cut down the duties on all other goods and led eventually to the complete adoption of free trade. The corn laws, it is true, were first strengthened, then experiments were made with sliding scale duties, designed to keep the price of grain stable, and finally they were suddenly wiped out at the time of the Irish famine of 1846. They had political support because of the predominance of the gentry and the landed interests in both houses of parliament. But industrially as well as politically they were vulnerable, and inevitably collapsed in a crisis like that of the famine. The other series of events began with Huskisson's measures of 1824, which reduced duties, especially on raw materials such as wool, and went on with a succession of measures until the last remnant of protection disappeared in 1860. The notable steps were Peel's act of 1842, an important and far reaching measure; Peel's second important act, in 1846, contemporaneous with the corn law repeal; Gladstone's famous budget of 1853; and finally in 1860 the removal of the silk duties, the last of the protective duties which had been retained. This final step of 1860 was taken in connection with the Cobden-Chevalier treaty with France, noted below. For half a century thereafter, England was on a free trade basis and was the stronghold of free trade. The system was suited to her industrial development during the period, enabling her manufactures to develop at an extraordinary rate, while foodstuffs and raw materials were imported in ever increasing volume. The system seemed entrenched beyond attack, and this notwithstanding the fact that the landed interest was hard hit by the decline in agricultural prices from 1873 to the dose of the century. It was not until World War I that a change took place, and it then took place to an extent which could not have been expected and indeed, was not expected when the initial steps were taken. Very shortly after the outbreak of the war, in 1915, certain duties were imposed upon lixuries, the so-called McKenna duties; being at the rate of

334% on watches, motor cars and parts, cinema films and the like. Immediately after the war some further changes were made in the same direction, yet still susceptible of interpretation on other grounds than that of a return to protection pure and simple. In 1919 imperial preference to the colonial products, long urged by the colonies themselves, was granted on tea, coffee, cocoa, sugar, the most important being the preference on sugar. In 1920, again, the imports of dvestuffs and coal-tar dyes were completely prohibited, this being in the nature of a war measure, designed to ensure the domestic production of military explosives, and also that of dvestuffs whose importance to textile industries was deemed cardinal. In 1921 came the Safeguarding of Industries act, which went a step further, imposing a duty of 331% on the product of the so-called key industries, such as optical instruments, barometers, wireless apparatus In the same year came the anti-dumping act, imposing a 331% duty on goods sold in England below cost or sold at particularly low prices because of depreciated currency elsewhere Some of these duties were repealed by the MacDonald Labour government in 1924. But all were re-enacted in 1925, and then at last the Baldwin government took steps which clearly were not explicable on political or military grounds, or as means for meeting special emergencies. In 1925 not only were the McKenna duties restored, but, what was more important, the safeguarding of industries' provisions were given a wide scope. In advocacy of them, most was said about the desirability of preventing unemployment through the protection of established industries. The board of trade was made a sort of tariff commission which should investigate particular cases and recommend to parliament advances in duties; not merely for key industries or because of special circumstances, but as part of a general industrial policy While the import duties to which this measure led were not, as compared with the entire volume of Britain's trade, of great substantive consequence, they marked unmistakably a departure from the principles of the free trade regime as it existed before 1914

France.-The tariff history of France during the 19th century, like that of England, is divided into two parts, one running to the year 1860, and the other beginning after 1860. France emerged from the revolutionary wars with a cumbrous system, resting partly upon the highly complicated measures left over from the mercantilism of the 18th century, and for a part upon complete prohibition of importation (directed primarily against England) which had been adopted during the war period and was left in force, largely through inertia, for almost half a century thereafter. The tariff system of France, in other words, from 1815 until 1860, was rigidly protectionist. In 1860 the Cobden-Chevalier treaty made an abrupt change, to which the Emperor Napoleon III was led in some part by intellectual conviction, but much more by the desire to get on good terms with Great Britain. The treaty provided for great reductions on manufactured goods imported from England, while England in her turn not only conceded the free admission of silks, but also reduced duties on French wines. After 1860 France virtually universalized these lower duties, extending them by a series of commercial treaties to almost all the countries of the continent. These treaties commonly contained the most-favoured-nation clause, and were in turn fortified by treaties which the various countries concluded between themselves as well as with France. The result was an interlacing network of commercial engagements which covered almost the whole of Europe, and brought about not a system of free trade, but one of nearer approach to free trade than had ever before been widely practised Such, at all events, was the situation for two decades from 1860. The French people, however, had always been restive under the treaty system imposed upon them by the will of Napoleon III. The English treaty, which was terminable after the lapse of ten years, was at first renewed with reluctance, and finally terminated for good in 1891 The protectionist revival culminated in the great Méline act of 1892. By that France established a double system: maximum duties which were not to be exceeded, and specified minimum duties which the government might concede to other countries in return for concessions supposed to be equivalent. The maximum duties, however, were in no case to be reduced on agricultural products; for in France, as in England, agricultural producers were hard hit by the decline in prices. One important purpose of the act was to deprive the immistry of discretionary power as regards reductions through commercial negotiation, the minimum duties which might be conceded to other countries were specified by the legislature. The system was mantaned in essentials, though not without some modification, until the outbreak of the war in 1914. The revival of high protection in France did not run its course without serious difficulties, especially in the way of controversy on rates with other countries. There was a tarif war with Italy in 1888–90 and one in 1892–95 with Switzerland. In 1910 there was again a revision upward, which, however, left the general system intact.

One further factor in French tariff policy during this period was the treaty of Frankfurt (1871) terminating the war of 1870-71. By that treaty France and Germany had guaranteed each other most-favoured-nation treatment-not complete, but almost complete, in that they guaranteed to each other the same rates as they conceded to the important neighbouring countries of central Europe Being incorporated in the general treaty, these provisions, unlike the special commercial treaty of 1860 with England, could not be denounced; and they were felt by both countries to hamper their commercial negotiations, being the more unwelcome because of the constantly growing national antagonism. When all treaties and engagements with Germany, and practically those with other countries also, were swept away with World War I, France was able to proceed untrammelled with a new course of policy. It rested upon the maintenance of a high protective system, susceptible of some liberalization through special bargains with other countries, by which these were to be induced to admit French goods at lowered rates in exchange for specified concessions in the French duties, varying from country to country. In 1920 the maximum and minimum system was virtually given up and the government given free hand in commercial negotiations. The result was a highly complicated series of engagements, which brought into vivid contrast two essentially different lines of policy. that of special bargaining, and that of equal treatment under a most-favoured-nation clause. The second policy was unpopular in France, partly because of its association with the treaty of Frankfurt, but partly for other reasons connected with peculiarities of French foreign trade. Not only as regards France, but as regards Europe at large, the alignment was marked by one or the other of these two ways of procedure. Those in favour of closer commercial relations preferred the most-favoured-nation method. while high protectionists looked to the policy of specific bargainings. On the whole France was not successful in securing what it wished by bargaining, even though it had political advantages in dealing with states like Czechoslovakia, Hungary, Yugoslavia, and even Belgium. In 1927 it was compelled to arrange with Germany a treaty virtually upon most-favoured-nation basis, a change which marked a halt in the other policy, and perhaps the beginning of a general trend the other way.

Germany.-The tariff history of Germany, like that of German history in general, is closely connected with Prussia. Prussia took the lead in the creation of the German customs union (Zollversin). It arranged a partial union in 1819 which was followed by the Zollverein of 1834, including practically the whole of the later empire. Prussia was then a grain exporting country, and favoured a liberal tariff system. As time went on, manufacturing industries developed, especially in the west and south of Germany, and contests arose within the Zollverein between the free trade and protectionist parties. In these, upon the whole, the anti-protectionists were victorious until after the establishment of the empire. A commercial treaty with France in 1862, a sequel of the Anglo-French treaty of 1860, confirmed the liberal tendency. But after 1871 Germany, like France, and at about the same time, turned the other way. Under Bismarck's lead, and in consequence of an alliance between the industrialists of the west and south and the agricultural interests of the east (now threatened by imports), Germany returned in 1879 to protection. Grain duties were imposed, and proved an important source of revenue, because imports continued on a large scale; at the same time the

continuing imports made the landed interest firmly protectionist. At the beginning of 1802 Germany entered upon a policy of commercial treaties which were based upon special negotiation with each particular country; though they were prevented by the treaty of Frankfurt from having as much effect in the way of discriminations between countries as might otherwise have been the case This policy of specialization was continued in the legislation of 1902, when rates were further increased and further commercial treaties were mitiated As in the case of France, the policy of specialized commercial negotiations led to quarrels and retaliations, there being tariff wars with Russia, Spain and Canada. After World War I, Germany for a while was restricted by certain provisions of the Versailles treaty. These required her for five years from the date of the treaty (that is, during 1919-24) to give most-favoured-nation treatment to the Allies, while at the same time leaving the Allies free. With the termination of this arrangement in 1924 Germany proceeded more freely, and in 1925 adopted a new tariff A protectionist regime was established both for agricultural products and for manufactured goods, with an expectation, however, that the duties might be reduced through bargaining for lower duties by other countries on German goods. Success in this direction was achieved in 1927 by the commercial treaty with France, which provided for certain reductions upon French goods, and also secured for German goods imported into France treatment virtually on a most-favoured-nation basis. Other treaties contained similar provisions, and emphasized the acceptance by Germany of the most-favoured-nation policy and disposition to moderate the protectionist regime. This attitude prevailed until the depression of the 1930s.

Other Countries.-The same trend in tariff legislation appeared in other countries during the years succeeding 1860. In almost all, the protectionist movement gathered strength again after 1880. Austria, Russia and Italy turned to high tariffs, sometimes mitigated by commercial agreements, sometimes aggravated by the failure of commercial negotiations The greatest extreme was reached in Russia, which under the leadership of Count Witte developed a system of protection more extreme than that of any other country, not excepting the United States After World War I, when the financial and treaty arrangements had all to be remodelled, there was the same resurgence and accentuation of protective tariffs. The main cause lay in the strengthening of national feeling and in the persistence of nationalist antagonisms engendered by the war. The new states which arose after the war or were greatly enlarged by it, such as Poland, Czechoslovakia, Yugoslavia, Greece and Rumania, turned to protective measures. In good part, they were influenced by imitation of the larger powers, and not least by mitation of the United States

(F W. T.; H. CHA.)

GENERAL SURVEY OF THE SITUATION PRIOR TO WORLD WAR II

Prior to World War I .- Viewing the situation generally, two broad periods can be distinguished in the development of import tariffs and the related conditions upon international trading after 1900. The first period, running up to the outbreak of World War I in 1914, was marked by three outstanding characteristics: (1) the levying of import duties was practically the only form of official control generally used by governments to regulate the importations of foreign goods; (2) in height, the duties of most countries were moderate compared with those which have prevailed during more recent years, and they were marked by considerable stability, with material changes made only at long intervals; and (3) equality of competitive opportunity for the products from all foreign sources was the rule in most markets, with preferences favouring the products of some countries over those of others the exception and found mainly in the trade relations between a few countries and certain of their colonies or dependencies.

Decades of the 1920s and 1930s.—The second period, comprising the two decades between 1919 and 1939, was characterized by more frequent changes, by a trend toward higher duties, and by the development of other methods of regulating imports

and of special arrangements between many countries regarding their trade. These practices became particularly marked during the great depression, after a decade of shifting tendencies

As political and economic conditions gradually improved and became fairly well stabilized toward the middle of the 1920s, many governments felt they could cleax the seventry of the increased tarifis and emergency controls upon foreign tade, resorted to, especially on the continent of Europe, during World War I and the disturbed period immediately following. This gave courageous tone to the recommendations of the first World Economic conference, held at Geneva in 1927 Indeed, for a number of years pinch to 10 sept. Here was a great for the continuous commercial treaties were negotiated in the latter 1920s in which governments exchanged reductions in their respective duties on the distinctive products of the other.

With few exceptions, these treates carried the most-favourednation clause, i.e., each confuacting country promised to accord to imports from the other as good treatment as the best that was then—or might later be—granted to the same products from the

nation most favoured.

Developments During the Depression.—Shortly after the onest of the general economic depression late in 1929, however, this liberal movement lost impetus. It gave way to a tightemic of import controls, which soon developed into a distinct movement toward restrictive economic nationalism, and an increasing degree of governmental inner vention into foreign trade operations. The upward revision of the import duties of the United States adopted m June 1930 was the first important step in this direction and was quickly followed by similar trade-estrictive measures on the part of other countries. The adoption by Great Britain of a general tariff early in 1932, which made most imports from nonempire sources subject to duty, after almost a century of practically free trade, was another of the outstanding developments.

Added to the usual pressures during a period of declining economic activity and shrinking markets, to maintain employment and support prices, the problem of many governments was agenvated by the practical stoppage of new international lend ings, and by the succession of depreciations of various important currencies, starting with the British pound sterling in Sept. 1931. To the resulting dislocations of existing competitive relationships and the distortions of national trade balances and budgets, there are the starting of the starting control of the st

The increases in import duties resorted to by many countries during the early days of the depression were soon followed by measures for controlling directly the importation of foreign goods or the transfer of funds to pay for them. In the fall of 1931, there began to be revived the practice of limiting to specified quotas the quantities of particular classes of goods permitted to be imported, as a whole or from particular countries, or of making foreign commercial transactions generally subject to official licence. Initiated by France, the practice spread within a few years to almost all countries of Europe and, in lesser degree, to certain extra-European areas (see QUOTA). Centralized control on the transfer of funds abroad, precipitated by the financial difficulties of certain central European banks in 1931, was soon resorted to by one government after another, spreading from Europe to Latin America and other outlying regions, as another means of regulating the volume and direction of a country's foreign trade, and of adjusting adverse trade balance situations. Originally temporary and defensive measures, both import quotas and exchange controls soon came to be widely used as aggressive means, by which the operating government bargained for assurance of the admission of larger quantities of its national products into the territories of others, for release of funds due its citizens or for other special advantages. The relative allocations of imports or of exchange to different countries were, in some cases, put on a frankly preferential basis.

The Ottawa agreements of 1932, whereby the various parts of

the British empire undettook to supply their import needs as far as possible from within the empire, constituted an outstanding development of another type but in the same trade-diversonary direction. That objective was sought either through enlarged duty preferences among the British countries, or through additional tariff or quota handcaps on the competing products of outsiders, chiefly the latter. The Ottawa agreements had wide repercussions

A world economic conference was convened at London in 1933, with the hope of finding solutions for the general economic depression through concerted action. Apparently, however, it came too late to supersede the various national recovery programs, conceived from a purely domestic or regional viewpoint, which had already developed momentum in many of the important countries. With little prospect, then, of early relief through material expansion of their exports, many governments fell back upon the further restriction of imports by various methods, or upon special arrangements for the official direction of their reduced purchases to selected countries Bilateral agreements, frequently revised, came to be an important method whereby pairs of governments endeavoured to provide specifically regarding the volume or the make-up of the trade between their nationals, or the total balance of payments between their countries Almost inevitably, these arrangements tended to become exclusive in the character of their favours, and discriminatory against the commercial interests of other countries. The basic import duties were often overshadowed as the prime regulators of trade movements, and existing obligations to accord treaty countries equality of tariff treatment were progressively nullified

Several of the major countries of Europe, notably Germany, who happened to need large quantities of foods or raw materials from other European and certain overseas countries, beyond the value of their exports to them, used that fact as a barganing weapon. They insisted upon arrangements whereby the foreign exchange resulting from their imports was to be reserved by their exploying countries—primarily, if not exclusively—for the purchase of their own export products, for preferential debt payments, thawing of frozon credits, etc. Thus, there spread the idea that the trade or total payments between each pair of countries should approximate an annual balance. The result was some diversion of tade, but mainly a shrinkage of the total volume, with the balance usually struck closer to the level of the lower of the two currents of

Meanwhile, the sharp drop in the export trade of the United States, involving serious domestic readjustments, prompted the government of that country to obtain congressional authorization, in June 1934, for initiating a program of trade agreements intended to differ from the narrowly bilateral type then prevalent Over the subsequent decade, agreements were concluded with 28 foreign countries for the reciprocal reduction of excessive tariffs and other trade barriers on each other's distinctive products. Through these, the United States sought to revive progressively the freer flow of international trade generally, and to give a new turn to the commercial policy of the nations. A distinctive feature was the reassertion of the most-favoured-nation or equality-oftreatment principle, and its application to all forms of trade barriers, including quotas and exchange controls as well as tariffs In all cases but Cuba, the benefit of the concessions made by the United States were extended to the like products of all other countries, except those materially discriminating against the commerce of the United States.

Despite the moderating influence of the United States trade agreements program, the dominant trend in the trade policies of most countries during the 1330s continued in the other direction. The observed cumulative results of the trade restrictive and diversionary measures before long led various officials and business leaders of the 'very countries pursuing those practices to recognize that, in overlooking the essentially multilateral character of world commerce and financial relations, the measures by which particular countries or pairs of them sought to improve their own position too often only aggravated the position of others and provoked counteraction which rebounded to their own disadvantage.

for checking the growing deterioration of the general economic relations between nations which came to mark the 1930s

Partial explanation probably lay in the fact that, in addition to the continuing economic uncertainties, political considerations and pressures were becoming increasingly important factors in the commercial policies of various countries. The lengthening shadows of the impending war, which finally broke out in 1939. were frequently impalpable factors in the restrictive measures or unusual trade-control arrangements of many peacefully intentioned governments during the latter 1930s. As later became too clear, they were the obvious explanations for the actions of certain other governments, such as deliberately curtailing imports of certain essential products, either in order to foster selfsupply even at high cost, or to divert their limited exchange resources to increased importations which advanced the country's "rearmament program," or enlarged its national reserves of strategic commodities

## INTERNATIONAL TRADE CONTROLS DURING WORLD WAR II

Outside of the two secluded axis-controlled regions in Europe and in the far east most international trade routes were kept substantially open during the war by the British and American navies. despite heavy sinkings However, the enlargement of the war to almost global dimensions, and the intensification of the war production programs of the Allies, called for the drastic diversion to war purposes of all available resources. The consequent shortage of many types of goods for ordinary civilian use, and of the shipping to carry them, limited during the war the volume of ordinary commercial interchanges of goods within the nonaxis world Under the circumstances, the usual tariffs and other trade controls of the importing countries became subordinate to the governmental decisions of the exporting countries, as to whether the particular goods could be spared, as to the particular destination and as to current availability of transport.

To a large extent, governments themselves participated in the procurement and distribution of many classes of commodities These took the form either of direct bulk purchasing by official agencies or of governmental over-all contracts or arrangements regarding supplies, shipping and exceptional risks, with the actual transactions consummated through private trading channels Such government-to-government or governmentally arranged transactions were often found the only way of ensuring adequate supplies of essential foreign materials or products at noninflated prices, and of effecting such disposition of the limited resources of goods and ships among competing claimants as would best serve the national interests and support the Allied war program.

As the war progressed, the enlarged production programs of the Allies and of the countries friendly to them resulted in huge international movements of special supplies and equipment, either for direct use in connection with military operations or for the support of the basic economies of the combatant nations. These exceptional movements were facilitated by the introduction of two new forms of commercial policy,

A series of combined boards was established in 1942 for the most effective utilization of the joint economic resources of the United Nations toward the prosecution of the war, covering the fields of raw materials, foods and industrial production, as well as munitions and shipping. Imitated by the United States and the United Kingdom, with the participation of Canada and certain other British dominions in particular fields, the combined boards encompassed their own resources and those of other accessible areas in the procurement of materials and products. In the allocation of the aggregate supplies thus made available, they envisaged the needs of all the United Nations engaged in the war, in accordance with their relative essentiality and urgency. The Anglo-American governments also undertook a measure of responsibility toward supplying the other United Nations with their essential civilian import requirements, so far as the naturally prior claims of the military programs allowed. While the two governments operated jointly in programs for meeting the essential needs of

No effective methods of collective action were found, however, the peoples in certain regions, notably the near and middle east, the United Kingdom was especially concerned with the British empire and with the overseas colonies of friendly European countries, while the United States undertook to share, between its own population and those of Canada and Latin America, the goods

in short supply available for civilian consumption

In the matter of payment for these exceptional movements of goods between the various active belligerent allies, another new principle of commercial policy was introduced. Early in 1941, when the ability of Great Britain to pay in dollars for the huge quantities of munitions and supplies needed to continue the war was rapidly diminishing, the United States Lend-Lease act authorized the president to make available to the government of any country whose defense be deemed "vital to the defense of the United States," any articles, service or information, without regard to current compensation In return for such aid, "the benefit to the United States may be payment or repayment in kind or property, or any other direct or indirect benefit which the President deems satisfactory," This new policy of sharing one country's production and facilities with other countries engaged in a common struggle, without regard to their precise ability to make repayment-sometimes referred to as "mutual aid"-was soon adopted and put into wide practice also by various of the other United Nations, in accordance with their capacity to contribute goods or services By the end of 1944, the cumulative measurable value of the goods, facilities and services contributed under this principle by the various United Nations (chiefly the United States, the United Kingdom, Canada, Australia, New Zealand and India), for use by other United Nations in the common effort, had exceeded in magnitude the highest value recorded for the entire international trade between all countries during any prewar year A significant feature of the agreements with regard to the ultimate settlement of lend-lease, which were concluded by the United States with more than 30 of the United Nations, was the uniform pledge of all the contracting countries to collaborate after the war in a program designed to promote more liberal conditions for international trading and a more prosperous, expanding world economy.

## INTERNATIONAL TRADE CONTROLS AFTER WORLD WAR II

Transition from War to Peace .- The termination of hostilities in 1945 put an end to the forced commercial seclusion of most of Europe and of the far east, as well as to the arbitrary diversion of the resources within those regions to Germany and Japan. However, the war had left in its wake widespread destruction and disorganization. Drastic changes had taken place in the economic and often even in the political position of many countries and colonies, and there were more to come It was evident that the process of restoring a satisfactory and stable structure of world commerce would be long and difficult, and that for many countries the pattern of trade and of the measures for its control that would emerge might be quite different from those of the prewar period.

As goods and shipping again became available primarily for civilian use, the various joint programs under British-American auspices, through which many commodities in short world supply had during the war been procured in bulk and then centrally allocated among the Allies and friendly neutrals, soon tapered off. By the close of 1946, only the allocation of tin, coal, fertilizer and certain scarce farm products were still subject to international review. With termination of lend-lease and other mutual aid programs in the fall of 1945, the financing of most international shipments had promptly reverted to its usual cash or credit basis.

To facilitate the resumption of normal trade, the United States and Canada, upon whose supplies the Allied nations had come to rely heavily, relaxed their licence controls upon exportations The needs of the war-ravaged countries, especially in Europe, for supplies of foreign products for replenishment and rehabilitation were exceptionally large, and their current ability to pay for them with their exports or cash exceptionally low. To help finance this mutually beneficial flow of goods, several of the countries which had been outside the area of active conflict—notably the United States and Canada in the western hemisphere, and Switzerland and Sweden in Europe—extended sizable loans or established substantial official credits

Even in the formerly war-involved countries of western Europe, where there were the fewest political obstacles to the revival of foreign commerce, a large measure of governmental control and even official intervention in the conduct of foreign trade seemed unavoidable for a time Each government felt that its immediate responsibility for economic rehabilitation included planning for the country's essential import requirements. This involved direct supervision over the utilization of the limited amounts of foreign goods obtainable and of the means to pay for them, in order to ensure that the most vital needs of the nation were given priority. In fact, to reduce the cost of acquiring essential products needed from abroad, governments often suspended the collection of import duties on broad ranges of commodities. Official management of imports was all the more necessary because the revival of the exports of these countries' products, the principal means of paying for foreign goods, was retarded by the extreme domestic shortage of supplies and the serious derangement of internal production and distribution facilities

Soon after the end of the war, the liberated countries of western Europe became very active in the negotiation of trade agreements with each other and with other European countries, in order to facilitate the resumption of the traditionally large intra-European exchanges of distinctive products Unlike the prewar type of trade agreements, however, these did not deal with changes in the structure of their tariffs and other basic foreign trade controls. The negotiations centred rather upon the lists of goods which each country was especially desirous of obtaining from the other, and the delivery of which the other government agreed to facilitate through the granting of export licences, usually up to specified maximum quantities for each scheduled class of goods Since the reserve funds of the liberated countries were very limited and exchange values of their currencies uncertain, these agreements usually aimed at a balanced value for their over-all bilateral exchanges during the year, although some provision was usually embodied for reciprocal credits to cover limited overdrafts either

In most of the countries of eastern Europe, there was the handicap of political unsettlement in addition to economic disorder and meagre finances. That hampered the resumption of their foreign trade long after the close of the war. Aude from some goods obtained through exchanges with neighbouring areas on a barter basis, their principal early myorits were the relief shipments supplied by U N R.R.A. (United Nations Relief and Rehabilitation administration), the greater part of which came from the United States. The experimentation with state control of the domestic Corner German stellites, the heavy doliveners to the invaded eastern areas called for as reparations operated further to limit any stable trade with western Europe or with overease countries.

In most of the areas of the far east overrun by Japan, the process of liberation and of restoring something like a stable processor gime, often under new political auspices, moved very slowly. Excepting the Philippinas, such foreign trade as was possible for several years after the war was handled by governmental agencies or by officially designated organizations.

To ease the transition for the United Kingdom and the group of countries for which it is the financial centre, the United States extended to Britain a long-term loan of \$83,750,000,000. Even with that, however, the shrunken foreign exchange resources of the sterling area countries after the heavy war losses allowed little unital relaxation of their wartime restrictions on trade with outside countries.

With the passing of the special arrangements by which the Latin American countries had regulated their import requests to conform to the export controls of the United States, their principal wartine sources of simply, most of the governments of South America and certain of Middle America replaced them with stronger local import controls; 'However, in viewof, their improved financial position after the profitable wartime sales, few felt it necessary to apply these controls very restrictively

Trade Difficulties of the Early Postwar Years.-Even after the immediate transitional period following World War II, the course of international trade continued to be determined only to a small degree either by the height of the tariffs or by the export or import licensing systems, which came into common use in most countries outside of North America More determining were the acute needs of the war-involved areas for products essential to the rehabilitation of their economies and the unprecedented pent-up demand everywhere for goods that had not been freely available for a number of years The prime limitations upon meeting these exceptionally high demands for goods were two, the general world shortages of many essential commodities, especially foodstuffs and coal, and often of the means for transporting them, and the limited ability of many countries to pay for such foreign goods as were obtainable. Insofar as official trade controls were important, the decisions in the exporting country as to how much of particular commodities could be spared and where they should go were on the whole more influential than were the duties or other official conditions set by the governments of the importing countries upon their admission.

During 1946, as domestic production in various countries increased and supplies became generally more ample, restrictions on exportations were gradually relaxed. On the import side, direct exportations were gradually relaxed. On the import side, direct field licence, at least over the greater part of watern and souther field licence, at least over the greater part of watern and souther m Europe. Drawing upon their exchange reserves, and in the case of the countries of the sterling area and of western Europe upon the sizable extensions of credits earlier mentioned, most foreign countries expanded their purchasing eagerly. By 1947, the aggregate movements of goods in world commerce had recovered to above the prewar volume, and in terms of the higher prices the value was very much larger.

The very eagerness of the peoples of many countries to acquire large quantities of foreign goods, however, brought a sharp reaction in the way of official restrictions upon imports In the case of Europe, this was caused partly by the disappointingly slow recovery on the part of most countries in the production of essential commodities and in financial stabilization. Apparently the degree of disorganization in their internal economies had been underestimated, and their progress was further held back by severe weather, crop failures and strikes. The continued unsettled conditions in Germany, in the Danubian countries, and in the far east, which had been important sources of supply as well as markets for western Europe, was an additional retarding influence. This intensified the demand for substitute supplies from the western hemisphere, principally the United States. Moreover, the earnings from foreign investments, shipping and other sources, by which various European countries used to pay for much of their prewar excess of imports over exports, had shrunken during the war. In quite a number of countries, notably those of Latin America, the high rate at which their peoples had been buying foreign products since the war was well beyond the value of their current export earnings, and was itself responsible for their governments' resorting to stricter import controls as a safeguard for the nation's financial position.

By the close of 1947, new or tightened restrictions upon imports had been brought into operation in the great majority of countries in both hemispheres. By that time, both the accumulated foreign exchange reserves and the new credits obtained to tide over the transition had been seriously drained. To readjust their countries buying programs closer to the ability to pay, many governments curtailed the admission of various classes of goods regarded as not strictly essential. The cuts were applied with special severity to purchases from the follar countries, in order to conserve the limited dollar resources for the most essential produced by the conserved of the c

Particularly acute was the crisis that developed in the balance of payments of the sterling area. In July 1947, Gesta Butan had offered to make current sterling earnings freely convertible mot oblars, as agreed to in connection with the loan from the United States, with a view to starting the return toward the multilateral settlement of international balances. That offer brought so heavy a call upon Bartish dollar holdings as to force its suspension in a month. The effort to meet this crisis, through shap curtailment of imports into all the sterling area countries, exceted against a considerable number of other countries by materially shrinking their export markets

The Marshall Plan—It became clear that the war-disrupted countries of Europe needed further assistance to help rebuild their productive and trading strength and to ude them over until their own recuperative efforts, individually and jointly, had had time to bring results. Under stimulus from Secy of State George C. Marshall's offer of possible aid from the United States, the European countries met in the summer of 1947 to develop a cooperative program for common recovery. When the Soviet Union withdrew, along with the satellite countries of eastern Europe, it became the program of the 16 countries of seistern Europe, it

The large funds voted by the United States congress early in togs, and in each of several years thereafter, in support of this European Recovery program, the "Marshall plan," brought gratifying results in several ways in the expanded production and general reconstruction of the patiticipating European countries, in the more confident attitude is bred, and in its stimulus to close collaboration among themselves. Moreover, in increasing the putation of the program of the program of the program of the program, the side extended by the United States also busistered interational trade generally.

Despite this assistance, many countries were still unable to afford all the imported good desired, and selective restrictions continued. The purchases from dollar countries in particular were concentrated upon the most essential products. The inconvertibility of most currences, and often their unreal official exchange rates, hundered even such freet exchange of goods between counties as their recovering production might otherwise have allowed As a corrective to this situation, many countries tried what amounted to partial or selective depreciation of their currencies, by such devices as multiple exchange rates and exchange certaincates. The man objectives were to stimulate the foreign sales of their export products and to discourage or make mose costly the importation of classes of goods considered of secondary importance.

The type of trade agreement earlier described, which provided for reciprocal exchanges of supplies and anned at a bilateral annual balance of values, became the common pattern over a large part of the world. Although metapable so long as currencies were unconvertible and exchange reserves low, they came to have a distinctly constricting effect upon the potential expansion of foreign trade. The general resistance to the inclusion of nonessentals in the schedule of products that each country would admit from the other states of the control of

To ease the settlement of uneven balances in the trade among the European countries themselves, a special intra-European payments plan was inaugurated in 1948. Under this arrangement portions of the dollar aid allocated by the United States to respective ERP countries were made conditional upon their setting up special accounts of equivalent value in their own currencies, against which members with whom they had an export surplus could draw to finance their deficits. This was later replaced by a flexible system for clearing balances, the European Payments union,

The first broad efforts to loosen the "log jam" of governmental

restrictions upon the normal flow of goods and of payments, which had been building up since World War II, came in 1949. For, despite the vanous measures taken earlier, few countries yet felt able to relax materially their restrictive foreign trade controls For most countries of western Europe, the problem continued to be particularly acute and took two forms how to reduce their trade deficits with the dollar countries and how to open the way for larger trade exchanges with each other and their associated overseast territories.

In Sept 1949, Great Britain announced a 30% devaluation of its currency in terms of the dollar. This action was soon followed by all the sterling areas except Pakistan, and by all of the western European countries except Switzerland. Before long, many contress in Latin America and elsewhere made sharp cuts in the official exchange rates for their currencies as a whole or for transactions in particular categories of commodities. These moves were expected to reduce the overly high export prices that had developed under the inflationary conditions which, varying only in degree, had characterized the domestic economes in most countries since the war Along with the more realistic official realignment of currency values, commercial programs were initiated for more organized and infensive marketing of goods in dollar countries

On the problem of bringing about a freer flow of goods among themselves, the countries participating in the European Recovery program agreed in 1949 simultaneously to lift quota limitations upon their importations from the others in the group to the extent of at least 50% of past private trade in each major category of products. Early in 1950 they agreed upon a sense of steps for the progressive further liberalization of such quotas, with the hope of the trade among themselves ultimately becoming free of all hence restrictions. That program suffered several sebacks in the next few years, and by the close of 1953 had made only limited and uneven progress.

In the meantime, smaller groups of Buropean countries were actively considering various plans for a greater degree of trude beeralization among themselves, both for their own value and as possible intermediate steps toward for their own value and as possible intermediates steps toward for their own value and as general customs umon or economic mitegration of all western Europe. The only substantial progress actually made was the abolition of import duties on the movement of goods between Belgium, the Netherlands and Luxenbourg, which thus formed the Benelux Customs umon. However, other obstacles to the effective operation of this enlarged free market still persisted into the 1958. And its development into a full economic umon seemed remote.

In the major Assatic areas, progress toward resumption of nonmal commerce was still largely dependent upon political developments. Operating to hamper and even further to restrict trade operating were the following: (i) the spread of communist control over continental Chna, (2) the continued civil werfare in Indochans; (3) the internal disturbances in Burma; and (4) the disputes on both political and economic issues between India and Pakistan, which in Aug 1947 became independent countries.

On the favourable side was the setting up of an independent republic of the United States of Indonessa by the close of 1949. This promised to bring about the more stable condutions necessary to make available to world markets the various raw materials for which these islands had long been an important source. At about the same time the stabilization of the Japanese yean and the transfer from the Allied powers to the Japanese government of the authority to regulate the foreign trade of that country allowed its commerce to return rapidly to private channels.

Similar progress was concurrently being made in the principal other area occupied by the Allied powers, namely, western Germany. The adoption of a uniform conversion rate for the mark in 1948 and shortly thereafter the merging of the British, French and American zones for trade purposes greatly stimulated the revival of the German economy and facilitated direct private trade with foreigners.

Viewed broadly, the progressive improvement in production, monetary stability and trade balance which many countries were making gave promise, by the beginning of 1950, of early trade normalization. In fact, a number of governments began to liberalize their licence and exchange restrictions. The most pronounced steps were those taken by the countries of western Europe, earlier mentoned, to facilitate their exchanges of goods with each other Moderate relaxations were put into effect by Canada and several of the South American countries

An important contributory development at about this time was the substantial easing of the world shortage of dollars, which had for many countries been the prime problem in their trade imbalance. Their growing ability to supply themselves and each other with essential commodities, their improved export position pricewise as a result of the devaluations of 1948-49, joined with the strict selective curbs upon imports of less essential products especially from dollar sources, altogether resulted by the middle of 1950 in a marked narrowing of the dollar gap.

It is important to note, however, that this near closure of the dollar gap was the result more of the sharp decline in foreign purchases of United States goods from their earlier exceptional height, than of increases in the quantities of foreign goods sold in the

American market.

Trade Boom and Reaction After the Korean Outbreak.—
The sudden invasion of South Korean mid-1yop introduced we forces into the trade current. The resulting emergency pressures and the reactions to them oversladowed the normal recuperative forces for several years in determining the course of international trade and the character of the measures for regulating it.

The Pixt Phase—The threatened worsening of the international political situation led the United States and the other members of the North Atlantic Treaty organization (NA T.O.) to rebuild their defensive strength and stimulated a wide movement to acquire larger supplies of foreign products. At first, demand centred on basic raw materials for the enlarged midustrial production that was now anticipated and for military and commercial stock-pling. Before long the demand from many countries spread to broad ranges of commodities, in the aggregate well beyond the quantities readily available. Consequently, prices quickly rose to unusual heights, especially for primary products.

The widespread eagerness to stock up, in fear of later shortages and possibly higher purces, came at a time when—as carlier noted—most countries had greatly improved their financial position. This enabled a considerable number of governments in various parts of the world, especially in the western hemisphere, to take bold steps toward relaxing the operation of their import control of the world.

systems

On the other hand, as the intensified demand in international markets mounted, many governments imposed or tightened restrictions upon the exportation of their national products. This was done cheefly by enlarging the lists for which individual licences were required and by closer scrutiny of export applications as to quantity, destination and often price. The man objectives were commonly twofold: to ensure the retention of sufficient supplies for domestic consumption or processing without undue price rises; and to provide for some fair allocation of the products in exceptionally high demand.

In an increasing number of countries, national security considerations became an important factor in determining the destinations for which certain products would be licensed. The object was to prevent, or at least limit, shipments of commodities of strategic or other potential military value to countries with possible aggressive intentions. This program of tightening export centrols on such shipments and transhipments to the Soviet blow was most pronounced on the part of the United States, Canada, the western European countries, Japan and the Philippines.

The extraordinary itse in the market prices of various primary commodities led the governments of many countries to increase sharply the taxes upon their exportation or to impose new ones. The usual purposes were to divert part of the windfall gains to governmental use and to check the domestic inflation being engeldered. Certain countries also aimed to build up stabilisation funds to support the particular exporting industries during the investible lean years to follow.

An interesting experiment in joint action by the nations of the

free world for dealing with the problems of supplies of certain scarce basic materials, and their equitable allocation, was initiated early in 1951 under Anglo-Franco-American auspices. While all measures taken by the 28 participating countries were the result of voluntary agreements, the series of standing commodity committees making up the International Materials conference had a steadying effect upon the general raw materials situation, reducing the intense initial competitive bidding for supplies and the sharp fluctuations in market prices. Within less than three years they were able to go on a "stand-by" basis

The Second Phase —Beginning in the spring of 1951, there set

The Second Phase—Beginning in the spring of 1951, there set in a distinct slowing down in the volume of purchases of many base materials This brought a decline in their prices from the earlier peaks, although both demand and price for most primary commodities continued well above pre-Korean war level for another year or so. Joined with the gradual subsidence of the fears of extreme shortages was the growing resistance by government and merchants to what they considered excessive prices, notably

for rubber, tin, wool, jute and wood pulp

To the countries of Asia, Latin America and the overseas sterling areas, whose principal exports are primary products, the trade developments of 1050-51 usually brought distinct gains in their financial postion, though often at the cost of sharp domestic inflation. This condition continued even after the recession from the initial high demand and prices. For the mudustrial countries of western Europe and North America, on the other hand, the sharper rise in prices of raw-material imports than of their typical manufactured exports, combined with the need for greatly increased quantities of imported materials for industrial expansion in support of the rearmament programs, often created difficult veloped into acute balance-of-payments cries in France and Britain, and along with Britain in many of the other sterling-currency countries.

In fact, the sharpness of the fluctuations in international demand and prices brought on by the Korean conflict created problems for a great many countries. Even the primary producing countries of South America and Asia found before long that their high rates of importation were depleting their newly replenshed foreign exchange reserves and bringing back the earlier trade axis-times. Some governments sought to redress the situation through greater domestic austerity and intensified efforts to increase exports, but most often the immediate corrective adopted was renewed restriction of imports as a whole or from particular currency areas

The Third Phase.—During 1952 and 1953, the majority of the countries made substantal progress toward the restoration of balance in their external trade and financial position. In this they were aided by good harvests in most regions, the large inventories of foreign goods on hand from earlier purchases, and the general return to more stable market prices. Most of the improvement, however, was achieved through reducing the volume of their foreign trade by cutting back the country's imports to the level of earnings from current exports.

The recession in raw-material prices eased the problem of the industrial countries through improving their terms of trade. Obversely, for the primary producing countries, the sharp shrinkage in mome from their export staples had an adverse effect upon their external financial positions. This held back any appreciable relaxation of the import restrictions to which they had reveted after the period of overbuying. Even among the countries which succeeded in working back toward a more balanced position in their international payments, only a few had by the close of 193 fest warranted in doing much toward leaking the restrictions on their international payments, only a few had by the close of 193 fest warranted in doing much toward leaking the restrictions on their of Europe and of the sterling area apparently preferred to rebuild their foreign exchange reserves to a higher level, so as to be in a stronger position to withstand possible renewed strain upon their balance of payments.

On the export side, this third or readjustment phase of the trade shifts following the Korean outbreak did bring an appreciable relaxation of the licensing and rationing controls adopted during the scramble for supplies after mid-1950. Those controls that were still maintained had as their prime objects the implementation of reciprocal supply agreements and the checking of the shipment of strategic products to areas under Soviet domination At the same time, the wide resort to high export taxes on the part of the primary producers during the price upsurge of 1950-51 was reversed. Most of the extra levies were reduced or abolished to make the products more readily salable in world markets.

General Agreement on Tariffs and Trade.-While the majority of countries after World War II depended for the regulation of their foreign trade primarily upon administrative controls on the quantities of goods entering or leaving their territories and on the conditions of paying for them, most of the noncommunist governments regarded them as essentially short-run measures They declared themselves as looking forward to the time when improved conditions would enable them to liberalize or abandon most of these controls and to rely again primarily upon moderate and nondiscriminatory tariffs

The most important concrete expression of the desire of the nations to move toward that long-term objective has been the General Agreement on Tairifs and Trade (GATT), originally concluded at Geneva in 1947, and amplified at Annecy in 1949 and at Torquay in 1951.

in 1947, and amplined at Annecy in 1949 and at Torquay in 1951. By 1953, 33 countries were contracting parties, and accounted in the aggregate for about 80% of total world commerce

The GATT grew out of the proposal by the United States shortly after the close of World War II that the nations collaborate in a broad program, as envisaged in the lend-lease settlement agreements, to promote more liberal conditions for international trading and a prosperous expanding world economy. It consisted essentially of two parts. Specifically, there was the series of agreements that were negotiated specifically, to ever was the series of agreements that were rigidinate simultaneously by various pairs of governments for the reduction of existing import duties of each on selected products of particular nerst to the other party, or their binding against increase The aggregate concessions in the bilateral negotiations were then generalized to the same products from all of the participants Of a more general character was the code of principles regarding quantitative restrictions and other measures affecting foreign trade by which the contracting governments undertook to be guided, as soon as certain specified limitagovernments undertook to be guated, as soon as certain specified neutra-rements found themselves able to relax, if not to terminate, the various quantitative controls and other nonconforming practices that had been so promoment in the unsettled posture decade, the more liberal progressively to exert their beneficial influence.

In the meantime, the collective tainff agreements were regarded jin-

portant, both as an advanced concept of the desirable pattern of in-ternational trade arrangements and, at the least, as effecting a sub-stantial tariff truce through the stabilization of a large part of the import duties of the world Despite some withdrawals of specific duty concessions by a number of countries—a flexibility for which the duty concessions by a number of countries—a nexibility not which that the member governments agreed in Oct. 1953 to a second extension of their tariff undertakings as a whole to run to the middle of 1955.

Trading With and Within the Soviet Sphere.—As earlier

indicated, almost all of the countries of eastern Europe began to move toward centralized control of their economies as soon as World Wai II ended. Thereafter, their foreign as well as their domestic trade came

to be conducted almost entirely through agencies of the state or those authorized by it Moreover, as these countries had been remoulded along the lines of the Soviet Union, and—with the exception of along the lines of the Soviet Union, and—with the exception of Vigoslavia—had come increasingly under its direction, their commercial political programs of the Soviet bloc. They were, therefore, less responsive than the open-trading countries to the general shifts in world

sponave than the open-training countries to the general sunties in worst counteries after 95. U.S.S.R. and five of the countries in the Soviet sphere set up a Council for Economic Mutual Assistance as an offset to the ERP which was manugarated the preedding year by the countries of western and southern Europe and which those of the east had refused to join, While agreements for closer trade relations and in certain es also for industrial collaboration were concluded between various

cases also for industrial collaboration were concluded between various pairs of these countries, the only co-ordinated economic planning for the region as a whole was evidently that stemming from Moscow The strong mituence of the USSR was exacted toward making the Soviet bloc as nearly self-sufficient as possible. The ambituous production programs amonunced by the various satellities seemed designed primarily for meeting Russia's import requirements and sendarily their own needs or those of other mort culcuments and sendarily their own needs or those of other mort culcuments and sendarily their own needs or those of other mort culcuments and sendarily their own needs or those of other mort culcuments and sendarily their own needs or those of other mort fearmants and the save manufacturing facilities of the Soviet zone of Germany and the law materials of communist China were, likewise, increasingly integrated into the governmentally planned trading system of the Soviet Union and its European satellites.

Despite the long-term objective to reduce their dependence upon the west for supplies and markets, the countries in the Soviet sphere intermittently sought arrangements for trading with outside countries

to meet their immediate needs for raw materials and capital equipment to meet their immediate needs for raw materials and capital equipment not available from each other. Since credit was seldom obtainable, such trade exchanges were usually planned on a closely balanced basis. In part, the volume of this trade was limited by the restrictions imin part, the volume of this trade was inmited by the restrictions in proceed by various countries of the few world upon the restrictions. The Soviet blue of products that would be recommended by the restriction of the rest USSR and the other communist countries

No. 30 K and the other communist countries
After repeated attempts at collective trade, negotiations between
east and west at Geneva under the auspices of the Economic Commusion for Europe had yielded hitte result, Russia mivted the nations to
a Moscow Economic conference in the spring of 1952

There the Soviet spokesmen put forward vigorously the beneficial possibilities of larger exchanges with the communist countries, if only outside countries exchanges with the communist countries, it only outside countries would lift their export restrictions Only small-scale bilaterial transactions were known to have resulted, however, partly because of the inability of the Soviet bloc to supply many of the products sought by the others, and partly because of communist insistence on including in the proposed exchanges various products which the western govern-

ny use outsers, and party occases or communist measures on anadomic in the proposed exchanges vanues products which the western governments would not hence for algorithm of the proposed of the proposed of the community of the U.S. 8th of New York and London, 1931). Gottlined Haberley, The Theory of International Trade with 18s Applications to Commercial Policy (London, 1936). Jacob Vuner, Sudds: in the Theory of International Trade with 18s Applications to Commercial Policy (London, 1936). Jacob Vuner, Sudds: in the Theory of International Trade (New York and London, 1931). Jeague of Nations, The Policy of the Trade (Senter, 1981). Jeague of Nations, The Policy of the Trade (Senter, 1981). The York and London, 1991 Abher Isases, International Trade: Targir and Commercial Policies (Chicago, 1948). American Economy: Its Siricular and Operation (New York, 1981). The International Becompt. Its Siricular and Operation (New York, 1981). However, 1981 April 1982 (Policies The Policies The Changley Panorama, 1992–1953 (Berley Chalmess, World Trade Policies The Changley Panorama, 1992–1953 (Berley Nos), 1953). (H. Changley Panorama, 1992–195) (Berley Nos), 1953). Panorama, 1920-1953 (Berkeley, 1953).

TARIJA, a department and town of southeastern Bolivia The department lies on the northern frontier of Argentina, and is bounded west by Potosí, north by Chuquisaca, and east by Paraguay. Pop. (1950 census) 126,752. A1ea 11,979 sq mi The eastern part of the department belongs to the great Chaco lowland region. The Chaco districts are inhabited by small nomadic tribes of Indians, and the grassy Llanes de Manzo by the Chiriguanos, many of whom live in permanent villages, breed horses, cattle and sheep, and till the soil. In the mountains are remnants of the Quéchua, once masters of an empire. There are oil wells at Río Bermejo and Sanandita

The capital, SAN BERNARDO DE TARITA (DOD. census 1950. 16,869) is the only town of importance in the department. It is situated on the Río Tarija, about 85 mi. E. of Tupiza. It is about 6,500 ft. above sea level and its climate is mild. (J W. Mw)

TARIM, the river which gives its name to the great basin between the Tien Shan and Kunlun mountain systems of central Asia. The area of the basm is over 350,000 sq mi, and the length of the river may be said to be about 1,000 mi. The mountain frame dies away to the northeast in the arid Gobi, so that beneath the slopes of the Kunlun lies the Kansu highway from China, The river is formed by the confluence of the Kashgar and the Yarkand; it then flows for about 230 mi. northeastward between high banks, bordered by poplars and reeds, and joins the Aksu, a swift and powerful stream from the north; 20 mi, farther on the Khotan river flows in from the south, and after another 150 mi. it begins to come into direct conflict with the sand dunes of the great desert and to form lateral lakes in the hollows between the great dunes, which the Khotan river has had to fight in the lower part of its course Numerous streams flow in from the Kunlun northward parallel to and east of the Khotan river, but lose themselves in the desert, and the Khotan reaches the Tarim only about 40 days in a year. Farther to the east the Tarim breaks up in deltaic fashion and swings north and south Here it skirts the northeast front of the great dunes and has a number of long lakes on its course, stretching mostly north to south or northwest to southeast. The lakes act as filters and the river emerges from them bright and clear. A little north of lat. 40, at Airylgan, it receives the Koncheh river, which issues from the lake called Bagrach-Köl. This river has poplars on its left bank which hinder the spread of the desert from the north-east. Below Airylgan the remains of the river, which has diminished practically all the way down from its confluence with the Aksu, enter the dwindling lakes of Kara-Buran, a sort of ante-room to the real terminal basin of the river, the Kara-Koshum (Lop-Nor, q v ) at an altitude of 2.675 ft. above sea-level. In 1990-01 Dr Syen Hedin discovered several fresh desert lakes forming to the north of Kara-Koshun, and branches of the deltaic arms of the Tarım, or overflows of such branches, straining out in the same direction, facts which he interpreted as showing a tendency of the river to revert to its former more northerly terminal basin of the old (Chinese) Lop-

The lower part of the course of the river is, on the whole, moving south-westward into lower ground. Its course is so sluggish that sediment is deposited in its bed, which is thus raised above the surrounding country The river is usually frozen during December, January and February. The thaw in March causes a flood, followed by a greater one, due to the melting of snows on the mountains, and the high water can be traced down

the river during the summer

The basin is often divided into four main regions:-(a) The Takla-Makan desert (qv) or central area of bare drift-sand desert. Its borders on the west, north and east are determined by the belts of vegetation accompanying the Tisnaf, Yarkand and Tarim rivers respectively. The area has outliers beyond these riverine borders (b) The oasis belts south of the Tien-shan, east of the Pamir and north of the Karakorum and Kunlun 'The oases on the south he between the gravel glacis of the Kunlun and the sands of Takla-Makan. The best known are Karghalik. Khotan, Keriya, Niya, Cherchen and Charkhlik, Those on the north include Uchturfan, Aksu, Bas-Kuche, Kuerhlei, Karashar, Turfan, Pichan and Hami To the west the two chief ones are Kashgar and Yarkand The cultivable areas are usually greater in the west and the north than in the south (c) The terminal depression of Lop and the Turfan basin The Lop basin contains the terminal marshes of the Tarim river, the salt-encrusted bed of the former extension of Lop-Nor beyond the marshes, and the dune-covered area east of the final course of the Tarim river between it and the north-western shore of the old lake. The Turfan depression is enclosed on the north by a portion of the Tienshan; on the west by an outlying range of the same, and on the east and south by the barren hills of the Kuruk Tagh Within these boundaries there are belts of glacis, desert, oasis-cultivation and dune-covered desert, exactly as one finds them in the Taxim basin. (d) The Sulo-Ho basin, and the cultivated area along the route north of the Nan-shan, leading into Kansu from the eastern Tarm. The basin is covered with bare gravel, except for a narrow belt of vegetation accompanying the lower course of the river, and the limited area capable of cultivation by means of irrigation around the oasis of Tun-huang South of Tun-huang accumulations of drift-sand, approach or overlie the foothills of the Nan-shan.

Problems of Climatic History .- The present-day climate of the Tarim basin is discussed in the article on Sinkiang (q v.), but the problems of its possible changes of climate in the past have been the subject of much investigation during recent years. The expeditions into the Tarim basin which have been undertaken by Sir Aurel Stein and Dr. Sven Hedin have resulted in a great mass of evidence bearing on the problem. This evidence has been interpreted by various authorities, who have each put forward a theory to explain the facts reported by the explorers. The problem is connected with the supposed "desicca-tion" of Central Asia. (See Asia: Exploration.)

Great changes have come about in the Tarim basin during the last two thousand years. Settlements have been abandoned and fresh ones made; some regions, once prosperous, are now deserted and are quite uninhabitable; rivers have forsaken their old beds, and other rivers do not extend as far as they once did, while the lakes in the centre of the basin appear to be shrinking in size.

Historical Geography. The Tarim basin lies on a highway

Tien-shan and the southern one along the northern foot of the Kunlun. Both unite at Kashgar, whence the route leads over the Pamirs to the trans-Caspian lowlands

The region has always been one having an essentially "corridor" nature There is not, and never has been, sufficient atmospheric moisture or subterranean water supplies to support a large agricultural population The narrow belts of riverine jungle could never, within historic times, have afforded the possibility of nomadic existence to any but quite insignificant communities, such as the present Dolans on the Yarkand river. This point is very important, for it explains why the great nomadic tribes of the Wu-sun. Sakas, Yueh-chih, Huns, Turks and Mongols were always ready to raid, or to make tributary, the oases of the Tarim, but never crossed the Tien-shan, permanently to occupy the basin Nature has denied grazing grounds to the Tarim, and has thus protected it against ever becoming the scene of great migratory movements and the upheavals which accompany them Within the basin itself, the only basis of life was painstaking agriculture, possible only by means of irrigation. This mode of life did not appeal to the neighbouring nomads; the plateaux of the Tien-shan or the Mongolian steppes were more suitable for them. Because of these conditions, we find each great wave of Central Asian migration moving along the northern foot of the Tien-shan, or even further north

Modern Economic Conditions in the Tarim Basin.-The potential wealth of the Tarim basin is as yet untouched by modern developments. Hitherto its commercial importance as a highway has benefited those people who used the highway. Beyond the protection afforded at times by Chinese troops, and the benefits of an effective administration, which the region enjoyed when Chinese authority was sufficiently strong to assert itself, the native oasis dwellers have not prospered overmuch from the advantages which their land offers to neighbouring peoples as

an easy trade route between East and West.

The fertile "loess" which composes much of the western part of the basin is eminently suitable for cultivation. The total amount of land under cultivation could be increased if a scientific system of irrigation were developed by the Chinese administrators. The chief obstacle to wider cultivation of the oases as found in the people themselves They are mostly Turki, engaged in either agriculture or commerce, and, although they do not resent foreign interference, they show no desire to enlarge their commercial and agricultural enterprises. The attitude of the Chinese in the matter of foreign exploitation of the Tarim basin is very discouraging Foreign capital is needed to develop the resources of the country, and the Chinese are not anxious to admit this, owing to their dread of alien domination

The products are chiefly grain of all kinds, wool, cotton and silk. Khotan is the centre of the silk industry, and also the centre of valuable jade deposits Agriculture is the most im-portant and widespread industry. The natives depend on it for their existence, as foodstuffs are not imported from the neigh-bouring States. The cotton and jute industries could be turned into a flourishing trade if properly exploited, both products being of excellent quality. Soil, labour and material are there to cooperate in the development of these industries.

The political disturbances in the Tarim basin during the last century and the recent upheavals in China itself have been responsible to a large extent for the commercial apathy prevailing in East Turkistan. (See also Sinkiang, Kashgar, Khotan, Yarkand, Lop-Nor, and for bibliography see Asia.)

TARKANRÍ or TARKILANRI, a Pathan tribe inhabiting the valleys of Bajour, on the border of the North West Frontier Province of India.

TARKINGTON, NEWTON BOOTH (1869-1946), U.S author, was born in Indianapolis (Ind.), July 29, 1869 After studying at Phillips academy, Exeter (N. H.), he entered Purdue university, Lafayette (Ind.), but later transferred to Princeton, whence he graduated in 1893. He was a member of the Indiana House of Representatives in 1902-03 One of the most of the nations; the main routes through it being in an east-west versatile of American writers of fiction, Tarkington won early direction, the northern route along the southern foot of the recognition with his novel, The Gentleman from Indiana (1800).

Among his outstanding successes were the charming romance Mon- buttress of the Plateau Central, with the Montagne Noire (3,970 siem Beaucaire (1900), which was later presented on the films and on the legitimate stage, the humorous portravals of boyhood and adolescence, Penrod (1914) and Seventeen (1916), his delineations of the modern industrial city, The Turmoil (1915); The Magnificent Ambersons (1918), and The Midlander (1924), combined as Growth (1927); and The Plutocrat (1927) Perhaps his most finished novel was Alice Adams (1921), which, like The Magnificent Ambersons, was awarded a Pulitzer prize Tarkington was also the author of a number of plays including Beauty and the Jacobin (1912), Mister Antonio (1916), The Man from Home (1906), and Up from Nowhere (1919), the latter two with Harry Leon Wilson, Penrod Jashber (1929) He died on May 19, 1946

TARLAC, a municipality (with administrative centre and 42 barrios or districts) and capital of the rich province of Tarlac, Luzon, Republic of the Philippines It is located on the central plain of Luzon in the region drained by the Agno river Pop. (1939) 55,682, of whom 29,038 were males and 114 were white The region produces two crops of palay (rice) annually, one by means of irrigation. Other agricultural products are sugar, tobacco, corn, beans, sweet potatoes, coconuts and pineapples Pampango is the principal vernacular, but Tagalog, Ilocano and Pangansman are spoken in the municipality and elsewhere in the province Of the inhabitants aged 6 to 10 inclusive, 33 1% attended school in 1939, and 58 8% of the population 10 years old and over was literate. The number of parcels of private land declared for taxation in 1938 was 5,113 and the number of owners 3,030 Tarlac was founded in 1686 (C. S L)

TARLETON, SIR BANASTRE (1754-1833), English soldier, the son of John Tarleton (1719-1773), a Liverpool merchant, was born in Liverpool on Aug 21, 1754. Educated at Oxford, he entered the army and in Dec 1775 he sailed as a volunteer to America with Earl, afterward Marquess, Cornwalls. His services during the American War of Independence in 1776 gained him the position of a brigade-major of cavalry. In 1780, as commander of the British legion, a mixed force of cavalry and light infantry, he went to South Carolina, supporting Sir Henry Clinton in the operations which culminated in the capture of Charleston. After taking part in many successful engagements, he marched with Cornwallis into Virginia and was instructed to hold Gloucester This post, however, was surrendered to the Americans with Yorktown in Oct. 1781, and Tarleton returned to England on parole From 1790 to 1812, with the exception of one year, he sat as M P for Liverpool. In 1794 he was promoted to major-general, and in 1812 general; he held a military command in Ireland and another in England. In 1815 he was made a baronet. He died without issue at Leintwardine, Shropshire, on Jan. 25, 1833.

He wrote a History of the Campaigns of 1780 and 1781 in the Southern Provinces of North America (1781) which was criticized by Col. Roderick Mackenzie in his Strictures on Lieutenantcolonel Tarleton's History (1781), and in the Cornwallis Correspondence.

TARLTON, RICHARD (d 1588), English actor, according to Fuller (Worthies m, 139) was born at Condover, Shropshire. He was probably at one time an inn-keeper. In 1583 he is mentioned as one of the original company of queen's players and he had become an experienced actor; he was their chief comedian and remained with them until his death. He was Elizabeth's favourite clown, and his talent for impromptu doggerel on subjects suggested by his audience has given his name to that form of verse. For the queen's men he wrote The Seven Deadly Sins. Many songs and witticisms of the day were attributed to him, and after his death Tarlton's Jests, many of them older than he, made several volumes. He is said to have been the Yorick of Hamlet's soliloguy.

TARN, a department of France, formed in 1790 of the three dioceses of Albi, Castres and Lavaur, belonging to the province of Languedoc. Pop. (1946) 298,117. Area, 2,232 sq.mi. Tarn is bounded north and east by Aveyron, southeast by Herault, south by Aude, southwest and west by Haute-Garonne, northwest by Tarn-et-Garonne. The department forms the southern

ft ) near its southern border The general slope is from east to west, and in the east the Monts de Lacaune reach 4,154 ft at the Pic de Montalet The greater part of the department is floored by ancient rocks with some granite, especially in the north, and the general level is from 1,500 to 2,000 ft The Aveyron runs along the northern boundary, the Tarn across the middle of the department, and the Agout across the south, and they join one another west of the boundary on their way to Garonne The Aude receives the streams from a part of the Montagne Noire

The limestone and sandstone foothills are clothed with vines and fruit trees, and are broken by deep alluvial valleys of extraordnary fertility. The eastern portion of the department has the climate of Auvergne, the severest in France, but that of the plain is Girondin The winter average temperature reduced to sea level is 41° and the summer average temperature is 70°, but the great elevation often reduces these figures by 15° to 20°. The rainfall, 29 or 30 in at that place, exceeds 40 in on the Lacaune and Montagne Noire

The west and centre produces cereals, wheat, oats, maize and vines; the valleys around Castres provide natural pasture for cattle, market-gardening is carried on in the west. There are mines of coal and iron, and quarries of lime The industries include the manufacture of textiles, hosiery, brushes, morocco leather, hats, metal foundries, dve works and glassworks department is famous for its sparkling wines The department is divided into two arrondissements (Albi and Castres) and there are 36 cantons and 325 communes. The department is in the 16th military region, and the académie (educational division) of Toulouse, where is its court of appeal,

The chief towns are Albi (the capital and seat of an archbishop, with suffragan hishops at Rodez, Cahors, Mende and Perpignan). Castres, Gaillac, Lavaur, Mazamet and Cordes (qq v). Burlats has ruins of an old church and château; Lisle d'Albi, a bastide with a 14th-century church, and Penne has ruins of a mediaeval châtean

TARN, a river of southern France, 234 mr long, a tributary to the Garonne. It rises at 5,249 ft on the Hercynian gneisses of Mt. Lozère, flows westward and, having received the Tainon, enters a goige in the Jurassic limestones, which separates the Causse de Sauveterre from the Causse Méian. It receives the Ionte (left) and passes between the Causse Noir, the Larzac plateau and the Causse de St. Affrique (left) and the Lévezou range and the Plateau of Ségala (right). At Millau it receives the Dourble (left) and lower down the Dourdou (left) and from there to the cascade of Sabo, above Albi, the river crosses Permian and Sılurian rocks Having entered the plain, the river has cut out a deep bed in the Tertiary strata, passes Gaillac, and, after receiving the Agoût (left), it turns northwest, receiving the Tescou (right) at Montauban and the Aveyron (right). After passing Moissac it joins the Garonne on its right bank.

TARN-ET-GARONNE, a department of southwestern France, formed in 1808 of districts formerly belonging to Guienne and Gascony (Quercy, Lomagne, Armagnac, Rouergue, Agenais), with the addition of a small piece of Languedoc From 1700 to 1808 its territory was divided between the departments of Lot. Haute-Garonne, Tarn, Aveyron, Gers and Lot-et-Garonne It is bounded north by Lot, east by Aveyron, south by Tarn and Haute-Garonne, and west by Gers and Lot-et-Garonne. Area, 1,440 sq mi. Pop. (1946) 167,664. The department is the region focusing upon Montauban and includes the junction of the Aveyron and the Tarn and their union with the Garonne. These rivers separate hills of Pliocene strata, and in the extreme northeast stands out the edge of the Plateau Central and the limestone Causse de Quercy (1,634 ft.). The climate is mild and agreeable; the mean annual temperature being about 56° F. Rain falls seldom, but heavily, especially in spring, the annual rainfall being 28 or 30 in.

The wide alluvial valleys of the three large rivers are most productive. Cereals, especially wheat, maize and oats, occupy more than two-thirds of the arable land of the department. The vine is grown everywhere and large quantities of grapes are exported as table fruit. Potatoes are also grown Plums and apricots are abundant. The breeding of horses, especially for cavalry purposes, is actively carried on, and the rearing of horned cattle, both for draught and for fattening, is also important. Sheep, pigs, poultry, and silk-worms are also sources of profit. There are metal-founderse, various kinds of silk-mills, and manufactories of straw-hats, wool, paper and brooms. The principal exports are fruit, wine, flour, truffles from the Rouergue, and early vegetables. The canal of the Garonne traverses the department or 48 m and the Garonne and the Tarn furnish 82 m of navygable waterway. The department is served by the Orléans and the Southern railways. The department forms the diocese of Montauban under the archbishop of Toulouse, and belongs to the académic (educational division) of Toulouse, where is its court of appeal, and to the district of the XVII. corps d'armée (Tou-Careller, and the control of the Arthur and Careller, and the Careller, and th

Castelarrasin), 24 cantons and 195 communes

TARNOPOL, a province of Poland, bounded on the north
by the province of Volhyma, on the west by Lemberg (Lwow), on the south by Stanislawów provinces, and on the east by Russia Area 6,268 sq miles. Pop. (1931) 1,604,000 In 1931 49 3% were Poles, 45.5% Ruthenians and the rest mostly Jews thenians belong to the same race and religion as those in Stanislawów province (q v.), but the Poles are more numerous in Tarnopol, since they had been colonizing the Podolian plateau since the 14th century. Tarnopol is part of the plateau of Podolia joining up with the Lublin uplands, having the appearance of hills where the land slopes down to the Volhynian plain, especially in the Gologory. The south is bounded by the Dniester, with its lower valley, the tributaries of which drain the bulk of the province except in the north, where the Bug and Styr have their sources. These tributaries all flow from north to south and from the deep savines which are a feature of Podolia The plateau is sometimes flat, sometimes hilly and wooded, as on the Miodobory along the eastern border. The Strypa and the Lipa were scenes of stubborn Russian defense during World War I. Tarnopol is a fertile agricultural province, densely populated with small peasant proprietors. It is famous for its horses and cattle The chief towns are Tarnopol (pop 35,831), Zloczów and Barezany. The province was occupied by Soviet troops at the start of World War II and was conquered by the axis in 1941.

TARNOPOL, a town of Poland, in the province of the same name, 87 ml. E.S E of Lemberg (Lwow) Pop. (1931) 35,831, half of whom were Jews. The town was founded in 1540 by Jan Tamowald. It became a fortress and received many privileges from the Polsh kings. The ancient synagogue of the reign of Casimir the Great remains. Industry consists in com milling and the preparation of wax and honey. The chief trade is in horses, agricultural produce and spirits. Soviet troops occupied Tamopol in 1030, and it was captured by asis forces in 1040.

TARNÓW, town of Poland, in the province of Cracow. Pop. (1931) 45,235, of whom about 40% were Jews. It is situated on the river Bials, not far from its junction with the Dunajce, and is the seat of a Roman Catholic bishop. It possesses a cathedral in Gothic style, built in the 15th century, with monuments of the Tannowski and Ostrogski families, to which the town formerly belonged, another church, built in 1454, and a diocesan museum with Polish paintings of the 15th and 15th centuries. On a hill mear the town stand the ruins of an old castle of the Tannowski family and a small church over 800 years old. The town hall is an old and interesting building. Agricultural implements jass and chroory are manufactured. Tarnów was occupied by German forces in World War II.

TARNOWSKI, JAN (called Macuvus) (1488-1562). Pollah general. Aftèr a careful education at the palace of Matthew Drzewicki, bishop of Przemysl, he occupied a conspicuous position at court in the reigns of John Albert, Alexander and Sighsmud I. In izoo Tarnowski distinguished himself in Moldavin, taking part in the victories of Wisniowicc (1512) and Orssa (1514). He their travelled in the Near East, and northern and western Europe. While in Portugal he received from King Emanuel the chief command in the war against the Moors, and was pro-

moted by Charles V to a count of the Empire. On the death of Nicholas Fillei in 1526 Tarnowski became grand hetman of the crown, or Polish commander-in-chief, and won his greatest victory at Obertyn (August 22, 1531) over the Moldavians, Turks and Tatars. Tarnowski took the royal side during the "Poultry War" of 1537; and also in 1548 when the szlachta tried to annul by force the marriage of Sussmund Augustus (see Sigismund II) with Barbara Radziwill In 1553, indeed, he was in opposition to the young king; yet he remained emphatically an aristocrat, in-tensely opposed to the democratic tendencies of the szlachta. and working for a firm alliance between the king and the magnates. Though a devout Catholic, he was opposed to the exclusive jurisdiction of the bishops and would have limited the au-thority of Rome in Poland Tarnowski invented a new system of tactics to increase the mobility and security of the armed camps within which the Poles had so often to encounter the Tatars. His principles are set forth in his Consilium Rationis Bellicae (best edition, Posen, 1879) As an administrator he did much to populate the vast south-eastern steppes of Poland.

TARO (Colocasa antiquorum), a coarse herbaceous plant of the arum family (Araceae, q v), called also eddo, probably native to the Pacific islands, where it is extensively cultivated for its large, spherical, underground tubers, which form an important article of food, especially in Hawaii

It is closely alhed to the dasheen (C esculenta), native to the East Indies, a stately ornamental plant, with large shield-shaped leaves, various cultivated forms of which are known as elephant's-

TAROK, a game of cards very popular in central Europe and to some extent in France (tarot) and flally (tarotchi). It is the oldest surviving card game (see Carsos, FlaxInso). The modern game uses 54 cards, comprising 33 sult cards, 21 taroks (permanent trumps) and a joker. Each suit includes four court cards, instead of three as in the 32-card French pack. The taroks, origan-layl illuminated with indivulual designs of sectore significance, now are usually printed only with the Roman numerals from I to XXII.

The play of the game centres upon the manipulation of the taroks, each of which is privileged to win any suit card. Tarok includes many features that were borrowed by other games—competitive bidding, a seat or widow, melding of honour combinations, the sequence of matadors, the suttless or wild joker, the effort to capture specific counting cards in tricks and extra score for the last trick.

TARPAULING (as if tarpalling, from tar, and palling, a covering, Lat., palla, a mantle), is a heavy well-made, double warp plain fabric, of various materials, used chiefly in the manufacture of covers for weather protection. It is usually made from cotton duck, single filled, double filled, or Army construction. Certain tarpaulins are made from drill and flax. To render 1 proof against ram and other atmospheric influences, it is generally treated with waxes, petrolatums, and other waterproofing agents. Some tarpaulins are also made from jute (qw), most are equipped with grommets or eyelets in the corners, spaced around the cover. The fabric is fastened over the object to be protected.

TARPEIA, in Roman legend, daughter of the commander of the Capitol during the war with the Sabines caused by the rape of the Sabine women. According to the story, she offered to betray the citadel, if the Sabines would give her what they were on their left arms, meaning their bracelets, instead of this, keeping to the letter of their promise, they threw their shields upon her and crushed her to death Simylus, a Greek eleganc poet, makes Tarpeia betray the Capitol to a king of the Gaulis The story may be an attempt to account for the Tarpeian rock being chosen as the place of execution of trattors. According to S. Reinach, however, in Revue archéologique, xi. (1908), the story had its origin heaped up on consecrated ground that they might not be touched Tarpeia herself is a local divinity, the manner of whose death was suggested by the tumulus or shields devoted to her cult, a crime being invented to account for the supposed punishment.

See Sir George C. Lewis, Credibility of early Roman History; A Schwegler, Romische Geschichte, bk. ix, 10; Livy, I, 11; Dion, Halic,

II. 38-40; Plutarch, Romulus, 17; Propertius, iv 4, Ovid. Fasti, i. 261; assassinated at the instigation of the sons of Ancus Marcius C. W. Muller, Frag. Hist. Grace, iv. p. 367

TARPON (Tarpon atlanticus), a fish allied to the herrings, but with a large mouth and very large, thick, silvery scales It occurs in the warmer parts of the western Atlantic, and is an active fish, preving on the fry of other fishes It reaches a length of 7 ft , and a weight of more than 200 lb

TARQUINIA (anc. TARQUINII), a town of Italy, in the province of Viterbo, 62 mi. northwest by rail from the city of Viterbo, 490 ft above sea level Pop (1936) 6,368 (town), 8,118 (commune). It is picturesquely situated, and commands a fine view of the sea It possesses mediaeval fortifications, and no less than 25 towers are still standing in various parts of the town. which thus has a remarkably mediaeval appearance. The castle, on the north, contains the Romanesque church of S Maria in Castello, begun in 1121, with a fine portal of 1143, a caborium of 1166 and a pulpit of 1208, both in "cosmatesque" work, the pavement in marble mosaic also is fine There are several other Romanesque and Gothic churches and other buildings. The Gothic Palazzo Vitelleschi (1439) with remarkably rich windows, contains the fine Government museum, now including the Bruschi collection, of Etruscan antiquities from the tombs of the Etruscan city, which probably occupied the site of the Roman town, now deserted, its last remains having been destroyed by the inhabitants of Corneto (the mediaeval name by which the town was till lately known) in 1307 Scanty remains of walling and of

buildings of the Roman period exist above ground. The importance of Tarquinia to archaeologists lies mainly in its necropolis, situated to the south-east of the mediaeval town, on the hill which, from the tumuli raised above the tombs, bears the name of Monterozzi. The tombs themselves are of various kinds The oldest are tombe a pozzo, or shaft graves, containing the ashes of the dead in an urn, of the Villanova period, the earliest belonging to the stage known as First Benacci (see ETRUSCANS) and the latest to the middle or end of the oth century B.C. immediately after the coming of the Etruscans, a few contemporary graves of whom, containing Egyptianizing scarabs and some gold and silver, have also been found. In some of these tombs hut urns, like those of Latium, are found Next come the various kinds of inhumation graves, the earliest of which, the so-called warnor's grave, belongs to the early "Vetulonian" period, and the Bocchoris tomb to 730-690 BC. (MacIver, Villanovans and Early Etruscans, 1924, 40-56; 158-166): the most important are rock-hewn chambers, many of which contain well-preserved paintings of various periods

Tarquinia was the chief of the 12 cities of Etruria, and appears in the early history of Rome as the home of Tarquinius Priscus and Tarquinius Superbus. The people of Tarquinia and Veii attempted to restore Tarquinius Superbus after his expulsion In 358 BC, the citizens of Tarquinia captured and put to death 307 Roman soldiers; the resulting war ended in 351 with a 40 years truce, renewed for a similar period in 308 When Tarquinia came under Roman domination is uncertain, as is also the date at which it became a municipality; in 181 B.C its port, Graviscae (mod Porto Clementino), with Government salt-works 4 m S.W., in an unhealthy position on the low coast, became a Roman colony. It

exported wine and carried on coral fisheries.

TARQUINIUS PRISCUS, LUCIUS, fifth legendary king of Rome (616-578 B.C.). He is represented as the son of a Greek refugee, who removed from Tarquinii in Etruria to Rome, by the advice of his wife, the prophetess Tanaquil. Appointed guardian to the sons of Ancus Marcius, he supplanted them on their father's death He laid out the Circus Maximus, instituted the "great" games, built the great sewers (cloacae), and began the construction of the temple of Jupiter on the Capitol. He carried on war successfully against the Sabines and subjugated Latium, He is said to have raised the number of the senators to 300, and to have doubled the number of the knights.

The introduction of many of the insignia of war and of civil office is assigned to his reign, and he was the first to celebrate a Roman triumph, after the Etruscan fashion, in a robe of purple and gold, and borne on a chariot drawn by four horses. He was

The legend of Tarquinius Priscus is in the main a reproduction of those of Romulus and Tulius Hostilius There seems to have been originally only one Tarquinius; later, when a connected story of the legendary period was constructed, two (distinguished as the "Elder" and the "Proud") were introduced, separated by the reign of Servius Tullius, and the name of both was connected with the same events.

with the same events.
For the constitutional reforms attributed to Tarquinius, see Rome.
Ancient History, for a critical examination of the story, Schweegler,
Remunich Geschichte, lix xv. Sir George Cornewall Lewis, Credibity
of early Roman History, ch. 11; W line, History of Rome, 1, E Pais,
Sterned Roma, 1 (1893), who thentines Tarquinus with Tarpellus, the
eponymus of the Tarpen rock Ancient authorities.—Lavy 1, 34–41;
Don, Hali, in, 45–75, Oc. de Repub, n. 200

TARQUINIUS SUPERBUS, LUCIUS, son of Lucius Tarquinius Priscus and son-in-law of Servius Tullius, the seventh and last legendary king of Rome (534-510 BC) On his accession he proceeded at once to repeal the recent reforms in the constitution, and attempted to set up a pure despotism. Many senators were put to death, and their places remained unfilled; the lower classes were deprived of their arms and the completion of the fortress-temple on the Capitoline confirmed his authority over the city The outrage of his son Sextus upon Lucretia (av.) precipitated a revolt, which led to the expulsion of the entire family. All Tarquinius's efforts to force his way back to the throne were vain (see Porsena, Lars), and he died in evile at Cumae. In the story certain Greek elements, probably later additions, may easily be distinguished Tarquinius appears as a Greek "tyrant" of the ordinary kind; on the other hand, an older tradition represents him as more like Romulus This twofold aspect of his character perhaps accounts for the making of two Tarquinu out of one (see Tarquinius Priscus) The well-known story of Tarquinius' repeated refusal and final consent to purchase the Sibylline books has its origin in the fact that the building of the temple of Jupiter Capitolinus, in which they were kept, was ascribed to him

For a critical examination of the story see Schwegler, Romische Geschichte, bk. xviii.; Str. G. Concewall Lewis, Credibility of early Roman History, ch. 11, B + Pais, Storia di Roma, 1. (1898); and, for the political character of his reign, ROME: Ancent History. Ancient authorities—Luyy 1. 21; Dion. Hal v. 1-vi 2x.

TARRAGON (Artemisia dracunculus), a smooth green herb of the family Compositae, called also estragon, native to Europe and closely allied botanically to the mugwort and wormwood (qqv). It is widely grown in gardens for its slightly bitter aromatic foliage used in flavouring vinegar, pickles, salads and other dishes.

TARRAGONA, a maritime province in the northeast of Spain, formed in 1833 from the southern part of the province Spain, formed in 1833 from the southern part of the province of Catalonia, and bounded S.E. by the Mediterranean, N.E. by Barcelona, N. by Lérida, W by Saragossa and Teruel, and S.W. by Castellon de la Plana Pop. (1940) 339,299; area 2,426 sq mi. The Ebro flows through the southern portion of the province, and below Tortosa forms a conspicuous maishy delta, but elsewhere the coast-line is unbroken. The hills are clothed with vineyards, which produce excellent wines, and in the valleys are cultivated all kinds of grain, vegetables, rice, hemp, flax and

silk. Olive, orange, filbert and almond trees reach great perfection, and the mountains yield rich pastures and timber. Manufactures are well advanced, and comprise silk, cotton, linen and woollen fabrics, velvet, felt, soap, leather and spirits. There are also many potteries and cooperages and flour, paper and oil mills. Silver, copper, lead and other minerals have been found, and quarries of marble and jasper are worked in the hills.

TARRAGONA, the capital of the Spanish province of Tarragona, a flourishing seaport, and the seat of an archbishop; at the mouth of the river Francoli, 63 mi. by rail W.S W. of Barcelona. Pop. (1940) 33,708 (mum., 35,648).

Tarraco, the capital of the Iberian Cessetani, many of whose

coins are extant, was one of the earliest Roman strongholds in Spain. It was captured in 218 B.C. by Gnaeus and Publius Cornelius Scipio, who improved its harbours and enlarged its walls. A Roman monument on a hill 3 mi. E. is known as the Sepulcro de los Escipiones, and locally believed to be the tomb of the Scipios, who were defeated and slain by the Carthaginians under Hasdrubal Barca in 212 BC, but there is no good reason to believe that the monument is older than the 1st century AD As the Colonia Triumphalis, so called to commemorate the victories of Julius Caesar, Tarraco was made the seat of one of the four assize courts (conventus juridici) established in Hispania Citerior. Augustus spent the winter of 26 B C, here, and made Tarraco the capital of the whole province, which received the name of Hispania Tarraconensis. A temple was built in his honour It was afterwards restored by Hadrian (A.D. 117-138), and the city became the Spanish headquarters of the worship of the goddess Roma and the deified emperors. Its flax trade and other industries made it one of the richest seaports of the empire.

To the Romans the Visigoths under Euric succeeded in 467, but on their expulsion by the Moors in 711 the city was plundeted and hurned. In 1080 the Moors were driven out by Raymond IV. of Barcelona, and in 1118 a grant of the fief was made to the Norman Robert Burdet, who made it a frontier fortress against the Moors. The British took the city in 1705; the French captured it in 1811. In the civil war of 1936-39, Tarragona re-

mained in Loyalist possession until Jan. 15, 1939.

Tarraxona is on the coast railway from Barcelona to Valencia, and is connected with the Ebro Valley Railway by a branch line to Reus. The old town, with its dark and steep alleys, occupies a rugged hill which rises abruptly from the sea to an altitude of about 550 ft. Many of the houses in this quarter are very old, and are built partly of Roman masonry; one such fragment, immured in the palace wall, is inscribed with the epitaph of a charioteer (auriga) Massive ruined walls encircle the old town. Their lowest course is "Cyclopean," consisting of unhewn blocks about 12 ft long and 6 ft wide: Roman masonry of the Augustan age is superimposed. The six gates and the square towers are also, to a great extent, "Cyclopean." Tarragona cathedral is one of the noblest examples of early Spanish art. The main body of the building dates from the end of the 12th century and the first half of the 13th, and is of transitional character. On the north-east side is a cloister contemporary with the church, with which it communicates by a very fine doorway. The cloister contains much remarkable work, and the tracery of the windows bears interesting marks of Moorish influence. Two other noteworthy churches in the city are San Pablo and Santa Tecla la Vieia, both of the 12th century.

There is a fine Roman aqueduct; the Roman amphitheatre was dismantled in 1401 to furnish stone for the eastern mole, though a few rows of seats are left near the sea-shore; and the museum contains a large collection of Roman antiquities. The Torreón de Pilatos is said to have been the palace of the Emperor Augustus. When the monks of the Grande Chartreuse were compelled to leave France, they settled at Tarragona in 1903, and established a liqueur factory. A characteristic feature of Tarragona is the number of its underground storehouses for wine (bodegas); wine is exported in large quantities. Chocolate, soap, flour, ironware, paper, pipes and salted fish are also manufactured.

Control State Control

See G. W. Edwards, Spain (1926).
TARRASA, a town of Spain, in the province of Barcelona, 6 mi. W.N.W. of Sabadell on the Barcelona-Lérida railway. Pop.

(1940) 43,930 (mun., 45,081). Tarrasa was a Roman municipality, and a bishopric from the 5th century to the Moorish invasion in the 8th. Tarrasa is now mostly a modern industrial town.

the Stn. Latriasa is now mosty a mooten more and the TARRYTOWNS (Tarrytown and North Tarrytown, exBeekmantown), Westchester county, New York, U.S.A., on east bank of Hudson river, 25 mi. N. of New York city, opposite Nyack; served by New York Central railroad, motorbus lines and a ferry to Nyack, Pop. Tarrytown, 8.810; North Tarrytown, 8,833, 1950 federal census. Irvington adjoins on the south. The 8,833, 1950 federat census. Irvington adjoins on the south. Are main street, Broadway (Albany Post road), is part of the old King's highway, New York to Albany, laid out in 1723. In Tarry-town, at the junction, with Irvington, is "Sunnyside," Washington

capture of Major André, Sept. 24, 1780. In North Tarrytown, on the Post road, 1s the "Philipse Castle Restoration, with the Old Mill " The original buildings were erected in 1683 by Frederick Philipse, the wealthiest and most influential New Yorker of his time and associated with the West India company and Peter Stuyvesant, and their outstanding fort, house and church builder, The Old Dutch church, across the Post road, was also erected by him about that time. He and his wife are buried there After the revolution, the property was bought by Gerard G. Beekman, whose wife, a Van Cortlandt, became "Widow Beekman," the local traditional historical "little old lady." Around the Old Dutch church in Sleepy Hollow cemetery rest Washington Irving and other immortals. "Kijkuut," the estate and home of John D. Rockefeller, Tr., is at Pocantico Hills. Other modern estates include the Gould estate, and "Hillholm" of the late Worcester R. Warner, whose family have continued his local philanthropy and who joined the Rockefeller family and others in making possible the Philipse Castle Restoration of the Historical Society of the Tarrytowns, Inc. (founded in 1902). The Hokohongus (Washington Irving) treaty tree was long there The villages are partly residential Industries include automobile accessory plants. Tarrytown was incorporated as a village in 1870. Irvington in 1870 and North Tarrytown in 1875 The name is probably a corruption of the Dutch Tarwen Dorn (wheat town)

TARS, LOW-TEMPERATURE, the primary condensation products resulting from the carbonization of coal and such other organic substances as wood, peat, and lignite at temperatures not exceeding 700° C. The term "low-temperature tar" usually

refers to a low-temperature coal tar

Wood Tar is a by-product of the carbonization of wood. Two distinct types of wood tar are recognized. (1) hardwood tar and (2) resinous wood tar, the former derived from woods such as oak, beech, etc., and the latter from resmous stools and roots and particularly from pine wood.

Hardwood Tars The condensed volatile product of wood distillation is known as crude pyroligneous acid, which has the average composition. water 81%, methyl alcohol 3%-4%, acetic acid 6%-8%, tar 7%. After settling, the major portion of the tar separates from the aqueous acid although the latter always retains some tar in solution. The chemical constituents of wood tar form a complex mixture comprising the "fatty" acids, esters, ketones, alcohols, phenols (usually polyhydric) and their methyl ethers, together with waxes. The most important representatives of these groups present in the tar are formic and acetic acids, with their methyl esters, acetone, methyl and allyl alcohol, guaiacol, catechol, and esters of pyrogallol,

Beechwood tar is practically the only wood tar subjected to a complete straight distillation. Three fractions are usually collected, first the light oils and water containing acetic acid and methyl alcohol up to 180° C., then the heavy oils up to 240° C. and finally the pitch. The important fraction is the "heavy oil" from which beechwood creosote is obtained (see CREOSOTE).

The oils from wood tar are used as gum inhibitors in gasoline and as flotation oils; the pitch is used in briquetting.

Resinous Wood Tars are almost wholly represented by pinewood tar, which is commonly termed "Stockholm" or "Archangel" tar and is made extensively in the forests of the U S.S.R , Finland and Sweden It is an important commercial product and differs from hard wood tar in containing the pleasant smelling mixture of terpenes known as turpentine. Pine-wood tar is the residue left after the turpentine has been distilled, usually with the aid of steam. It is used widely in the manufacture of cordage, eg, tarred ropes and twine, and for impregnation of hemp fibre for oakum It is used to a slight extent in pharmacy as a component of some cintments and antiseptics. Distillates of pine-wood tar, particularly the creosote fraction, are used in froth flotation processes.

Peat Tar, a jet black, semisolid oil, lighter than water, which can be dehydrated by heating at 100° C. On distillation up to 360° C. a hard pitch is obtained along with an oily distillate, the Irving's home. Christ church, where Irving worshipped, is on 360° C. a hard pitch is obtained along with an oily distillate, the he Post road in Tarrytown. At the line between Tarrytown and latter consisting of a neutral fraction, containing the solid waxes, North Tarrytown, on Albany Post, road, is a memorial of the phenols and only traces of basic compounds. The most striking TARS 821

characteristic of the neutral oils is their high degree of unsaturation as manifested by absorption of atmospheric oxygen. The waxes, which resemble the montan wax of lignite, melt at about 40° C. The acidic (phenolic) constituents of the tar consist of phenol and its homologues, the cresols and vylenols in small quantity, mixed with tar acids boiling at 250°-360° C. The latter show a carbolic acid coefficient of 31, 10, they are 31 times more powerful than phenol as bactericides Among the phenolic constituents of peat tar, guaracol, methylguaracol and a methyl ether of pyrogallol have been identified These ethers are absent from coal tar, but are found in wood-tar creosote, of which they form the major portion. Peat tar may therefore be looked on as one of the transition steps from wood tar to coal tar. Although the products which can be isolated from neat tar are of undoubted value, the difficulty of winning and drying peat militates against the carbonization of this fuel on an industrial scale

Lignite and Brown Coal Tars resemble peat tar in many respects They are usually black oils of a buttery consistency owing to the presence of parafin wax. Of an average density of 0.95, they retain a high percentage of water but solidity completely at 6°-8° C. In contradistinction to tars from bituminous coal they are aimost completely solibile in herfol. a residue of

about 5% only being usually left.

They are parafinoid in nature, the wax content being as high as 10%. The crude wax melts at about 40° C but from it a series of waxes with meltung points from 46° to 73° C. has been obtained. The phenolec constituents resemble those of peat tar and are efficient bactericides. The basic components belong to the pyridine and quonoline series and are chiefly methylated derivatives. A distinctive characteristic of lightile tars is the presence of keoines in the neutral oils—a resemblance to the oils of wood iar. Lightile tars are of increasing morphorance as a source of fruits of the combustion engines, burning and lubriciting oils and

Low-temperature Coal Tars—r Vacuum Tar has only been produced experimentally with the object of elucating the composition of coal and the effect of heat upon this material. It is obtained when coal is actionamed at temperatures up to 450° C under a pressure of 5-40 mm and the average yield is 14 gal. (6 5% by weight) per ton of coal. It is usually lighter than water (0.99 spg r) and is especially interesting in that some of its constituents are identical with substances found in perforded in Cartesian of the Cartesian of 18 medical water of the composition of the control of the composition of th

Amongst the more interesting constituents of vacuum tar are the naphthene, CasHac called melene which is also found in Galician petroleum and in the distillate of bees' wax, and the hydrogenated phenols (dicohols) such as hexahydro-p-cresol and its homologues.

2. Low-Temperature Tor is produced by the carbonization of bitummous coals, containing 38%—35% solidle matter, at temperatures not exceeding 700° C, which is an optimum temperature for the production of gas, tar and smokeless fuel (see Low-Temperatures Carbon/Latron). It is essentially a mixture of these volatile products of coal which are lugid at ordinary temperatures and which have not been subjected to the secondary-termal decomposition incidental to high-temperature carbonaryation in horizontal retorts. It is therefore regarded as a "primary" tar. Many factors affecting the yield, composition and other than-acteristics of low-temperature tars have been varied in experimental plants with the result that there have been produced many types of tars to which it has been impossible to assign a common composation. Certain well defined characteristics may be shortly summarized of primary tars obtained by low-temperature carbonization processes which have been commercially established.

Low-temperature tar is usually a brownish black oil, much less viscous than the tar made from the same coal at high temperatures. It is obtained in an average yield of 16-18 gal, per ton of coal carbonized, or 8%-9% by weight. This is approximately double the weight obtained by distilling the coal at 905-1, 200° C. Its specific gravity is 10-1-07, and fing to the low temperature at which it is formed, it allowed a radinfield in character, where at which it is formed, it allowed which yaromatic. The most distinctive characteristics of low temperature tar are the almost entire absence of benzene and its homologues, naphthalene, anthrace can and plenoj; the unsaturated nature of the neutral oils, from which can be isolated solid parafims, and the presence of solid, amorphous compounds, of either basic or phenolic nature.

The crude tains a most unstable product and begins to decompose at about 200° C., finally yielding, when sattlied to 360° C, an average of 65% oily distillate and 35% pitch. The amount of pitch formed on distilling low-temperature tar is therefore only half that obtained in a smillar operation with high-temperature tar. The former, too, contains much less "free carbon" (\*s\*, materiasoluble in benzene) than the latter, the average amount being 2%—4%. By modified extractions with caustic soda and sulphuric add (see Coal Tark) the crude distillate can be divided into (\*s\*).

neutral oils, (2) phenols, and (3) bases

a. Neutral oils consist almost wholly of paraffins, naphthenes and olefines, with comparatively small amounts of methylated derivatives of naphthalene and anthracene On treatment with concentrated sulphuric acid, the neutral oils are absorbed with the exception of some 12% consisting mainly of paraffins Crude solid wax representing over 1% of the tar is obtained on cooling an acetone solution of the neutral oils In the paraffin series, all the lower members have been identified, and in the higher ranges, the solid members from C26H14 to C26H60 The latter melt at 62° C a- and β-methylnaphthalenes have been isolated, but no naphthalene Similarly &-methylanthracene occurs in a complex mixture of hydrocarbons crystallizing on cooling the high fractions of the distillates, but anthracene is absent Neither fluorene, nor carbazole has been identified in low-temperature tar: in addition to the hydrocarbons acenaphthene and diphenyl, there occur the fully hydrogenated products, perhydrofluorene, perhydroacenaphthene and dodecahydrodiphenyl

b. Phenols The extraction of the phenolic constituents of the tar or its distillates is complicated by the fact that resmous and asphalic substances accompany the phenols in solution in the al-lah. These impuritues, however, can be climinated by agitation of the alkaline solution with organic solvents or by saturation with salt. The crude phenols (10%—20% of the tar) obtained oaddification as a black oil, can be further purfied by extraction with light petroleum, followed by precupitation of the residue from an ethereal solution by fresh petroleum. The petroleum for the properties of the properti

colour from pale yellow to black

c. Basss The crude bases, representing s%p-4% of the tar, are also composed of a low mobile fraction and a higher viscous fraction containing solid, amorphous substances of unknown constitution. The lower bases consist of pyridne and quinoiline with their mono-, di- and tri- methyl derivatives Only traces of privary bases are present in the tar. There have been dendified pyridne, 2-methylpyridine, 3-methylpyridine, 4-methylpyridine, 2-dimethylpyridine, 2-distributylpyridine, 
Ultimation of Low-Temperature Tar Products.—The commercial possibilities of low-temperature tar have not yet been fully developed, but its application in various directions has been demonstrated. The low-boiling distillates, owing to their "insaturated" nature, form sustafactory fuel possessing certain anti-detonating qualities. It has been claimed that the higher fractions of the neutral oils form an exceptionally good lubricant, whist the "middle" or "dead" oils are suitable for combustion in the diesel engine. Special characteristics are also claimed for

low-temperature tar pitch, which can be used along with or in place of high-temperature tar pitch.

Hill the raids, which were made in Asia Minor regularly, place of high-temperature tar pitch.

See H H Lowry, Chemistry of Coal Utilization (1945)
(D D P, F E Cr)

TARSIER, a small arboreal mammal, Torsus, byflying a suborder of Pinnates (q.w.) Its name refers to the great length of the anklebones or tarsus, but an equally distinctive character of this animal is its enormous, goglelke eyes. The head in which these are set is rounded, the muzzle short and pointed, while the ears are large. Rather smaller than a squirrel, it has a slender body and long, thin tail which terminates in a truft of hair and serves as a rudder and halance. The fingers and toes end in diskike pads, which assist the animal to adhere to branches and other smooth surfaces. While it is doubtful if more than a single species exists, numerous races have been described on the various islands Sumaira, Borneo, Celebes and some of the Philippins. The tarsier feeds on insects and hands, sleeps during which the structure of its limit days is well adapted. It is a rev, not more than two being found together, and brings forth only one young at a time.

BIRLIOGARIX — C. Hose, Manuals of Borneo (1892), Fifty Fear of Romance and Research, pp. 95, 69 and appendix C.; G. Elliot Smith et al., Froc Zool Soc London (1915), H. H. Woolkard, "Monograph on Trassus," Froc Zool Soc. London (1915), W. E. Le Gros Clark, Froc. Zool. Soc. London (1944); F. Wood Jones, Man's Place among the Mammals (New York, London, 1936)

TARSUS (mod. Tersons), an ancient city in the fertile plain of Citica. The small Cydnus river flowed through the centre of the town, and its cool swift waters were the boast of the city. The city is first mentioned on the Black Obeliak, as captured by the Assyrians c \$50 s.C. It was probably an old Ionian colony, settled (like Mallus) under the direction of Claran Apollo. Its importance was the result of: (1) its occellent and safe harbour; (2) its possesson of a fertile terrorry; and (3) its command of the first wagouroad made across Mt. Tarura, which was cut originally only wide enough to carry the waters of a small affluent of the Cydnus. The greatness of Tarus rested therefore mainly on the two great engineering works, the habour and the road.

Tarsus is most accessible from the sea or from the east. Even after the Cihcian Gates were cut, the crossing of Taurus was a difficult operation for an invading army (as Xenophon and Arrian show). Hence Tarsian history (where not determined by Greek maritime relations) has been strongly affected by Semitic influence, and Dion Chrysostom, about AD. 112, says it was more like a Phoenician than a Hellenic city (which it claimed to be). After the Assyrian power decayed, princes, several of whom bore the name or title Syennesis, ruled Tarsus before and under Persian power. Persian satraps governed it in the 4th century B C.; and struck coins with Aramaic legends there. The Seleucid kings of Syria for a time kept it in a state of servitude; but it was made an autonomous city with additional citizens (probably Argive Greeks and Jews) by Antiochus IV Epiphanes in 171 B.C., and then it began to strike its own coms. It became one of the richest and greatest cities of the east under the Romans after 104 BC., and was favoured by both Antony and Augustus: the reception there by the former of Cleopatra, who sailed up to the city in a magnificent vessel, was a striking historic event. In spite of its oriental character, it maintained a university where Greek philosophy was taught by a series of famous Tarsians, who influenced Roman history, Chief among them was Athenodorus Cananites (q v.), teacher and friend of Augustus. St. Paul, a native of Tarsus, proudly describes himself as "a citizen of no mean city."

Taxus depended for its greatness on commerce, peace and orderly government. It was not a strong fortress and could not be defended during the decay of the empire against harian invasion. The Arabs captured the whole of Clificia shortly after An. 560, and Taxus seems to have been a ruin for more than a century after the conquest. But Harun al-Rashid rebuilt its walls in 787, and made it the northwestern capital of the Anto power in the long wars against the Byzantine

year by year, sometimes twice in one year, through the Cilician Gates and past the fortress Loulon, issued through the north gate of Tarsus, which was called the Gate of the Holy War The western gate remained standing, and was misnamed St. Paul's Gate The caliph Mamun died on such a foray in AD 833, havmg caught a chill at a great spring north of the Cilician Gates beside Ak-Keupreu. He was brought to Tarsus where (like the emperor Tacitus) he died and (like the emperor Julian) was buried. His illness recalls the fever which Alexander the Great contracted from bathing in the Cydnus Nicephorus Phocas reconquered Tarsus and all Cilicia for the empire in A.D 965 In the first crusade Baldwin and Tancred captured Tarsus, AD 1000, and there the two leaders had a serious quarrel. It formed part of the kingdom of Lesser Armenia for great part of the three centuries after AD 1180, and it was fortified by Leo II and Hethoum I. But Turkoman and Egyptian invaders disputed its possession with the Greek emperors and Armenian kings and with one another. Finally it passed into Ottoman hands about the beginning of the 16th century

The ruins of the ancient city are very extensive, but they are deeply buried, and make little or no appearance above the surface except in the Dunuk Tash (popularly identified as the tomb of Sardanapalus, a monument which, however, was at Anchiale, not at Tarsus). This shapeless mass of concrete was probably the substructure of a Giaeco-Roman temple, from which the marble coating was removed. The modern town has considerable bazaars and trade, but the climate is very oppressive, because of the proximity of vast marshes which occupy the site of the harbour and the lower part of the original Cydnus course. The river was diverted from its former course by Justinian in the 6th century The emperor's intention was only to carry off the surplus waters in time of flood and prevent mundations in the city, not to deprive Tarsus of what was its chief pride and boast, but gradually the neglect of subsequent centuries allowed the channel in the city to become blocked by accumulation of soil, and now the whole body of water flows in the new channel east of the city, except what is drawn off by an artificial irrigation course to water the gardens on the western side of the city. The population in 1050 was 33.822.

1950 Was 33,3822.

Brazconsaryur—The hierature regarding Tarsus is scanty, and few ancaret macroptions have been published. See W. B. Barker, Lores and ancaret macroptions have been published. See W. B. Barker, Lores and Six in Numinator Chronicle, pp. 195 fl. (1884), pp. 376 fl. (1864), E. Babelon, "Berses Achémendes," Cetalogue Bibl. Nat., the numinants works of B. V. Head, F. Inholo Bitmer, etc. Waddington in Salletin pp. 83–435 (Barden, City, N.Y., 1997), and "Chica, Tarsus and the pp. 83–435 (Barden, City, N.Y., 1997), and "Chica, Tarsus and the Great Tatuus Pars' in Geographical Journal, pp. 137–340 (1994). R. Heberdey and A. Wilhelm, "Escen in Killiden" in the Denkschriften Chieffen, V. Langlois and Macfondal Kinnel: Calladier in Journal of Hellene Studies, pp. 58 fl. (1994), studied Dion Chrysostom's two Tarsus Orations.

TARTAGLIA or TARTALEA, NICCOLO [Nicola Fontana] (c. 1506–1559), Italian mathematician, was born at Bresca. His childhood was passed in dire poverty. During the sack of Brescia in 1712 he was horribly mutiated by some French soldiers. From these injunes he slowly recovered, but he long continued to stammer in his speech, whence the nickname "Tartaglia" He was self-tauglia, but we find him at Verona in 1731 an esteemed teacher of mathematics. In 1534 he went to Venice For Tartaglia's solution of cubic equations, which he derived from his master Sciptone Ferro (d. 1525), see Browntons, Turcon or In 1548 Tartaglia accepted a stutation as professor of Euclid at Brescia, but returned to Venice at the end of 18 months. He ded at Venice in 1550.

Tartaglia's first punted work, entitled Nuova scienzio (Venice, 15,37), della Whit the theory and practice of gunnery. He found the elevation giving the greatest range to be 45°, but failed to demonstrate the correctness of his nutution. His Questii et invensioni diverse (1546), a collection of the author's replies to questions addressed to him, was dedicated to Henry VIII of England. Problems in artillery occupy two out of nine books; of the solution of cubic equations He published in 1551 Regola generale per sollevare ogni affondata nave, intitolata la Travagliata Innenzione (an allusion to his personal troubles at Brescia), setting forth a method for raising sunken ships, and describing the diving-bell, then little known in western Europe. His largest work, Trattato generale di numcri e misure, is a comprehensive mathematical treatise (Venice, 1556, 1560). He published the first Italian translation of Euclid (1543), and the earliest version of some of the works of Archimedes (1543), including De insidentibus aquae, of which his Latin now holds the place of the lost Greek text. Tartaglia claimed the invention of the gunner's quadrant

Tartaglia's own account of his early life is contained in his Quesiti, Tartagnas own account of me early me is contained in its Quesni,
bb. vi, p. 74. See also Buoncompagni, Intorno ad un testamento
inedito di N. Tartaglia (Milan, 1881), Ross, Elogi di Brescani illustri,
p. 386. Tartaglia's writings on gunnery were translated into English
by Lucar in 1588, and into French by Ruefiel in 1845

TARTAN, a worsted cloth woven with alternate strines or bands of coloured warp and weft, so as to form a chequeted pattern in which the colours alternate in "sets" of definite width and sequence The weaving of particoloured and striped cloth cannot be claimed as peculiar to any special race or country, for such checks are the simplest ornamental form into which dyed varns can be combined in the loom. But the term tartan is specially applied to the variegated cloth used for the principal portions of the distinctive costume of the Highlanders of Scotland. For this costume, and the tartan of which it is composed. great antiquity is claimed, and it is asserted that the numerous clans into which the Highland population were divided had each from time to time a special tartan by which it was distinguished. After the rebellion of 1745 various acts of parliament were passed for disarming the Scottish Highlanders and for prohibiting the use of the Highland dress in Scotland, under severe penalties. These acts remained nominally in force till 1782, when they were formally repealed, and since that time clan tartan has, with varying fluctuations of fashion, been a popular article of dress, by no means confined in its use to Scotland alone; and many new and imaginary "sets" have been invented by manufacturers, with the result of introducing confusion in the heraldry of tartans, and of throwing doubt on the reality of the distinctive "sets" which at one time undoubtedly were more or less recognized as the badge of various clans

Undoubtedly the term tartan was known, and the material was woven, "of one or two colours for the poor and more varied for the rich," as early as the middle of the 15th century. In the accounts of John, bishop of Glasgow, treasurer to King James III, in 1471, there occurs, with other mention of the material, the following:-"Ane elne and ane halve of blue Tartane to lyne his gowne of cloth of Gold." It is here obvious that the term is not restricted to particoloured chequered textures. In 1538 accounts were incurred for a Highland dress for King James V on the occasion of a hunting excursion in the Highlands, in which there are charges for "variant cullorit velvet," for "ane schort Heland coit." and for "Heland tartane to be hose to the kinge's grace." Bishop John Lesley, in his De origme, moribus, et rebus gestis Scotorum, published in 1578, says of the ancient and stillused dress of the Highlanders and Islanders, "all, both noble and common people, wore mantles of one sort (except that the nobles preferred those of several colours)" A hint of clan tartan distinctions is given by Martin Martin in his Western Isles of Scotland (1703), which work also contains a minute description of the dress of the Highlanders and the manufacture of tartan.

The following lines give a brief description of the colours of the tartans of the principal clans. The kilt-tartan colour is given in each case; the plaid-tartans vary in slight particulars.

Campbell of Breadalbane, green ground with black and blue half-inch wide crossings and double yellow overcheck Campbell of Argyll, green ground with wide blue and black crossings, narrow black crossings and alternate yellow and white overcheck. Cameron, red ground with wide green crossings and yellow overcheck. Forbes, green ground, blue and black wide crossings and narrow crossings of black, white overcheck. Fraser, red ground with green and blue wide crossings, and white overcheck on the

the sixth treats of fortification; the ninth gives several examples 1ed Graham of Monteith, green ground, wide cross bands of black with blue, and double pale blue overcheck. Grant, red ground with narrow and wide crossings of green and blue, pale blue overcheck Macdonell of Glengarry, green ground with wide crossings and black and blue, narrow crossings of four red lines and white overcheck Macdonald, green ground with black and blue wide crossings and four red overlines in two groups, and fine red overcheck Macdonald of Clanranald, green ground, wide crossings of black and blue, narrow crossings of red grouped together, and white overcheck. Macgregor, red ground, wide and narrow crossings of green, white overcheck edged with black. Mackintosh, red ground, wide crossings of green, narrow crossings of blue and blue overcheck. Mackenzie, green ground, wide crossings of blue and black, with one white overcheck and red overcheck. Macleod, green ground, wide black and blue crossings, overcheck of red and overcheck of yellow Macpherson, red ground with bright blue, green and black wide and narrow crossings, narrow white crossings and yellow overcheck Munro. red ground, green and black wide and narrow crossings, narrow red crossings, double yellow overcheck Murray of Athole, green ground with blue and black wide crossings and treble overcheck in red Royal Stewart, red ground with green and blue wide and narrow crossings, bright blue narrow crossings, and double overcheck of white and vellow.

See W and A. Smuth, Tartans of the Clans of Scotland (1850), J. Sobieski Stuart, Vestianum Scotlcum (1842); R. R. MTan, Clans of the Scottish Highlands (1845-46); J. Grant, Tartans of the Clans of Scotland (Edinburgh, 1885)

TARTAR, in chemical technology, a name applied to crude acid potassium tartrate (bitartrate of potash) deposited in wine casks or vats during the process of vinous fermentation as a crystalline crust of "argol," containing about 75% of potassium bitartrate. This argol when partly purified by recrystallization is known as "tartar," and when further purified and freed from colouring matter it becomes "cream of tartar" Cream of tartar is used medicinally as a diuretic and purgative.

The term "tartar" was formerly employed in a wider generic sense by the iatrochemists who included under this heading both the above tartarus vnn and various substances obtained from it and even salts such as salt of sorrel (potassium oxalate) which resembled it. Thus sal fixim tartan was dry potassium carbonate which on exposure to air deliquesced to oleum tartari per debouium. Neutral potassium tartrate was termed tartarus tartarısatus because it was prepared by neutralizing ordinary tartar with the sal fixum (K2CO2). Spiritus tartari employed by Paracelsus was prepared by dry distillation of tartar. This iatrochemist also used the term in a still wider sense to signify abnormal sediments deposited from animal secretions such as the concretionary masses separating in the liver, kidney or bladder, and usually referred to as "stone '

Wine "Lees" and Argol .- Tartanc acid occurs in the juices of various fruits, particularly the grape and tamarınd. grape this acid passes into the expressed juice and during fermentation of a deposit of sparingly soluble acid potassium tartrate is thrown down which forms the "lees" of wine. During the process of maturing, a further quantity of this tartrate is precipitated and the deposit of "argol" constitutes the main source of commercial tartaric acid.

Cream of Tartar .- Granulated argol is dissolved to saturation in boiling water and the clear solution allowed to crystallize. The coloured crystals are redissolved in hot water and decolorized by means of pipe clay or egg albumen. On subsequent crystallization, small, hard, colourless, transparent, rhombic prisms of cream of tartar are obtained. This salt dissolves in 15 parts of hot water but requires for solution 416 parts of water at o° C. It dissolves freely in solutions of boric acid or borax giving soluble cream of tartar, a white powder, permanent in air when made with bonc acid but deliquescent when prepared with borax. Ignition of the salt produces inflammable gases leaving a residue of potassium carbonate and carbon. Rochelle salt or potassium sodium tartrate, KNa(C4H4O6), a purgative drug, is made by dissolving cream of tartar in aqueous sodium carbonate.

Tartar Emetic (polassium antimony) tartinto), a long-known drug, being mentioned by Basil Valentine, is prepared by warming three parts of antimony oxide or powder of algaroth (q v) with four paits of cream of lartar in presence of water. It separates from the filtered solution in colouries octabedra which gradually lose their combined water, becoming opaque. It is soluble in 145 parts of cold and 1 y parts of howater. It has a nauesous metallic taste and produces womiting when taken internally. In large dooses it is possionous. Besides its medicinal use as an emetic and in the treatment of certain tropical diseases, it is employed as a mordant in dyeing and calloo printing. (G T M. X.)

TARTARIC ACID is one of the most important of the organic acids and probably one of the first to be recognized, for its sparingly solible acid potassium sait (see TARTAR) was known to the Greeks and Romans in the form of a deposit from fermented grape juece K W Scheele first isolated tataric acid in 1769 by boiling tartar with chalk and decomposing the product with sulphure acid. Ordnary startaric acid crystallizes from water in large colourless hemshedral monochine prisms containing no water of crystallization. It melts at 168–170° C and at higher temperatures decomposes into a variety of products; its formula is CAHQO, (See Prayuro Acid).

Manufacture.—The stating material, argol or wine less, is rousted in the dry site, suspended in water and neutralized with calcum hydroxide or calcum carbonate. The precipitated calcum tartne is filtered and treated with dulte subplume and, sparning soluble calcum subplate remains largely undissolved, whereas the tartaric acid passes into solution. The dilute thought so concentrated in vacuum pans to the crystallizing point and cooled. The crude product is redissolved in water, treated with chemical switch remove impurities and decolorized by heating the solution with charcoal. The filtered colourless solution is concentrated and allowed to crystallize. After the granular material is removed by centrulygation and dried in a rotary drier, the pure tartaric acid meets the requirements specified in the Pharmacopoen of the United States of America.

Applications,-Tartaric acid is used as a mordant in wool dyeing It is employed by the calico printer in conjunction with bleaching powder for the liberation of chlorine, as a resist for alumina and other basic mordants and in the discharge colours for Turkey red By successive nitration and oxidation, tartanc acid is converted into dinitrotartaric acid and dihydroxytartaric acid. the latter being an intermediate in the manufacture of the wool dye, tartrazine Tartaric acid also serves in certain photographic processes for printing and developing; ferric tartrate is used in blue-printing It is employed for the production of baking pow-ders, Seidlitz powders, sherbet and similar effervescent drinks Medicinally it is used to make effervescent saline draughts and cooling drinks for febrile and diabetic patients If unneutralized it must be taken in a largely diluted solution, otherwise severe gastroenteritis may result. It is used mostly in the form of potassium bitartrate (cream of tartar) and other salts the actions of which vary. Lime water, magnesia and alkalies are antidotes.

Chemical Properties.—Tartaric and is oudised by hydrogen peroxide in presence of ierrous salts to dhydroymaleic and (H. J. H. Fenton, 1894) and reduced by hydriodic and and phosphorus to make and suscine acids Tartaric acid prevents the precipitation by alkalis of many metallic hydroxides (e.g., copper and iron). Calcium chloride gives a white calcium tartate in neutral solution, the precipitate being soluble in cold aqueous potash but reprecipitated no boiling. Added to concentrated subhuric acid contaming 1% of resortion), tartaric acid develops a violei red contention. With warm ammountant silver intract in furnishes a

Steensomeric Tartaric Acids.—Tour varieties of tartaric acid after recognized: (1) The ordinary dextroorbary tartaric acid found either free or as potassum and calcium tartarics in the judices of tamarida, mulberries, pineapples, unripe, beetroot and especially in grapes; (2) laevarotatory tartaric acid, which occurs naturally in the fruit and leaves of Bauhinie steindate, a native tree of the French Sudan, but which originally was obtained by the resolution of the salts of nacemia acid. Except as regards its

interactions with other optically active substances, its chemical properties are identical with those of the dextro-scal and mall its physical properties it resembles thus and except that it turns the plane of polarization of high to the left and its crystaline sails show hemisherial faces like those of the devito-scal the opposity situated, as object to mixro mags. (3) reaction and the opposity of the normal carde, (Gafbol), 2HLO, which is obtained from the by the oxidation of fumance acid or by mixing molecular proportions of the n- and t-acids, (4) mesotiatatic acid, melting at 150°-160° C, is obtained when cunchonne tatitate is heated for some time at 170° C, to obtained when cunchonne tatitate is heated for some time at 170° C, and also by the oxidation of malece acid, it is marker bike is accemic acid, but unlike the lattic is not resolvable into optically active varieties by L. Pasture forms the foundation of modern conceptions of standard by L. Pasture forms the foundation of modern conceptions of standards of the conception of the conception of the conception of the conception of the conception of the conception of the conception of the conception of the conception of the conception of the conception of the conception of the conception of the conception of the conception of the co

TARTARUS, in Greek mythology, the son of Aether and Ge, father of Typhoeus and the gants In the lited the word denotes an underground prison, as far below Hades as earth is below heaven, in which those who rebelled against the will of Zeus were confined In later commentaries Taitarius is the place of punishment of the wicked after death (See Abviss)

TARTINI, GIUSEPPE (1692-1770), Italian violinist, composer and musical theorist, was born at Pirano, Istiia, on April 8. 1692 In early life he studied, with equal want of success, for the church, the law courts and the profession of arms As a young man he was wild and irregular, and he crowned his improprieties by clandestinely marrying the niece (or the daughter of a dependent) of Cardinal Cornaro, archbishop of Padua The cardinal resented the marriage and Tartini, thinking his life in danger, fled for safety to a monastery at Assisi, where his character underwent a complete change He studied the theory of music under Padre Boemo, the organist of the monastery, and learned to play the violin in so masterly a style that his performances in the church became the wonder of the neighbourhood For more than two years his identity remained undiscovered, but one day the wind blew aside a curtain behind which he was playing. His retreat was betrayed to the cardinal, who, hearing of his changed character, readmitted him to favour and restored him to his wife

Tartini next removed to Venice, where he repaired, by the aid of good instruction, the shortcomings of his own self-staught method. After a period of study at Ancona, he returned to Padua, where he was appointed solo violinist at the church of San Antonio From 1733 to 1735 he acted as conductor of Count Kinsky's private band in Prague In 1728 he founded a school for the violin in Padua The date of his presence in Rome does not seem to be clearly established, but he was in Bologna in 1739. Afterward he returned to Padua, where he duel Feb 16, 1737.

Tartim's numerous compositions illustrate his passonate and masterly style of execution, in which he surpassed all his contemponaries. He frequently beaded his pieces with an explanatory poetical motto, such as "Ombra cara," or "Volgete il riso in punto o me pupille." He told Lalande in 1766 that the sonata known as II Trillo del Diavolto, or The Dewit's Sonata, was the fruit of a dream, in which the devil played an exquisite sonata Tratin's first book of sonatas was published at Amsterdam in 1734, the second at Rome in 1745, and many chamber works appeared during his lifetime.

Tartini contributed to the science of acoustics by his discovery (independently of Sorge, 1740, to whom the purmary credit is now given) of what are still called "Tartini's tones" (see SOUND and Hasams), or differential tones. When any two notes are produced steadily and with great intensity, a third note is heard, whose vibration number is the difference of those of the two primary notes. It follows from this that any two consecutive members of a harmonic series have the fundamental of that series for their difference tone—thus, \$\frac{E}{E}\$, the fourth and fifth

harmonic, produce C, the prime or generator, at the interval of two octaves under the lower of those two notes;  $\frac{E}{G}$ ; the third and fifth harmonic, produce C, the second harmonic, at the interval of a fifth under the lower of those two notes. The discoverer was wont to tell his pupils that their double-stopping was not in tune

1872) gave the same admonition Tartini made his observations the basis of a theoretical system which he set forth in his Trattato di Musica, secondo la vera scienzia dell' Armonia (Padua, 1754) and Dei Principi; dell' Armonia Musicale (Padua, 1767, Eng trans 1771). He also wrote a Trattato delle Appogiature, post-

trans 1/11.

Interest the state of the state 60,100. The name, Tartu, adopted after Estonian independence m 1918, means lowland of Tar or Taara, a god of Estonian mythology probably related to the Scandinavian Thor The principal part of the town lies south of the river, and the more important buildings are clustered around the two eminences known as the Domberg (cathedral hill) and the Schlossberg (castle hill), which in the middle ages were occupied by the citadel, the cathedral and episcopal palace. Following a great fire in 1777, the town was almost entirely rebuilt, and its fortifications were transformed into tree-lined promenades. In addition to the 13th century church of St. John, one of the finest and greatest brick buildings in mediaeval Livland, Tartu possesses a university, with an observatory, an art museum, a botanical garden, and a library of 250,000 volumes housed in a restored portion of the cathedral The Estonian National museum in its dome-shaped building is located just outside the town.

The university, chartered by Gustavus Adolphus of Sweden in 1632, moved to Parnu on the advance of the Russians in 1699 and again moved during the occupation by Peter the Great. Not until 1802, under the patronage of Alexander I, was the university restored. German influence predominated until the Russification of 1895. In 1919 the institution was reopened as the Estonian university. Although the technical school was moved to Tallinn, the university still had 3,219 students in 1938. The astronomy department became famous, owing partly to the labours of F. G. W von Struve (1820-39) and partly to Fraunhofer's great refracting telescope, presented by Alexander I

The foundation of Dorpat is ascribed to Yaroslav, prince of Kiev, and is dated 1030 In 1224 the town was seized by the Teutonic Knights, and in the following year Bishop Hermann erected a cathedral on the Domberg. From that date till about, 1558 the town enjoyed great prosperity, and the population reached 50,000. In 1558 it was captured by the Russians, but in 1582 was yielded to Stephen Bathori, king of Poland. In 1600 it fell into the hands of the Swedes, in 1603 reverted to the Poles, and in 1625 was seized by Gustavus Adolphus of Sweden The Russians again obtained temporary possession in 1666, but did not effect a permanent occupation till 1704. In 1708 the bulk of the population was removed to the interior of Russia. The town passed from Russian to Estonian rule in 1918, but suf-Bolshevists. In 1940 the town again fell under soviet and in 1941 under German occupation.

TARWEED, the name given in the United States to various plants of the tribe Madieae of the family Compositae (q,v), natives chiefly of the Pacific coast of North America. They are mostly annuals, with showy yellow or white flowers. Some 25 species occur in California, Oregon and Washington. Several of these, as the yellow tarweed (Hemizonia virgata), the coast tarweed (H. corymbosa) and the clustered tarweed (H. fasciculata), are valuable honey plants The most widely known species is the Chile tarweed (Madsa sativa), native to Chile and naturalized in California and Oregon, a useful forage plant, the seeds of which yield a pleasant, edible oil.

TASCHEREAU, SIR HENRI ELZEAR (1836-1911), chief justice of Canada, was born at St. Mary's in Beauce county (Quebec), on Oct. 7, 1836, the son of P. E. Taschereau. He was educated at the Seminary of Quebec, and was called to the bar there in 1857, becoming a Q.C. in 1867. He entered parliament, and was elected conservative member for Beauce county in the Legislative assembly (1861-67). He gained a reputation in 1874-75 with his work on Criminal Law Consolidation and Amendment

unless they could hear the third note, and Henry Blagrove (1811- Acts of 1869 for the Dominson of Canada with Notes, Commentaries, etc (vol 1 Montreal, 1874; vol in Toronto, 1875, and later editions), and soon afterwards published Le Code de Procédure Civile du Bas-Canada (Quebec, 1876) He became successively puisne judge of the superior court of Quebec (1871), judge of the supreme court of Canada (1878), and chief justice of Canada (1902-06), being knighted in 1902 In 1895 he had become dean of the faculty of law at Ottawa university, where he had previously held a chair Taschereau became a member of the judicial committee of the privy council in 1904. He died at Ottawa on April 14, 1911.

TAS-DE-CHARGE, m architecture, a French term for which there is no English equivalent, given to the lower courses of a Gothic vault, which are laid in horizontal courses and bonded into the wall; they generally rise about one-third of the height of the vault, and as each course projects beyond the course below, following the curve of the vault, they lessen the span to be vaulted.

TASHI LHÜNPO: see Shigatse.

TASHI LHUNKU: 388 SHIGATSE.

TASHKENT, a city of Asiatic Russia, and the capital of the Uzbek SSR, in 41° 30′ N, 69° 20′ E, situated in a loess oasis, watered by the interlocking Chirchik and Keles tributaries of the Syr-Darya Irrigation cultivation is very ancient in the oasis, the town itself dates back at least to the seventh century A.D In 582 the Turks of Transoxiana divided into two khanates, the western one having two headquarters, one at Urumchi and one north of Tashkent, and it is recorded that the Chinese in 659 claimed the territory of the western Turks, including Tashkent It was captured in 1865 by the Russians and was made the administrative centre of the former Government of Russian Turkestan The Russians then built a new town nearly 8 m long and 4 m, broad, considerably to the north-east of Eski-tashkent (old Tashkent), which is now practically deserted

The houses are low because of frequent earthquakes, and are almost hidden by the poplar, willow and fruit trees which surround them and line the broad streets. Its population in 1939 was

585,005.

Tashkent has cotton-cleaning factories, makhorka-tobacco factories, a leather, machinery and cellulose industry, and sawmills; there is a municipal electricity, water and tram service. Much fruit and agricultural produce are grown in the oasis. The population is mixed, Russians, Sarts and Uzbeks predominating Under the postrevolutionary régime efforts were made to raise the status of women. The town has a good library, a museum which includes a collection of Graeco-Bactrian coins, and a Teachers' training col-

TASHKURGHAN or KHULM, a khanate and town of Afghan Turkestan. The khanate hes between Kunduz and Balkh. The ancient town of Khulm stood in the Oxus plain, surrounded by orchards of famous productiveness; but it was destroyed by fered during German occupation and the later struggle with the Ahmad Shah Abdall, who founded Tashkurghan in the middle of the 18th century, and took all the inhabitants away from Khulm to populate it. Ancient Khulm is now only a mass of ruins; but Tashkurghan, lying two or three miles to the south of it, has become the great trade-mart of Afghan Turkestan, At Tashkurghan the caravans from India and Bokhara meet, and

from here the merchandise is distributed.

TASMAN, ABEL JANSZOON (c. 1603-1059), the greatest of Dutch navigators, the discoverer of Tasmania, New Zealand, the Tonga and the Fiji Islands, and the first circumnavigator of Australia, was born at Lutjegast in Groningen, about 1603 In 1634 we first meet with him in the East Indies, sailing from Batavia (Feb. 18) to Amboyna. After a short visit to Holland he was again in Batavia in 1638. On June 2, 1639 Tasman, with Matthew Quast, was despatched by Antony Van Diemen, governor-general of the Dutch East Indies, on a voyage to the north-western Pacific, in quest of certain "islands of gold and silver," supposed to lie in the ocean east of Japan On this voyage Tasman and Quast visited the Philippines and improved Dutch knowledge of the east coast of Luzon; they also discovered and mapped various islands to the north, apparently the Bonin archipelago, Sailing on to N. and E. in search of the isles of precious metals, they ranged about fruitlessly in the northern Pacific. In October the awagators decided to return, and, after touching at Japan, anchored at the Dutch fortress-station of Zeelandia in Formosa on Nov. 24, 1639. After this Tawam was engaged in operations in the Indian seas (easiling to Formosa, Japan, Cambodia, Palembang, etc., as a merchant captain in the service of the Dutch East India. Company) until 1649, when he set out on his first great "South Land" expedition Several Dutch navigators had already discovered various portions of the north and west coasts of Australia (as In 1605–66, 1616, 1618–19, 1622, 1627–28, etc.), but Taman now first showed that this great South Land was an

Van Diemen's Land and New Zealand .- Sailing from Batavia on Aug 14, 1642 with two vessels, the "Heemskerk" and "Zeehaen," and calling at Mauritius (Sept. 5 to Oct 8), Tasman sailed first S, then E., almost seven weeks, and on Nov 24 sighted (in 42° 25' S, as he made 1t) the land which he named Anthoonii van Diemen's landt after Van Diemen, now called Tasmania He coasted its southern shores, and, running up Storm Bay, anchored on Dec. 1, in Frederick Henry's Bay, on the east coast of Tasmania. There he hoisted the Dutch flag. Tasman then steered E for the Solomon Islands, and on Dec. 13 discovered a "high mountainous country," which he called Staten landt ("Land of the States," ie, of Holland, now New Zealand). Tasman believed the newly discovered land to form part of the same great antarctic continent as the other Staten land; which Schouten and Lemaire had sighted and named to the east of Tierra del Fuego He anchored on Dec. 18 in 40° 50' S., at the entrance of a "wide opening," which he took to be a "fine bay" (Cook's Strait). He gave the name of Moordenaars (now Massacre) Bay to this spot, where several of his men were killed by the natives (Dec. 10). He then sailed along the south shore of Cook's Strait, but without discovering the full extent of the strait here dividing New Zealand into two main islands. Returning westward he then coasted the west side of the North Island, till, on Jan. 4, 1643, he reached the northern extremity of New Zealand.

Thence he bone away to N N.E and on Jan 19-25 he discovered various Islands of the Tonga or Friendly group. Here the ships provisioned, for the first time since leaving Mauritius Thence Tasman steered N. and W. reaching on Feb. 6 the eastern part of the Fijs archipelago, which he called Prince William's Islands and Heenskerk's Shouls. He reached the western extremity of New Guinea on May 18. He arrived at Batavia on June 15, 1643 after a ten months' voyage.

Second Voyage.-The materials for an account of Tasman's important second voyage in 1644 are scanty. He was instructed to obtain a thorough knowledge of Staten Land and Van Diemen's Land, and to find out "whether New Guinea is a continent with the great Zuidland, or separated by channels and islands," and also whether the new Van Diemen's Land is the same continent with these two great countries or with one of them." In this voyage Tasman had three ships under his command, the "Limmen,"
"Zeemeeuw" (or "Meeuw"), and "Brak" (or "Bracq"). He
coasted the south-west coast of New Guinea; he mistook the western opening of Torres Straits for a bay, but explored (and perhaps named) the Gulf of Carpentaria: for the first time the coast-line of this great bay was mapped with fair accuracy. Though pre-ceded by Jansz (1606) and Carstensz (1623) on the east shore of the gulf as far as 17° S., Tasman first made known the south, and most of the west, coast. Beyond this he explored the north and west coasts of Australia as far as 22° S., and established the absolute continuity of all this shore-line of the "Great Known South Continent"; his chart gives soundings for the whole of this coast. Tasman's achievements were coldly received by the Dutch colonial authorities; but on Oct. 4, 1644 they rewarded him with the rank of commander (he had frequently enjoyed the use of the title already). He was also made a member of the Council of Justice of Batavia. He was a member of the committee appointed on April 18, 1645 to declare a truce between the Dutch East India Company and the vicercy of Portuguese India. In 1647 he commanded a trading fleet to Siam, and in 1648 a warfleet sent against the Spaniards of the Philippines (May 15, 1648,

345

to January 1649). By 1653 he had quitted the company's service He died probably before Oct. 22, 1659, and certainly before Feb 5, 1661

5, 1661

See R H Major, Early Voyages to . . . Australia (London, Hakluyt Socaty, 1899), especially pp xcm-cni, 43-58 (here are printed the instructions for Tasman and has colleagues on the voyage of 1644), G Collingrades, Discovery of Australia (Sydney, 1895), especially pp, G Collingrades, Discovery of Australia (Sydney, 1895), especially pp, Johnson . Johnson, etc. (Amsterdam, 1899)—here the Life of Tesman, with its appendices, in separately paged (165 pp). See also Anaded der Noderlanders in de Ontokhamy on Australia, 1600–1765 (in Dutch and English, Leydness and London, 1899), especially pp, vi, viii, 213–202, pp. 1800, happendices in Separately and Colleges of Demonstration of Australia (1900–1900), and the Colleges of Col

TASMANIA, a State of the Commonwealth of Australia consisting of one large and numerous smaller islands, the largest of which, King, Flinders and Cape Barren Islands, lie in Bass Strait (total area, 26,215 miles-roughly that of Scotland-forming 0-88% of the area of the Commonwealth). The island of Tasmania extends from about lat 40° 40' S, to lat, 43° 40' S, is of a maximum length (N-S.) of 180 m and breadth (E.-W) of 190 miles, and has a shield-shaped general outline tapering southwards It lies upon the main continental platform and at various periods formed part of the continent to its north Bass Strait, though some 140-150 miles wide, is relatively shallow so that Tasmania is linked to the mainland by a submarine ridge carrying only 30-40 fathoms from which rise the groups of islands mentioned above. The latest severance of Tasmania is probably geologically recent and a rise of c, 200 ft .-- or a corresponding fall in sea-levelwould reunite it to the mainland It is, in fact, essentially a portion of the eastern highland belt of Australia (see Australia. Geomorphology) and has the same general physiographic character modified, to some extent, by climate. Subjected to repeated strains and stresses, and also to active denudation, throughout its history, the island-mass has assumed the character of an extremely irregular upland block, or group of blocks, with generally flattened tops but steep, and often precipitous (step-faulted) sides—cf. the term "tiers"—and possessing several coastal, and also some inland, lowlands in which crustal oscillations have produced features of both emergence and of submergence. The nearness in time of some of the most influential of these movements is proved by the freshness and sharpness of many of the forms (eg, "drowned" coastal features, valley gorges, waterfalls and generally ungraded stream courses), by the signs of dislocated drainage, and by the general irregularity, and even wildness, of the topography. The extensive and varied igneous intrusions-Palaeozoic granites and serpentine, Cretaceous diabase, Tertiary basalts, etc —evidence the intensity of the move-ments, while weathering has flattened, but also in part, by means of differential erosion, diversified the surface.

Physiography.-Several divisions may be distinguished. (i.) The south and west are occupied by a broad belt of highlands presenting abrupt irregular fronts to the west and north. They are composed mainly of very ancient sedimentary rocks (Pre-Cambrian-Palaeozoic schists, quartzites, slates, sandstones and limestones) much intruded by granite and other igneous formations. The general surface level rises to some 4,000 ft with many summits approaching 5,000 ft, (Cradle Mountain, 5,069 ft ), but the incision of streams and the cutting of deep valleys and gorges (King River, 3,000 ft. deep, and of the valleys of the Arthur, Pieman, Gordon Rivers) has given rise to a wild, inaccessible, and little known landscape, with some lakes and forests, much poor and sterile rock and soil, but possessing great actual and potential mineral wealth. (ii.) The Central (Lake) Plateau, only partly dissevered from the above, consists mainly of Mesozoic rocks (Permo-Carboniferous) and slopes down from a general level of 3,500 ft. in the northwest to lower levels in the southeast, in which direction it is drained by the streams of the Derwent system. To the north and northeast it presents a towering es-

carped front ("tiers") with individual elevations of over 4,000 ft. potentially, the most valuable in the Commonwealth though its fashioned mainly out of igneous (diabase) intrusions. The rocks contain some oil shale and coal, but for the rest supply only grasslands The heights which flank the central east coast are a portion of this formation, being severed only by the Macquarie-Coal River depression (elevation 660 ft. near Tunbridge) (iii) The northeast highlands, though detached from the central massif by the broad Tamar-Esk depression, resembles it in being a plateau with levels rising to 3,000-4,000 ft. The Palaeozoic sediments have been penetrated by igneous intrusions of various dates and composition (granite, diabase, basalt), the harder of which form great bosses (Ben Lomond, highest elevation in the island, 5,760 ft) They constitute a group of wild and mineralised mountainblocks towering above the adjoining lowlands (iv ) The northern lowlands a down-faulted area fronting Bass Strait and broadest in the northwest, consist substantially of the same rocks as the highlands behind (pre-Cambrian schists, Palaeozoic slates, sandstones, etc ) and, besides rich deposits of metallic ores, include valuable limestones, oil-shales and coal Many of these rocks yield infertile soils, but the great basalt (Tertiary) flows which characterise this area redeem this quality, and these lowlands, with their irregular terrain and diversified potentialities form one of the richest regions. (v.) The east and southeast lowlands are even more irregular, and are worked out mainly in Mesozoic (Triassic-Jurassic) strata which contain coal. Diabase and older rocks form irregular, rough and infertile ranges, spurs and platforms over considerable areas, but the later strata yield soils useful for pasturage and cultivation

Lakes are an especial feature of the Tasmanian highlands, and especially of the central plateau Here, at an elevation of about 2,500 ft., the heavy ramfall is held up in impervious (diabase, etc ) rock-basins, and elsewhere (eg, in the west) are lakes of glacial origin. Great Lake (alt 3,800 ft.) is 15 miles long and its natural depth was only 20 ft. It has importance in connection with a great hydro-electric supply scheme.

The coast-line (900 miles) receives its special character from recent subsidence, though there has been a still later but smaller elevation. Where the coast runs parallel to the grain of the highlands it is mostly closed (e.g., on the west) and presents few good openings. On the northeast and southeast, on the other hand, are many curious features of submergence (e.g., Freycinet and Tasman's peninsulas) and also some fine "drowned valley" harbours (Tamar, Derwent, see Launceston, Hobart) (v. inf).

Climate.-Tasmania lies in the southern temperate zone in the track of the east-moving cyclonic systems ("lows"), while no part is far removed from the sea. Hence its climate is cool. equable and moist, somewhat resembling that of southwest England and Ireland. Like these, too, its weather conditions are exceedingly variable-hardly four consecutive days showing the same conditions-but in its case there is added to this variability an extraordinary local diversity due to the irregular and sharp-cut topographical features. Thus there is strictly no general climate of Tasmania, but, within limits, temperatures, and particularly rainfall, show remarkable ranges (eg., 130 in at Lake Margaret on the west coast, 18 in. at Antill Ponds in the east midlands). Broadly speaking temperatures range from 65° F in summer to 45-50° F in winter, the east coast having temperatures in general c. 4° above those of the west coast owing to the influence of warm (north) and cool (south) sea-currents respectively. Rainfall is greatest in the west, where the highlands force precipitation from the moist westerly winds (40 in av. ann. along the coast, rising to 60 in., and to 140 in. in the central northwest, with a late-winter maximum (e.g., Queenstown: 100 in.; Aug., 10 in.; Feb., 4 in.). The northeast highlands also receive 40-80 in., but the eastern and central lowlands are in the "rain-shadow" of the western heights and receive some 20 in. more or less with a maximum in spring and summer when southeast winds blow in with rain. (See also LAUNCESTON.) It is the cool and moist climate of Tasmania which lends it that relatively verdant and garden-like character which is such an attraction to Australians from hotter and drier latitudes.

Vegetation .- The natural vegetation was one of the finest and

natural riches have been largely dissipated The chief controlling factor appears to be rainfall-or rather, availability of moisture. Thus the beech forests-so-called "myrtle"-which are peculiar to Tasmania are found in various separate areas but always where the av. ann. rainfall is over 50 in Eucalypts form the bulk of the forests in areas of intermediate rainfall and range from swamp and blue "gums" in the lower river-flats to the "snow" or "mountain" gum on higher slopes. Some of the "pines" (Huon, "celery-top," etc) are also denizens of the lower and wetter "celery-top," etc) are also denizens of the lower and wetter valleys, eg, in the southwest. The "wetter" forests have also often a dense and almost impenetrable undergrowth (tree-ferns, laurels, etc ). In the drier "rain-shadow" lowlands of the east and centie the forests become thinner-though the trees tend to become individually finer—and a type of wooded "park" or grass-land prevails. The wind-swept plateau-tops carry little but stunted scrub, grasses, and bog and moorland vegetation merging in places into "alpine," and the lower hills which lie along and immediately behind the west coast, with their relatively light nainfall (20-40 m) are matted over with the strange and impassible "horizontal" (bauera) scrub. The western mountains and valleys still contain fairly large forest patches (eg., the fine eucalypt forest of the Huon Valley), and the northeast also is well clad In the lowlands and on the more accessible slopes the forests have been largely destroyed or wastefully depleted for their valuable contents Commercially useful timber is supplied by many of the gums—blue, yellow (cider), swamp and stringy gums, peppermint, etc—by the soft-wood pines, the beech, the blackwood of the northern basaltic slopes and valleys and also by the acacias (eg, the "black wattle" supplying tanning bark). Tasmania has a relatively large extent of forested land (1,500,000)acres, nearly 9% of total area) But, from the scientific forester's point of view, the forests are not as valuable as might appear. There were (1940) only 1,593,000 ac. of reserved forests, or, with timber and fuel reserves, 2,544,000 ac.

General Economic Aspects.-The extraordinary diversity of soil, climate, and of topographical feature within even a quite restricted area has given to Tasmanian land development a sporadic and somewhat "patchy" nature. This, and the very large extent (about 3) of broken and uncultivable terrain, has prevented the growth of large and simple types or areas, such as, e.g., the wheat belt in Australia, and has rendered difficult any large-scale unified economic organization.

Mining and Metallurgy.-If Tasmania's mineral output is not relatively large it is large in proportion to the area of the State. The island contains some notable individual deposits and its reserves are also probably considerable, much of the country being as yet inadequately prospected. The minerals fall into two main classes. (a) metallic minerals occur chiefly in the older rocks of the western highlands where the extensive igneous activty has led to mineral concentrations. In the central west the Oueenstown-Gormanston area was developed, under conditions of extraordinary physical difficulty, upon a large scale, outlet being chiefly by Macquarie Harbour (Strahan, Pillinger). Northwards from this are the Zeehan-Dundas, Read-Rosebery, Waratah, Mt. Bischoff and other areas.

Many of these mines produce varying quantities of silver, lead, copper and gold, partly as a by-product, e.g., in copper refining. The copper is produced almost entirely by the Mount Lyell Mining and Railway Company which owns extensive workings, railway lines, electric (power and light) supply schemes (Lake Margaret). The output of this Company's mines in 1938 was 12,720 tons copper, 67,176 oz. silver, 7,919 oz. gold; the year's profits amounted to more than £803,000. Mount Bischoff is still noted for tin, while the Read-Rosebery zinc reserves are estimated at over 2,500,000 tons. In addition valuable osmiridium alluvial deposits occur along the west coast, The similar rock formations of the north, north-east and east contain gold (Bea-consfield, Lefroy, Lisle, Mathinna, Mangana) but more impor-tant is tin, the bulk of the Tasmanian output coming from the north-eastern fields (Gladstone, Derby, Branxholm, Ringarooma) and also from the east (St. Helen's, etc.), while a rich deposit

has also been discovered on King Island, Tasmanian iron reserves are estimated at 100,000,000 tons, the ore occurs in the ancient rocks of the west and north, notable deposits being at Rio Tinto (Savage River on the west coast. about 50,000,000 tons) and at Burme where the Blythe uver has cut through a deposit of 17-30,000,000 tons The iron ores are as yet little exploited (b) Non-metallic minerals consist chiefly of coal, oil shales, limestones and pottery clays Coal (actual and probable reserves, 244,000,-000 tons) occurs in the Permo-Carboniferous, Trias-Jura and Tertiary strata along the north and east coastal areas and is increasingly mined around St Mary's, in the Mersey valley, etc. In the northern coastal areas occur large deposits of oil shales, while limestones and clays in great quantity occur there and elsewhere The shales are as yet little worked, but the limestones and clays form the basis of the potentially important cement industry of Maria Island, etc , the limestones of Melrose are exported through Devonport for fluxing purposes to New South Wales (see BROKEN HILL), those near Hobart (q v ) are used for the carbide industry (1942-43 £190,803), and the clays are also used for tile, etc , manufacturing (eg, near Launceston) Metal concentrating and refining is conducted on a large scale on the Zeehan and Mount Lyell areas, but Mount Bischoff ores are smelted at Launceston (q.v). The important Electrolytic Zinc Company's works at Risdon (see Hobart and Broken Hill) recovered (1938) 47,370 tons zinc (£915,617) and cadmium valued at £60,760 from Bioken Hill ores (exclusive of Tasmanian concentrates treated). The Mount Lyell Mining and Railway Co. has also engaged in the production of superphosphates, sulphuric acid, etc As elsewhere in Tasmania the growing success of mining, metallurgical, etc , industries is due to hydroelectric power.

Timber, Fruit, etc.—Tasmania's sawmill output (1939-40) was 79,330,000 super ft , of which about 80% is exported Recent discovery of the high value of Australian hardwoods for making paper-pulp has led to the establishment of a promising new industry which, able to absorb poorer timbers and "offal" formerly wasted, has, allowing for re-growth, unlimited reserves. The cultivation of imported soft-wood species also holds out promise. Fruit-growing in Tasmania has progressed as over-sea markets have become available. The apple crop in 1937 was worth £989,-000, and was much more important than potatoes, hay or wheat.

Agriculture and Dairying .- The products of arable agriculture are characteristically wheat, oats, potatoes and fodders. Tasmania was once the granary of Australia, but the uncertainty and dampness of the native climate, together with the competition of the later-developed and more suitable continental wheat-lands, have discouraged home production. A little is grown near Launceston and Hobart under the influence of the milling industry there (1924-25: 13,000 ac., 231,000 bu.; 1927-28. 28,000 ac., 672,000 bu.; 1935-36 19,500 ac., 570,895 bu.), but Tasmania tends to import wheat and similar products. Her position opposite the port and market of Melbourne-and more remotely and occasionally, that of Sydney-greatly aids this process of specialization. Oats, barley (malting), hay (chaff), pulses, potatoes -and also dairying with its associated pig-rearing, bacon-curing, cheese and butter making-have in fact a distribution influenced by climate, soils and commercial position. The central northern lowlands-from Deloraine, through Westbury, Longford, Evandale, to Lilydale-centre on Launceston which is a market and exporting centre. The 15-mi.-wide strip of fertile coastal lowlands which stretches northwest to Stanley, backed by a similar belt of pastoral country and, beyond this, by timber areas, finds an outlet in such ports as Ulverstone, Penguin, Burney,

Pastoral Industries. As more intensive forms of land utilization have progressed; the pastoral industries have tended to decline, especially as in Tasmania there is small room to move away as settlement advances. To some extent, however, this tendency has been checked by specialization, "meat" cattle, for example, being replaced by dairy herds, while in the case of sleep, careful lotal adaptation has led to survival, e.g., of "utility" (meat-wool) types as elements in a mixed farming regime. Notable, also, is the achievement of several long-established sheep-breeding families in rearing high-class strains.

Sheep .- The whole of the west of the island is too wet, or too wild, for sheep, and these are confined mainly to the areas with 30 in or less av ann rainfall which comprise the southeast + of the island, relatively few being scattered along the north coastlands The greatest concentrations are in the upper and central Macquarie River basin and in the northern hill lands of the Derwent-Coal basin ("The Midlands"). The Longford, Evandale and Oatlands districts show densities of 300 per sq mi, and here the sheep fit into the farming rotation and are mainly marketed as meat, fresh (Launceston, Hobart) or refrigerated (export) In the north other cultivations (v sup) are more profitable. In the poorer and rougher eastern hill and coast lands fewer are kept. but the central highlands provide good summer grazing grounds for sheep from the adjoining districts to the east Cattle, apart from dairy cattle (v. sup), are decreasingly important, but they are found in the rougher lands around the borders of, and between, the better farming areas along the north and east and more particularly in "the midlands" (se, northern Derwent-Coal River hill lands) and here tanning assumes local importance

Manufacturing Industries; Power Supply.-These have grown up upon the basis of the primary producing industries and are still often locally associated with them extraction and refining of metals, sawmilling, making of jams and preserves, dairy products, bricks, tiles and pottery; tanning, etc (v sup) Secondary are the chemical, cement, carbide and electrode industries, making of furniture, agricultural implements, etc. A new tendency, however, has now appeared, namely for industries of a larger and more derivative type to concentrate in Launceston and Hobart (qq.v.) As this tendency develops greater strength, the manufacture of chemical products, cement, iron, paper, artificial silk, woollen and other textiles may be expected to assume considerable proportions. The reasons lie partly in the presence of raw materials, partly in the favourable position of Tasmania with relation to (chiefly) Victoria, New South Wales and South Australia, but mainly in the fact that Tasmania, along with a cool climate, possesses reserves of water power The water power resources are the property of the state which develops them and sells power in bulk to large consumers and municipalities, though it also retails power to consumers in Hobart. The total power in Tasmanian hydroelectrical plants was 143,000 hp in 1940-41. This was made up mainly by plants at Waddamanna, as well as at Tarraleah on the upper Derwent River. A new dam at Miena has increased the supply of the Waddamanna water The Great Lake scheme (63,000 hp) was completed. Advantage has been taken here of the Great Lake, whose area was increased to 60 sq mi and depth to 55 ft by means of a dam, and also of a difference in level of 1,250 ft between the parallel valleys of the Shannon and the Ouse The Shannon scheme, adjacent (13,000 hp), was being extended Launceston (qv) and its district. as well as Hobart, is supplied from the Great Lake system, other systems being the Lake Margaret-Zeehan, Zeehan-Rosebery (under construction), Country District and North-west Coast Service. So far only 52,000 h p has been utilized, the Electrolytic Zinc Works (Risdon) consuming 35,000 h.p.; the Carbide works. 3,500; Hobart, 8,500; Launceston, 3,000. The further reserves of Tasmania are estimated at over 500,000 continuous h.p. Besides the State schemes the Mount Lyell Mining and Railway Co. can supply 8,000 continuous h.p., and there are numerous smaller mining and municipal supplies. The coasts abound in good natural harbours-though some are exposed and not very usefulbut the main sea traffic centres on Hobart, Launceston, on the north coast ports and on those of Macquarie Harbour.

See G. L. Wood, The Tasmanian Environment (1923); A. Lowndes and W. Maze, Land Utilisation, Tasmania (Sydney, 1937); G. Taylor, Australia (1943).

Statistical Summary\*: Area and Occupation -26,215 sq mi. (16,778,000 ac) = 0.88% of the Commonwealth, wholly in temperate zone Coast-line: 900 mi = 1 mi. per 29 sq mi. of land surface. Of the total area 6,325,889 ac. had been alienated or were in process of alienation in 1939; 7,791,189 ac were occupied by the crown or unoccupied, 297,481 ac, were leased for timber:

\*The Australian governments have largely postponed publication of later data (1944).



Chief Resources of Tesmania

31.347 were for mining purposes, and the rest were for pastoral or agricultural purposes or for closer or soldier settlement Average iuial holding (1939) 586 ac

Pobulation (1933) 227,599, of which 115,097 were males and 112,502 were females The State contains 3 42% of the population of the Commonwealth and has a density of 8 68 per sq mile. Its natural increase (1936-40) was 12,614 although in the same period it lost 793 more persons through emigration than it gained through immigration Metropolitan Hobart and suburbs (54,890 ac), 60,406 (1933) = 26 5% of total population

Production (net value) (1939-40). total, £14,438,000; agricultural and pastoral, £4,236,000; manufacturing, £6,253,000, min-

ing, £2,144,000

Mining (gross value of metal contents of ores produced, 1938): Total, £1,953,000 copper, £580,000; tin, £244,000, lead, £163,-000, zinc, £356,000, silver, £104,000, coal, £62,000 (83,000 tons), in 1030 £74,000 (99,000 tons), osmiridium, £3,000, limestone flux (1939), £79,000, gold, £195,000. In the case of copper, lead and tin, the 1938 figure fairly represents the general level of annual production Zinc production from Tasmanian-mined ores was only resumed in 1936 after a five year suspension, the value of the year's output dropped slightly in 1938 from the 1937 figure. Production of coal decreased steadily for some years, but in 1939 production was increased by almost 16,000 tons and value increased more than £12,000 over 1938 Silver, osmiridium and wolfram fluctuate widely from year to year

Trade, Commerce, Communications — Trade. Total (1937-38) £22,900,000 (£94 0 per caput). Exports: £11,136,000. Metals: c £2,500,000; fruits, £1,500,000; jams and other prepared foods, £390,000; potatoes, £521,000, dany produce, £452,000; wool, £817,000; hides, etc, £347,000, timber, £541,000

Imports: £11.800.000. Food and drink £2.657,000; metals and

machinery, £3,681,000, clothing, etc., £1,708.000.

Shipping (entered and cleared): 2,000-2,500 vessels, 1,500,000-2,750,000 tons (net) Railways: Government lines (1939-40) 644 42 miles (of this, all is 3'6" gauge). Private (1939-40) 116 34 miles. Gross revenue (government railways) (1939-40) £536,000; working expenses, £688,000, loss after payment of working expenses and interest, £245,000

Social Conditions .- Education. (1939) State schools, 448; teachers, 1,264; average weekly enrolment, 30,865; average daily attendance, 28,189; expenditure exclusive of buildings, £320,616. Private schools, 63; teachers, 330, enrolment, 7,003; average attendance, 5,324. (O. H. T R; X)

History.- Tasmania, or, as it was originally called, Van Diemen's Land, was discovered in 1642 by the Dutch navigator Tasman (q.v.), who named the territory after his patron, Van Diemen In the 18th century the island was visited by French and English explorers, including Capt Cook in 1777. The news that the French explorer, Baudin, had surveyed the south of the island in 1800 stimulated the British to forestall the French. In 1802 the "Cumberland," a small schooner, landed at King's island in Bass strait, and in 1803 Lieut, Bowen was sent by Governor King of New South Wales to form a settlement on the south coast of Van Diemen's Land. In 1807, Col. Paterson occupied Port Dalrymple on the north side of the island, During the same year Col, Collins, who had failed in an attempt to colonize the shores of Port Phillip, transferred his soldiers, convicts and officials to the neighbourhood of Hobart, and was appointed commandant of the infant settlement. The difficulties of the settlers

were increased by the hostility of the blacks The first collision took place at Risdon, a few days after the landing of Lieut Bowen's expedition, and for this the white settlers were entirely responsible Hostilities between the races were incessant from 1802 till 1830 In 1831 George Robinson induced the remnant of the blacks to leave the mainland and take refuge first in South Brum and subsequently in Flinders island, their numbers having then diminished from 5,000, the original estimate of the aboriginal population, to 203 The last pure-blooded Tasmanian died in 1876, at the age of 76

The growth of population was extremely slow, and in 1808 a census showed that there were only 3,240 people on the island, all told Soon settlers began to arrive, and as their number in the colony increased, an agitation arose for more political freedom and improved administration, in consequence of which, in 1822, courts-martial were replaced by courts of justice, and in 1825 the colony was made independent of New South Wales, Col. At thur being appointed governor. In 1828 the Van Diemen's Land company commenced sheep farming on a large scale in the northwest district of the island under a charter granted three years before, and in 1829 the Van Diemen's Land establishment obtained a grant of 40,000 ac at Norfolk Plans for agriculture and grazing grant of so,000 ac at Norfolk Plans for agriculture and grang In 1834 Foultand bay, on the mainland of Austriala, was occupied by settlers from Van Diemei's Land, and in 1835 there was a migration, large when compared with the population of the island; to the shores of Port Philip, now Victoria. At that date the population was 40,171, a large proportion being convects, for in four years 5,000 proson were not all satisfied with the system of government, and an agitation commenced m Van Diemei's Land, as well as in New South Wales, for the introduction of representative mistitutions and the abolition of transportation. This system was abolished in New South Wales in 1849, and in the siland, which is the intermit had been the receptacle for convokes from the United Kington, India and the colognist, in 1853. In the same year representative institutions were introduced and the colony was renamed Tasmania, three years later responsible government was granted. The discovery of gold in Victoria caused the value of exports to that colony to rise from £665,760 in 185z to the value of exports to that colony to rus from £65,2700 m 185; to 1,175,5310 m 185,5 while the population dimnaished through magration fundamental through magration and the state of the

TASMANIAN DEVIL (Sarcophilus ursinus), is a large, heavily built relative of the dasyures. In size it may be compared to a badger. The general colour of the fur is black tinged with brown, with white patches on the neck, shoulders, rump and chest It is a burrowing animal, nocturnal and carnivorous, and commits great depredations on the sheep yards and poultry lofts of the inhabitants. (See Marsupialia)

TASMANIANS. The Tasmanians, who are now extinct, were of medium height, had black to dark brown skins; woolly hair, heavy brows; longish, oval or pentagonal, flattish and small sized (cranial content) heads; short broad noses and large teeth.

Culture .- They were food gatherers, expert hunters and trackers of game, nomads, moving in small groups of the family type. with very little government but recognizing the areas belonging to other groups as reserved and not to be interfered with except on risk of war. Hereditary or permanent chiefs do not seem to have been found. No marriage ceremony is recorded and there seems ground for holding that they were polygynous. They are typical representatives of the Early Stone and Wood Age. The stone implements are very crude in form and finish (akin to Mousterian products) and were made of phthanite, a fine grained sandstone. Fire was made with the groove and saw or with the drill Stones with black and red bands were used for tallies or mnemonics for absent friends. All have been lost and their exact significance is not quite clear. They made rough drawings on bark, with charcoal, ornamented themselves, using red othre for the hair and wore shell necklaces, fillets of gay flowers, or festoons of showy berries. Huts and wind-breaks were used as shelters. Skins were thrown over the back against rain but otherwise they were naked. Scarification was practised and they

rubbed themselves with powdered charcoal and red ochre They greased their bodies against rain. They made rafts generally of the bark of some species of Eucalyptus, which was rolled up into cigar shaped bundles, three going to a raft, broad in the middle and tapering to a point at each end These were good fair weather craft but dangerous in storms They used their spears for fishing but had neither bow and arrow nor boomerang

Language.-There were five dialects, classified on a geographical basis in two main groups as eastern and western Enough remains to show that they were all related and were dialectical variations from a common archetype The language is said to have been musical and soft, vowels being peculiarly full and round They had no d, f, v, s, or z Words began generally with a consonant, cr, pr and tr being common, other combinations being rare Words end with a vowel as a rule. Distinct forms were used for singular and for plural.

BIBLIOGRAPHY.-H Ling Roth, The Aborigines of Australia, 1890, a careful and complete collection of earlier information which has been used by later writers See also W J Sollas, Ancient Hunters, 3rd ed 1024.

TASSIE, JAMES (1735-1799), Scottish gem-engraver and modeller, was born at Pollokshaws, near Glasgow, on July 15, 1735, and died in London on June 1, 1799. During his earlier years he worked as a stonemason until he removed to Glasgow to attend the academy established by the brothers Foulis, the printers, and became one of its most distinguished pupils Subsequently he visited Dublin and became acquainted with Dr. Quin, who had been experimenting in imitating antique engraved gems in coloured pastes. He engaged Tassie as an assistant, and together they perfected the discovery of an "enamel," admirably adapted by its hardness and beauty of texture for the formation of gems and medalhons Tassie went to London in 1766. After a hard struggle the beauty and artistic character of his productions came to be known. The empress of Russia commissioned a collection of about 15.000 examples; all the richest cabinets in Europe were thrown open to him for study and reproduction; and his copies were frequently sold by fraudulent dealers as the origmal gems He exhibited in the Royal Academy from 1769 to 1791, In 1775 he published the first catalogue of his works, followed in 1791 by two volumes quarto, enumerating nearly 16,000 pieces.

Tassie also executed many large profile medalhon portraits of his contemporaries. They were modelled in wax and were then cast in white enamel paste, the whole medallion being sometimes executed in this material; while in others the head only appeared in enamel, against a background of ground-glass tinted by paper placed behind. At his death, in 1799, Tassie's works numbered

about 20,000 pieces.

21.38 g G

His nephew, William Tassie (1777-1860), also a gem-engraver and modeller, succeeded to the business. His portrait of Pitt, in particular, was very popular, and circulated widely. He bequeathed to the Board of Manufactures, Edinburgh, a valuable collection of casts and medallions by his uncle and himself.

See Gray's James and William Tassie, 1895.

TASSO, BERNARDO (1493-1569), Italian poet, father of Torquato Tasso (q.v.), was born at Venice on Nov. 11, 1493, of a noble family of Bergamo. He was attached to the service of the prince of Salerno, and married a Neapolitan lady, Porzia de' Rossi. When his patron came into conflict with the Spanish Government of Naples Bernardo was proclaimed a rebel and his property sequestrated. In 1556 his wife Porzia died under mysterious circumstances Next year he entered the service of the duke of Urbino, and became a considerable figure in the literary circle of his court. He wrote a long, complicated and dull roman-

tic poem in octave stanzas, entitled Amadigi (Venice, 1560). Bernardo died at Ostiglia on Sept. 4, 1569.

TASSO, TORQUATO (1544-1595), Italian poet, son of the preceding, was born at Sorrento on March 11, 1544. He was brought up at Naples, where he lived with his mother and his

handsome and brilliant lad, now became the companion in sports and studies of the young heir, Duke Francesco Maria della Rovere He met there many of the most famous scholars of the day, including Aldus Manutius and the critic Speroni At Venice, whither his father went to superintend the printing of the Amadigi (1560), he found himself the pet and prodigy of a distinguished literary circle He was then sent to study law at Padua, but his distaste for the subject led Bernardo to allow his son to exchange the study of law for that of philosophy and poetry at Padua, and then at Bologna In 1561 he published some poems, and before the end of 1562 produced a narrative poem, Rmaldo, in twelve cantos which proposed to combine the regularity of the Virgilian with the attractions of the romantic epic Tasso, who was still only 18 years old, sought to give the adventures of Roland a classic form He was now famous In 1565 he became attached to the learned court of Ferrara, at first in the service of the Cardinal Luigi d'Este

The years between 1565 and 1570 seem to have been the hap-piest of Tasso's life, although his father's death in 1569 caused him profound pain. He was the idol of the most brilliant court in Italy. The princesses Lucrezia and Leonora d'Este took him under their protection. He was admitted to their familiarity, and there is some reason to think that neither of them was indifferent to him personally. In 1570 he travelled to Paris with the cardinal. Frankness of speech and a certain habitual want of tact caused a disagreement He left France next year, and took service under Duke Alfonso II. of Ferrara The most important events in Duke Attonso 11. Of Ferrara The most important cross in Tasso's biography during the following four years are the publication of the Aminta in 1573, and the completion of the Gerusalemme Liberata in 1574. The Aminta is a pastoral drama of very simple plot, but of exquisite lyrical charm. It was represented at Ferrara in the summer of 1573, at the critical moment when modern music, under Palestrina's impulse, was becoming the main art of Italy.

The Gerusalemme Liberata occupies a larger space in the history of European literature, and is a more considerable work. Yet the commanding qualities of this epic poem, those which revealed Tasso's individuality and which made it a classic, beloved by the people no less than by persons of culture, are akin to the lyrical graces of Aminta. It was finished in Tasso's 31st year, and was read to the duke and to Princess Lucrezia in the summer of 1575

As in the Rinaldo, so also in the Jerusalem Delivered, he aimed at ennobling the Italian epic style by preserving strict unity of plot and heightening poetic diction. He chose Virgil for his model, took the first crusade for subject, infused the fervour of religion into his conception of the hero Godfrey. But his own natural bias was for romance. Godfrey, a mixture of pious Aeneas and Tridentine Catholicism, is not the real hero of the Gerusalemme. Fiery Rinaldo, Ruggiero, impulsive Tancredi, and the chivalrous Saracens with whom they clash in love and war, divide our interest and divert it from Goffredo. The action of the epic turns on Armida, the beautiful witch, sent forth by the infernal senate to sow discord in the Christian camp She is converted to the true faith by her adoration for a crusading knight, and quits the scene with a phrase of the Virgin Mary on her lips. Brave Clorinda, donning armour like Marfisa, fighting in duel with her devoted lover, and receiving baptism from his hands in her pathetic death, Erminia seeking refuge in the shepherd's hut-these lovely pagan women, so touching in their sorrows, so romantic in their adventures, so tender in their emotions, rivet our attention, while we skip the battles, religious ceremonies, conclaves and stratagems

Tasso's self-chosen critics suggested every course but the right one, which was to publish the Gerusalemme without further dispute. Tasso, already overworked by his precocious studies, by exciting court-life and exhausting literary industry, now grew almost mad with worry. His health began to fail him. He complained of headache, suffered from malarial fevers, and wished to leave Ferrara. The Gerusalemme was laid aside in manuscript for only sister Cornella, and was educated by the Jesuits. He was a a time. He opened negotiations with the court of Florence for an precocious child and famous in Naples for his learning when, at exchange of service. This irritated the duke of Ferrara, who feared ten years old, he joined his father in exile in Rome. In 1537 he that the Medici might get the coveted dedication of that already accompanied his father to the court of Urbino. Torquato, a famous epic. Therefore he bore with the poet's humours. MeanTATA 831

while Tasso became the subject of delusions-thought that his servants betrayed his confidence, fancied he had been denounced to the Inquisition, expected daily to be poisoned. In 1576 he quarrelled with a Ferrarese gentleman, Maddalo, who had talked too freely about some love affair, in the summer of 1577 he was relating his sorrows once more to the princess Lucrezia, when he magined a servant was listening and rushed on him, knife in hand He was shut up in a room in the palace, and the duke then took him to his country seat of Belriguardo The often told story, immortalized by Goethe, that a compromising haison with Leonora d'Este came to light, and that Tasso agreed to feign madness in order to cover her honour, must be dismissed. The poet's own temperament and the critics of his Gerusalemme Liberata had aggravated his ill-health He was now placed in a Franciscan convent at Ferrara He escaped at the end of July, disguised himself as a peasant and went on foot to his sister Cornelia at Sorrento

He seems to have found peace and healing with his sister, but after a time missed the court cucle, and asked to return to Ferrara There his old irritability returned. In the summer of 1578 he ran away again; travelled through Mantua, Padua, Venice, Urbmo, Lombardy. In September he reached Turm on foot, and was courteously entertained by the duke of Savoy. Wherever he went, "wandering like the world's rejected guest," he met with the honour due to his illustrious name But life was intolerable to him outside Ferrara In February 1579 he returned at an ill-chosen moment. Alfonso was about to contract his third marriage, this time with a princess of the house of Mantua. The princesses did not want to see him The duke was engaged Tasso broke into terms of open abuse, and was sent off without ceremony to the madhouse of St. Anna There he remained for seven years until July 1586. After the first few months of his incarceration, during which he was treated with the harshness then usual towards the insane, he obtained spacious apartments, received his friends, and went abroad attended by friends Except for occasional odes or sonnets-some written at request and only rhetorically interesting, a few, like the famous canzone asking for the intercession of Luciezia and Leonora, inspired by his keen sense of suffering and therefore poignant-he neglected poetry.

Long ago his papers had been sequiestrated. Now, in 1580, he heard that part of the Gerusdamen was being published without his permission and without his corrections. Next year the whole poem was given to the world, and in the following six months seven editions appeared. The prisoner had no control over his editors; and from the masterpiece which placed him on the level of Petrarch and Ariosto he never derived one penny of pecuniary profit. The fame of the poem rangely spread throughout Europe, within twenty years of its publication it was translated into English in the well-known version, stelf a masterplece, of Siz Edward in the well-known version, stelf a masterplece, of Siz Edward in the well-known version, stelf a masterplece, of Siz Edward (1600). A rival poet as the court of Ferrara, Battesta Guardi, undertook to revise and re-edit his blyrics in 1582 In 1585, two Florentine pedants of the Della Crusca academy declared war against the Geracalemme.

In 156 Tasso left. St. Anna at the solicitation of Vincenzo Gonzaga, prince of Mantua. He followed his young deliverer to the city by the Mincio, basked awhile in liberty and courty pleasures, enjoyed a splendid reception from his paternal town of Bergamo, and produced a tragedy called Torrissonado, the first sketch of which dates from 1574. But in the autumn of 1587 we find him wandering once more, through Bologna and Loreto to Rome, where he stayed in the house of an old friend, Schjöne Gonzaga, now patriarch of Jerusalem. Next year he wandered off to Naples, where he wrote his unfinished poem on Monte Oliveto. In 1589 he returned to Rome, but fell ill The patriarch in 1590 gain received him. But Tasses 'deless spirit over 'Rome' Rome of the Patria of the State of the Stat

His health grew feebler and his genius dimmer. In 1502 he

gave to the public a revised version of the Gerusalemme, called the Gerusalemme Conquistata. All that made the poem of his early manhood charming he rigidly erased The versification was degraded; the heavier elements of the plot underwent a dull rhetorical development. During the same year a poem on the Creation in blank verse, called Le sette Giornate, saw the Light

In 1394 Clement VIII and his nephew, Cardinal Aldobrandin of St Giorgo, nivited Tasso to Rome There he was to assume the crown of buys, as Peturato Bassumed it, on the Capitol. Worn out with illness, Tasso reached Rome in November. The ceremony of his coronation was open easigned him a penson; of the control of the Capitol Common of the Capitol Commo

He passed away on April 25, 1595, and the cell he occupied became a place of pilgrimage for his admirers. The last twenty years of his existence had been meffectual. At the age of thirty-one the Gerusalemme, as we have it, was accomplished. The work, too, was already runging with the music of Aminta. More than this Tasso had not to give to literature. But those succeeding years of derangement, exile, imprisonment, poverty and hope de-

this Tasso had not to give to literature But those succeeding years of derangement, each; improsument, poverty and hope deferred endear the man to us

(J. A. S; X.)

BIRLINGBARY—The best edition of Tasso's works is that of Rosmi 33 vols (Psa, 1871-29); C. Guasti has othred the prose works a vols florence, 1879) and the letters y vols. (Florence, 1853). English translations of Gerusalemme include the often reprinted translation by Redward Fauritax (stoos) and that by J. K., James (1884). One of the prose work of the prose work of the prosent

TATA, SIR DORABJI JAMSETJI (1859–1932), Indian capitalist, was born at Bombay on Aug 27, 1859, being the elder son of the famous Parsee industrial pioneer, Jamseijt Masaruji Tata. Upon leaving Cambridge, he entered his father's business and pursued his father's great conceptions until they culminated in striking advances in Indian industrial development and also in the establishment in 1905 of the Indian institute of scientific research at Banquiore. See TATA SONS, LIMITED.

TATA, JAMNSETJI NASARWANJI (1839-1904), Parsee merchant and philanthropist, was born at Nosari, in the state
of Baroda, in 1839, and went as a boy to Bombay, where he was
educated at the Elphinstone College. In 1838 he entered his
father's office, and began a commercial career of the highest emnence, beginning with cotton mills at Bombay and also at Nagpur,
and ending with the formation of a company to work the iron
ores of the Central Provinces on modern principles. He also introduced a slik industry after Japanese methods into Mysore. But
his greatest benefaction is the endowment of a research institute
at Bangalore. He dide at Nauheim, in Germany, on May 19, 1904.

TATA, SIR RATAN (1871-1018). Parsee financier and philanthropis, was born at Bombay on Jan. 20, 1871, the son of the famous Parsee merchant Jamsetji Nasatwanji Tata (2.2.). He was educated at St. Xavier's college, Bombay, and entered his father's firm. On the death of the elder Tata in 2004 Ratan Tata and his brother, Dorabij Jamsetji Tata (b. 1859), inherited a very large fortune, much of which they devoted to philanthropy and to the establishment of industrial enterprises. See Tata Sons, Limited.

In England he founded (1912) the Ratan Tata department of social science and administration at the London School of Eco-

nomics, and in the same year established a Ratan Tata fund at the University of London for studying the conditions of the poorer classes. He died at St. Ives, Cornwall, on Sept. 5, 1918

TATAR REPUBLIC, an Autonomous Soviet Socialist Republic, created in 1920, in the Russian SFSR, and bounded on the south by the regions of Kuibyshev and Chkalov, on the west by the Chuvash ASSR and the Marii Autonomous Area, on the north by Kirov region and the Udmurt ASSR, and on the east by the Bashkirian ASSR Area 25,907 sq mi Pop (1939) 2,919,423 (urban 621,859, rural 2,297,564). The republic is drained by the Volga and Kama and their tributaries, the Vvatka, joining the Kama in the east, and the Svyaga flowing northward to the Volga in the west. Forest-pine, fir and jumper in the north, and birch, ash, lime, alder, willow and elm in the southoccupies about 17% of the republic, and in the north there is some marsh land. Of the land favourable to cultivation, 78% is tilled, agriculture being the main occupation of the people Black earth is found in the southwest, along the valley of the Svyaga and in a few other places, the remaining soils being gray forest, clays and sands. The climate is continental, five months of the year having an average temperature below 32° F, and the rainfall averages 16 in per annum in good years, but may fail periodically, resulting in such famines as those of 1911 and 1921, these being caused by insufficient spring rain; summer and autumn rains are more reliable. The prevailing winds are from the southwest and often bring dust storms that cover the crops. In June and July thunderstorms with destructive hall are a source of damage

Agriculture and Industries .- These difficult conditions, giving harvests for export in some years and reducing the region to famine in others, are an indication of the need for more intensive forms of agriculture. Up to 1920 there was no many-field system and the peasants mainly used old-fashioned instruments The tragic holocaust of the famine year was specially severe in the Tatar area, and after that time about 5% of the fields were tilled on more intensive lines, and there was greater care in the choice of seeds and crops. Attempts were made to encourage maize, potato and beet cultivation, and to diminish the sowing of buckwheat, which gives a very unreliable harvest. Better instruments gradually replaced the traditional ones. In 1937 there were about 40,000 tractors used by the agricultural population of the republic, and the crops increased considerably. Rye (48 8%), and oats (19 2%) are the chief crops Others are buckwheat, millet, grasses, lentils, flax and hemp. The mineral wealth is not great

Factory industries are mainly centred on Kazan (q v.), which was the only town in 1939 with a population of over 16,000 The chief future for factory industry lies in food production. Condensed milk plants have been established in the region. The leather industry dates back to the Bolgar empire, and the Morocco and Russia leather of the Tatar republic finds a ready market even beyond the U.S.S.R. Nearly half the pelts obtained in the soviet forests are dressed in Kazan. There is some flour milling, two factories produce agricultural machinery, three work in hemp and jute and one in linen goods. A synthetic rubber plant has recently been erected. Glass, bricks, lime, alabaster and silicate are produced A typewriter factory produces a large part of the typewriters used in the soviet east. There are four printing presses producing Tatar magazines, papers and books. There is also a large cinema film factory, Before World War I the koustar or peasant industries of the region flourished. The government subsequently took measures to restore these industries, since they are a means of giving the peasant sufficient income to prevent his wandering in search of employment, and they also provide for the workless and landless peasant. Among the varied peasant products, sleighs, tarantasses and carts are famous, and are in demand in Siberia. Tatar guitars, dulcimers and violins are noted.

Tanguage and Education.—A great problem of the republic is its low rate of literacy. The position is difficult; partity because the budget of the republic at present shows a mixted deficiency and school premises and materials are not available. The greatest difficulty, however, is the 'wirety of languages. The Tatar population numbers 48,3%; Great Riskissian 43,1%; Chruscht 49,%

941.11.

Mordva 14%, and various other nationalities 23% Assimilation has hardly existed in the past and it is quite common for a village to have a group of Tatars in one section, of Finns in another and of Great Russians in another, each using its own language and following its own customs 'Under the Issarst regime education was mainly Russian. After the foundation of the republic, Tatar became the official language of the administration and by 1925 there were many more Tatar schools than before the revolution, but the training of teachers is a difficulty Moreover the Tatar population is rural, and the greater proportion of the town population is Russian, and as there is a possibility of education in rural districts for about 30% of the children and in towns for about 70%, the problem is complex

History—From the 5th century on there was a strong immigration of Bulgaranas muto the region, they formed an important history of Bulgaranas muto the region, they formed an important fishante—Bolgaran or Bolgary, 50 mm. S of Kazan, being the centre, its runs are to be seen. This kingdom reached its zenth in the roth century, but was ruined by the Mongoli unvision of the 13th century. Intermixture between the Bolgars and the Mongolis and between local Finnish tribes has given the Volga. Tatars a distinctive character. After the fall of the Golden Horde, these morthern Tatars formed a khanate with Kazan as its centre, and there began the immigration into the region of refugee tribes, Mordva, Chuvash, Meschyeraks and Bashkirs. After the capture of Kazan in 1552, a policy of colonal Russian settlements on the Volga, with lines of forts to protect them from attacks by the natives, was pursued. The problem facing the Tatar ASSR is the establishment of co-operation among these elements.

(R M F;X)

TATARS (the common form Tartars is less correct), a name given to nearly 3,000,000 mhabitants of the Russian empire, chiefly Moslem and of Turkish origin. The majority-in European Russia-are remnants of the Mongol invasion of the 13th century (see Mongols), while those who inhabit Siberia are survivals of the once much more numerous Turkish population of the Ural-Altaic region, mixed to some extent with Finnish and Samoyedic stems, as also with Mongols. The name is derived from that of the Ta-ta Mongols, who in the 5th century inhabited the northeastern Gobi, and, after subjugation in the 9th century by the Khitans, migrated southward, there founding the Mongol empire Under the leadership of Batu they moved westward, driving with them many stems of the Turkish Ural-Altaians toward the plains of Russia. The present Tatar inhabitants of European Russia contain very little admixture of Mongolian blood, but belong to the Turkish branch of the Ural-Altaic stock, only Batu, his warriors, and a limited number of his followers being Mongols. while the bulk of the 13th-century invaders were Turks On the Volga they mingled with remnants of the old Bulgarian empire. elsewhere with Finnish stems, and with remnants of the ancient Italian and Greek colonies in Crimea, and Caucasians in Caucasus The name of Tatars, or Tartars, given to the invaders, was afterward extended to different stems of the same Turkish branch in Siberia, and even the bulk of the mhabitants of the high plateau of Asia and its N.W. slopes, described under the name of Tartary The Tatar inhabitants of the Russian empire formed three

large groups-those of European Russia and Poland, those of Caucasus, and those of Siberia. (1) The Kazan Tatars, descendants of the Kipchaks settled on the Volga in the 13th century, where they mingled with survivors of the old Bulgarians and partly with Finnish stems. They speak a pure Turkish dialect: they are middle-sized, broad-shouldered and strong, and mostly have black eyes, a straight nose and salient cheek bones. They are Mohammedans; polygamy is practised only by the wealthier classes. They are excellent agriculturists and gardeners, very laborious, and have a good reputation for honesty. (2) The Bashkirs who live between the Kama, Ural and Volga are possibly of Finnish origin, but now speak a Tatar language and have become Mohammedans (3) The Astrakhan Tatars are agriculturists and gardeners The Kundrovsk Tatars still continue the nomadic life of their ancestors, (4) The Crimean Tatars who occupied the Crimea in the 13th century, have preserved the name of their leader, Nogai The mountain Tatars closely resemble those of Caucasus, while those of the steppes—the Nogais—are plates, hoops, strips, bars, sheet-bars, tin-bar, sheets—black and deudedly of a mixed origin from Turks and Mongols.

galyanized—rails, fish-plates, sleepers, light and heavy structural

(a) The Tatus of Caucasia, who inhabit the upper Kubun, the steppes of the lower Kuma and the Kura, and the Aras, of these the Nogais on the Kuma show traces of an intimate mixture with Kalmucks. They are nomads, supporting themselves by cattle-breeding and fishing, few are agriculturists. The Karachais in the upper valleys about Elbura live by agaicaliture (6) The mountain Tatais, divided into many tribes, are scattered throughout the provinces of Baklu, Elivian, Tiffis, Kutus, Daghestian, and partly also of Batum. They are certainly of a mixed origin, and pursent a variety of ethnological types All who an entire Amenians nor Russans, nor members of any distinct Caucasian tribe, are often called Tatais. Although most fevent Shi-ties, they are on very good terms with their Sunnite neighbours. Polygamy is airse and their women go to work unveight.

The Siberian Tatars occupy three distinct regions-a strip running west to east from Tobolsk to Tomsk, the Altar and its spurs. and South Yeniseisk They originated in the agglomerations of Turkish stems which in the region north of the Altai reached some degree of culture between the 4th and the 8th centuries, but were subdued and enslaved by the Mongols They are difficult to classify, for they are the result of somewhat recent minglings of races and customs (7) The Baraba Tatars take their name from one of their stems (Barama), live in Tobolsk, a few in Tomsk, by agriculture, either in separate villages or along with Russians (8) The Cholym or Chulym Tatais on the Cholym and both the rivers Yus speak a Turkish language with many Mongol and Yakut words, and are more like Mongols than Turks (9) The Abakan or Minusinsk Tatars occupied the steppes on the Abakan and Yus in the 17th century, after the withdrawal of the Kirghizes, and represent a mixture with Kaibals (whom Castrén considers as partly of Ostiak and partly Samoyedic origin) and Beltirsalso of Finnish origin. Their language is also mixed. They are known under the name of Sagais (10) The Tatars of the northern slopes of the Altai are of Finnish origin They comprise some hundreds of Kumandintses, the Lebed Tatars, the Chernevyie or Black-Forest Tatars and the Shors, descendants of the Kuznetsk or Iron-Smith Tatars They are chiefly hunters and have maintained their Shaman religion and tribal organization into suoks They live partly also on cedar-nuts and honey collected in the forests Their dress is that of their former rulers, the Kalmucks, and their language contains many Mongol words, (17) The Altai Tatars, or "Altaians," comprise-(a) the Mountain Kalmucks who have nothing in common with the Kalmucks except their dress and mode of life, while they speak a Turkish dialect, and (b) the Teleutes, or Telenghites, a remainder of a formerly numerous and warlike nation who have migrated from the mountams to the lowlands, where they now live along with Russian peasants.

BILLOGARMY —Whibelm Radion's Reise durch den Alta, Aus Sibrien; "Pictresque Russau" (Edmojetanya Roxinya); Semenov's and Potainis "Supplements" to Ritter's Asien; Harkavi's report to the congress at Kazafi, Hartakabi's "Hist, of Cirmean Tatars," in Yvestins Europy, 1866 and 1867; "Katchinsk Tatars," in Irvestita Russ George Soc, xx, 1884, Various scattered articles on Tatars will be found in the Revue orientale pour les Etudes Oural-Absiques, and in the publications of the university of Kazafi. See also E. H. Parker, A Thomand Years of the Tartars, 1855 (chaft) a summary of Chinese accounts of the early Turksh and Tatar tribes), and Skime and Rosi,

Heart of Jaffs (1890).

TATA SONS, LIMITED. A private limited company owned by members of the house of Tata, and founded in 1887 by Jamseth N Tata, Indua's greatest pioneer industrialist. It has, since its inception, launched several concerns and today it manages and controls directly or through associated ouganizations a network of national undertakings in India with an aggregate capital of about \$\frac{1}{2}\sigma\_0\

persons. Its principal industrial undertakings are iron and steel, a hydro-electric system and textiles.

The Tata Iron and Steel Co. Ltd. is the largest industrial concern in India; it owns and operates the biggest steel plant in the British Empire with an annual capacity of a million tons of steel. It produces over three quarters of India's requirements of billets, 21–260

plates, hoops, strips, bars, sheet-bars, tin-bar, sheets—black unid aglvunized—rails, fish-plates, sleepers, light and heavy structural sections in ordinary and high-tensile steel. It is known for the high standard of its wages and for the supenor working and living conditions of its employees A unique feature is the creation by the company of its own town, well-planned and now housing over 100,000 persons, out of what was a jumgle but a few years ago

The hydro-electric undertakings cost approximately £12,000,000, and consist of three companies, the Tata Hydro-Electric, the Andhra Valley and the Tata Power Supply Companies The three power stations are fed by separate lake-systems and have a total capacity of 25,0000 hp. The Tata Gnd transmits energy for

industrialized Bombay and its hinterland

The textile interests of the firm are represented by four companies, the Central India Sg. Way & Milg., the Ahmedabad Advance, the Svidesin Mills and the Tata Mills, representing a total investment of over \$2,00,000 The mills have over \$900,000 spindles, \$7,000 looms and bleaching, dyeing, printing and finishing plants

The Nagpur mills of the Central India Mill Company made history technically by being the first in the world to spin cotton

twist commercially on ring frames.

In addition to these three main undertakings, the firm controls a large soap and oil manufacturing industry, aur transport services for mais and passengers which operate a network of 3,700 routernless covering the Indian pennsula, and a hotel company which owns and operates the Taj Mahal Hotel in Bombay Amongst its most recent activities is the founding of another key industry, the Tata Chemicals Company, with the object of making Indian industries independent of essential chemical supplies from abroad.

Among other concerns launched by the firm, from time to time, a ret the New India Assurance Company, the largest composite Indian insurance house, two cement factories—now merged in the combine known as the Associated Cement Companies, and an investment corporation recently promoted, principally to under-

write and finance new industrial projects

The founders of the firm bequeathed their entire fortunes, over £3 million, to charity. Scientific research, medical relief and social service form the three major channels for Tata benefactions.

TATE, SIR HENRY, 181 BARY, ct. 1898 (1819-1899), Eng-

lish merchant and founder of the National Gallery of British Art, was born at Chorley, Lancashire, in 1819 He became a prosperous sugar-broker in Liverpool, and about 1874 removed to London, where he greatly increased the operations of his firm and made "Tate's Cube Sugar" known all over the world He gave £42,000 to the Liverpool University College, founded in 1881, and a still larger sum to the Liverpool hospitals When he came to London, he presented four free public libraries to the parish of Lambeth He owned one of the best private collections of modern pictures in England. This he offered to the Nation with £80,000 for a building if the government would provide the ground; and in 1892 this offer was accepted. A new gallery, controlled by the Trustees of the National Gallery, was built on the site of Millbank Prison. The gallery was opened on July 21, 1897, and a large addition to it was completed just before the donor died. Tate died at Streatham on Dec. 5, 1899

TATE, NAHUM (1652-1715), English poet laureate and

TATE, NAHUM (165s-2715), English poet laureate and playwright, was born in Dublin in 165s. He was the son of Faithful Teate (as the name was spell), who wrote a quain poem on the Trinity entitled Ter 7tie. Nahum Tate was educated at Trinity college, Dublin, graduating S.A. in 167s. He wrote at Trinity college, Dublin, graduating S.A. in 167s. He wrote at Trinity college, Dublin, graduating S.A. in 167s. He wrote the properties of the properties of the properties of the properties of the properties of the properties of the properties of the properties of the properties of the properties of the properties of the properties of David (1666), in which he collaborated with Nicholas Brady. A supplement was licensed in 17cg. Some of these hymns, notably "While Shepherds watched," and "As pants the hart," rise above the general dull level, and are said to be Tatte's work.

Tate was commissioned by Dryden to write the Second Part of Absalom and Achitophel. The portraits of Elkanah Settle and Thomas Shadwell, however, are attributed to Dryden, who probably also put the finishing touches to the poem. Of ins numerous poems the most original is Pouncea, Power on Tea (1700). In spite of his consistent Toryism, he succeeded Thomas Shadwell as poet laureate in 169. He died within the precented of the Missouthwark, London, where he had taken refuge from his creditors, on Aug. 12, 1715.

TATI, a district of the Bechuanaland protectorate. Area about 2,500 sq mi The railway from Capetown to Bulawayo crosses the territory with a station at Francistown, pop. (1936) 15,864, the principal settlement. Francistown stands 3,254 ft above the

sea and 18 126 mi SW of Bulawayo by rail

The town of Tatı, on the river of that name, is 18 mi. S E of Shashı rıver railway station Tati owes its importance to the presence of gold, first discovered by the German traveller Karl Mauch in 1867 Mining began in 1868, but it was not until 1895 that woik on a large scale was undertaken The imming right are vested in a company, called the Tati Company, Ltd. (See BECHANALAIDA, RRODESIA).

TATIAN (and cent. An ), Christian apologist, mussionary and heretic. Such knowledge as we have of his life is derived from (1) his own Oratio ad Graecos (see § 3), (2) Irenaeus, Adv. Heareste, i, 38, i, (3) Rhodon, quoted in Eusebius's Hist Eccl. V, 13, 1, (4) Clement of Alexandria, Strom., 1, 1, 13, (5) Eusebius, Chronicon somo An V 17, (6) Eiphanus, Paenrom, 1, 3, 46. Convenent collections of these passages may be found in E Schwart's Tations Oratio ad Graecos, Teste und Intervachungen, iv, 1, 51–55, and in A Harnack's Geschethe der altebruitlichen Literatur, 1, 485–66 From these data the following outline of his hie can be reconstructed. He was a Syrian' (Clem Alexand Epiphanis) born in Mesopolama (Or., 43) and educated in Greek learning, in which he became proficient (Or., 1 and 42). He was initiated unto the Mysteries, though into which is not stated (Or., 20), but after this became acquainted with the Old Testament and was converted to Christianny.

Tatian then went to Rome, where he was a hearer of Justin, and together with the latter incurred the enmity of a certain philosopher Crescens Since this fact is mentioned both in Justin's Apology and in Tatian's Oratio ad Graecos, and the Apology can be dated with fair security about AD 152 (see JUSTIN MARTYR), the conversion of Tatian must have been before this date After the death of Justin he became a heretic-according to Eusebius's Chronicon in 173 Among his pupils were Rhodon, and, perhaps Apelles (see Victorinus Reat schol 44, in Ep Hieronymi ad Avitum, ep 124) and Clement of Alexandria (Storm, 1, 1, 11). He made a missionary journey to the east and worked in Cilicia and Pisidia, using the Syrian Antioch as the centre of his efforts (Epiphan ) The heresy which Tatian either founded or adopted was that of the Encratites. Their main doctrines were the evil nature of matter, an absolute forbidding of marriage, abstinence from wine and perhaps from meat. It would also seem that Tatian beheved in the existence of acons, one of whom was the Demiurge of the world. He denied the salvation of Adam It is also stated that in his celebration of the Mysteries (s.e., the Euchanst), he used only water. (See Tertullian, De Jejun, 15; Hippolytus, Philos., 8, 4, 16 and 10, 18; Jerome in Amos, ii, 12 and Iren., Adv. Haer, i, 28, iii, 23.)

Writings—According to Euschius (Hist. Eccl., iv. 20) Tatian wrote many books; of these the names of the following have survived: (1) On Anneals (mentioned in Or., \$5); (2) On Demons (mentioned in Or., \$6); (3) Address to the Greeks (4) Book of Problems (Eus., v. 15, 1—2 quotation from Rhodon) an attempt to deal with the contradictions to be found in the Bible; (2) Aganust Those Who Have Discussed Drivine Things (mentioned in Or., 40 as a book which Tatian intended to write, but there is no evidence that he carried has plan into effect); (6) On Perfection According to the Saviour (Clem Alex, Strom., in 12, 80.); (7) The Distinssuron; (78) a recension of the Pauline epistles. Of these books only two—the Distensaron and the Address to the

'Tatian describes himself as an "Assyrian," and though the terms "Assyrian" and "Syrian" are used very loosely by ancient writers, it is probable that he was born E. of the Tigris; i.e., not in Syria as we understand it. Epiphanius, in another passage, calls him an Assyrian.

Greeks-are extant.

The Address to the Greeks (Oratio ad Graecos) (see edition by J C 70 tion, in Corp apole div sace, Jena, 1851) belongs to Tatan's Catholic period. He has the double purpose in view of exposing the weakness of the pagan view of the universe and of commending the Christian explanation. The omissions in the Oratio are even more remarkable than its statements. There is at the most not more than an allusion to Christ, who is never mentioned by name, and though there are frequent allusions to the regaining of life, which is accomplished by union with the Logos, there is no reference to the doctrines of the incarnation or of the atonement. The Oratio was probably written in Greece about AD 150.

TATRA MOUNTAINS, a name usually reserved for the highest group of the central Carpathans (va., the Vysoké Tatry), which rises abruptly as an isolated igneous group, partly in Slondvaika and partly in Poland, from a high plateau of about 2,600 ft to altitudes exceeding 8,400 ft, and extends between the rivers Vth, Poprad, Dunajee and Arva The mountains have a westeast length of about 20 mi and a width varying from 9-15 mi, notable peaks being Gerlachowka (8,737 ft), the highest in the Carpathians, Lomincký (8,642 ft.) and Kriván (8,190 ft.) In everything except glacures the range bears the Aipine imprint Small spas, well-cumpped and the range bears the Aipine imprint Small spas, well-cumpped controlled, summer controlled and the state of

South of the valley of the Váh runs a lower parallel range of similar structure, the Nízské Tatry, reaching its maximum heights in the peaks of Dumbier (6,707 ft ) and Králová Hola (6,373 ft )

(W S L)

TATSIEN-LU (TACHENLU, KANGTINO), a town in the territory of Sikang, west of China, situated more than 8,000 ft. above sea level. It is a great mart for Thete, and from Tatsien-In the two trade routes, the Ayalam and the Janglam, diverge, the former making for Ladakh and the latter for Kashgar Pop est. 20,000

TATTA or Thuro, an ancent town of India, in Sind province, 7 mi. from the right bank of the main channel of the Indius and 13 mi from a station on the North-Western railway, the population (1941) was 8,262. That was the capital of the Samma dynasty in Lower Said in the 16th century, and long continued to be the centre of trade in the country, to which it sometimes gave its name in early European travels. Its former importance reflected its location at the apex of the India delta. An Reclifi factors was catabliched these as each but can obtain the second of the country and the second of the country are catabliched these as each but can obtain the second of the country are catabliched these as each but can obtain the second of the country are catabliched these as each of the country in the country are catabliched these as each of the country are catabliched these as each of the country are catabliched.

English factory was established there in 7,758, but soon withdrawn. TATTERSALL'S, London horse auction mat, founded in 1766 by Richard Tattersall (1,744—95), who had been stud groom to the second duke of Emgston. The first premises occupied were near Hyde Park corner, in what were then the outskirts of London Two "Subscription rooms" were reserved for members of the Jockey club, and they became the rendezvous for sporting and betting men. "Tattersall's Committee" and "Tattersall's Sing" are the descendants of these subscription rooms but are not in any way connected with the horse mart. The former is a strong, but unofficial, organization that looks after the purity of the turf from the point of view of the bookmaker and bettor althe; and the latter is the name given to the principal betting enclosure on any racecourse on which meetings are held under Jockey club or National Hunt rules. By a house of lords decision Tattersall's Ring is not a "place" within the meaning of the Betting act, 1853.

Ring is not a "place" within the meaning of the Betting act, 1853.

TATTLER, a North American wading but (Heteractitis in-canus), about 11 in. long, slaty gray above and white barred with gray below. It breeds on the Pacific coast north from British Columbia, wintering in the Hawanian Islands and the Caliboagos.

TATTOOING: see MUTILATIONS AND DEFORMATIONS.

TAUCHNITZ, the name of a family of German printers and publishers. Karl Christoph Traugott Tauchnitz (176:-1836), born at Grossbardau near Grimma, Saxony, established a printing busness in Lelpiagi in 1796 and a publishing house in 1798. He specialized on the publication of dictionaries, Bibles and steroetyped editions of the Greek and Roman classics. The busness of the Greek and Roman classics. The busness

(1798-1884), until 1865, when the business was sold to O Holtze. He left large sums to the city of Leipzig for philanthropic purposes Christian Bernhard, Freiherr von Tauchnitz (1816-95), the founder of the firm of Bennhard Tauchnitz, was the nephew of the first-mentioned His printing and publishing firm was started at Leipzig in 1837. The Library of British and American Authors, begun in 1841, was taken over in 1934 by Oskar Brandstetter of Leipzig In 1929 the collection numbered more than 4,800 vol In 1868 Tauchnitz began the Collection of German Authors, followed in 1886 by the Students' Tauchnitz editions

TAULANTII, in ancient geography, an Illyrian people in the neighbourhood of Epidamnus (Thuc i, 24). They were originally powerful and independent, under their own kings. One of these was Glaucias, who fought against Alexander the Great, and placed Pyrrhus (q v ), the infant king of Epirus, whom he had refused to surrender to Cassander, upon the throne (Plutarch, Pyrrhus, 3). Later the Taulantii fell under the sway of the kings of Illyna.

TAULER, JOHANN (c 1300-1361), German mystic, was born about the year 1300 in Strasbourg, and was educated at the Dominican convent in that city From Strasbourg he went to the Dominican college of Cologne, and perhaps to St. James's college, Paris, ultimately returning to Strasbourg In 1338-39 Tauler was in Basel, then the headquarters of the "Friends of God" (see Mysticism), and was brought into intimate relations with the members of that pious mystical fellowship He died on June 16, 1361

Tauler's sermons were printed first at Leipzig in 1498, and re-Tauler's sermons were printed into at Leipzig in 1498, and re-printed with additions from Meister Eckhart and others at Basel (1522) and at Cologne (1543) There is a modern edition by Julus Hamberger (Frankfurt, 1864), and A W Hutton edited Tauler's Ser-mons for Festivals under the title of The Inner Way See H Dennile, mons for neutrus under the tute of Lee Inster way See I Dennie Das Buck vow gestlicker Armist (Stresburg, 1877), Carl Schmidt, Dan Buck vow Gestlicker Armist (Stresburg, 1877), Carl Schmidt, Tauker Life and Sermont (1857); R. A. Vanghan, Hours with the Mystics, and ed., vol. 1, pp 134-907; Peeger's Gestle der deutschen Mystic um Mittelalter, vol m. W. R. Inge, Christian Mysticasm; R. M. Jones, Studiest in Mystical Religion (1903).

TAUNG-GYI: SEE SHAN STATES

TAUNTON, a municipal borough and market town of Somer-setshire, England, on the river Tone, 44\frac{2}{3} mi S W. of Bristol by the Western region railway route. Pop. (1951) 33,613. Area 3.8 sq mi. The town is chiefly built on the south side of the river in Taunton Deane valley. Taunton is the county town of Somerset, and is in the Taunton parliamentary division.

There is evidence of an early settlement near the suburb of Holway, and Taunton (Tantun, Tantone, Tauntone) was a place of considerable importance in Saxon times King Inc erected an earthen castle here about 700, and a monastery was founded before 904. The bishops of Winchester owned the manor, and obtained the first charter for their "men of Taunton" from King Edward in 904, freeing them from all royal and county tribute. Before Domesday Taunton had become a borough with very considerable privileges, governed by a portreeve appointed by the bishops. Two members were returned to parliament from 1299 bishops. Two members were returned to parliament from 1885. The Saturday market dates from before the Conquest.

Its main streets converge upon a triangular space, where there is a market cross. The parish church of St. Mary Magdalene is a fine Perpendicular building. Remnants of Norman work are preserved in the chancel arch, and of Early English work in the north aisles and transepts. The tower is also a notable feature. Little is left of an Austin priory established in the reign of Henry I by William Giffard, bishop of Winchester, who also built the castle, now a museum for prehistoric, Roman and mediaeval antiquities. At the Restoration it was dismantled and its moat filled in. Among the schools is a grammar school founded in 1522 by Richard Fox, bishop of Winchester. The town was incorporated in 1627.

TAUNTON, a city of Massachusetts, U.S., one of the county seats of Bristol county, 35 mi. S of Boston, at the head of ocean navigation on the Taunton river, 14 mi. above Fall river. It is on federal highway 34 and is served by the New York, New Haven and Hartford railroad.

The population of Taunton was 40,100 in 1950 and was 37,395 in 1940 by the federal census. Within the corporate limits of the

was carried on by his son, Karl Christian Phillipp Tauchnitz city (which has an area of 44 25 sq mi ) are several villages. The old "common," fringed with lofty elms, is the centre of the business section of the modern city, and about a mile from "the Weir," at the harbour Its manufacturing industries are extensive and varied, including large cotton mills, and plants producing aluminum, chemicals, silverware, stoves and ranges, soap, plastics, drills, gears and a number of other products Taunton was founded in 1638 and became the frontier town of Plymouth colony.

Miles Standish was engaged on the original survey. The town was incorporated in 1639, taking the name of the English home of many of the settlers. It was a base of operations during King Philip's Wai. In 1686 it refused to comply with the demands of Sir Edmund Andros for a tax levy In 1774, after the passage of the Boston Port bill, a red flag inscribed "Liberty and Union" was raised on the common in token of sympathy with Boston During the Shays' rebellion the courthouse was twice besieged by insurgents who were dispersed on both occasions by one of the judges, Gen David Cobb Industrial development began with the establishment of ironworks in 1656 Brickmaking and shipbuilding were important early industries, and for some time Thomas Coram, founder of the London Foundling hospital, was one of those engaged in the latter In the adjoining town of Berkley is the famous Dighton rock, with inscriptions long attributed to the Norsemen, but believed by some to be the work of Indians or of a Portuguese explorer. Taunton was chartered as a city in 1864. It was one of the first cities in the United States to operate its own electric-lighting plant, which it acquired in 1897

TAUNUS, a wooded mountain range of Germany in the province of Hesse-Nassau It lies between the Rhine and the Main on the south and the Lahn on the north, and is about 55 mi Its southern edge stands 5 to 10 mi. back from the Main but slopes steeply to the Rhine, and from Bingen downward forms precipitous crags, many of which are crowned with picturesque ruins. It has an average elevation of 1,500 ft, but the loftiest peaks occur in the east, where the Grosser Feldberg (2,887 ft ) Kleiner Feldberg (2,714 ft.) and Altkonig (2,618 ft.) dominate the Wetterau and the valley of the Main Above the Rheingau (the slopes to the Rhine between Biebrich and Bingen). the altitude averages 1,500 to 1,700 ft. The geological core of the system consists of (?Archean) argulaceous schists, capped by quartaite (Devonian) and broken through in places by basalt. On the northern side, which sinks on the whole gently toward the Lahn, the higher greywacke formation (Devonian) attains a considerable development. The hills are generally well-wooded, with firs and beeches. The lower slopes are, where possible, planted with vineyards, orchards and chestnut and almond groves The vineyards of the Rheingau are specially famous, and yield many famous brands of wine. The Taunus is also famous for its mineral springs and health resorts.

There are ruins of the castle of Kuno (above Falkenstein); of a fortress at Konigstein; a Cistercian abbey at Eberbach; and two concentric lines of pre-Roman fortifications at Altkonig, The chief historical monument, however, is the Saalburg, a Roman fort serving as a centre of communications along the limes or fortified frontier line drawn from Rhine to Main by Domitian (see LIMES GERMANICUS).

At Niederwald (q.v.) is the gigantic "Germania" statue in commemoration of the 1870 war. The steep crags of the western end of the Taunus, where they abut upon the Rhine, are rich in the romantic associations of the great river. Here are the rock of the siren Lorelei; the old castles of Stahleck and Pfalz; and the quaint mediaeval towns of Kaub and St Goarshausen.

TAURI, the earliest known inhabitants of the mountainous south coast of the Crimea (Herodotus iv, 103). Nothing is certain as to their affinities. They probably represent an old population perhaps connected with some Caucasus stock. They are not likely to be Celts. They were famous in the ancient world for their maiden goddess, identified by the Greeks with Artemis Tauropolos or Iphigeneia (q.v.), whom the goddess was said to have brought to her shrine at the moment when she was to have been sacrificed at Aulis. Orestes sought his sister, and almost fell a victim to the Tauric custom of sacrificing to the maiden shipwrecked strangers. a real custom which was the ground of the whole myth His adventures were the subject of plays by Euripides and Goethe Towards the end of the 2nd century B C we find the Tauri dependent allies of the Scythian king Scilurus, who from their harbour of Symbolon Portus or Palacium (Balaclava) harassed Chersonese (q v) Their later history is unknown. (E, H M)

TAURINI (tou-re'në), an ancient Ligurian people, although the name may be of Celtic origin, who occupied the upper valley of the Padus (Po) In 218 B.C. they were attacked by Hannibal with whose friends, the Insubres, they had a long-standing feud They later became subject to the Romans, and the colony of Augusta Taurinorum (Torino, Turin) was founded in their territory (probably by Augustus after the battle of Actium) Both Livy (v. 34) and Strabo (iv. p. 200) speak of the country of the Taurini as including one of the passes of the Alps, probably the Mont Genèvre or Col d'Argentière

TAUROBOLIUM, properly the shooting of a bull, hence a rite of baptism by bull's blood, usually in connection with the worship of Cybele (q v ), though not limited to it Of oriental origin, its first known performance in Italy was in AD 134 Prudentius describes it in Peristephanon (x, 1066 et seq ) the person undergoing the ceremony, clad in a toga worn cinctu Gabino, with golden crown and fillets on his head, takes his place in a trench covered by a grating, on which a bull is slain.

The taurobolium was often performed as a measure for the welfare of the emperor, empire or community, its date frequently being March 24, the Dies Sanguins of the annual festival of the Great Mother and Attis (qq.v). But its usual motive was the purification or regeneration of an individual, who was occasionally spoken of as renatus in aeternum, reborn for eternity, in consequence of the ceremony (Corb Insc Lat vi. 510-512), more commonly the effect was considered to endure for 20 years

TAURUS ("the Bull"), in astronomy, the second sign of the zodiac denoted by the symbol & It is a constellation of very great antiquity, the Pleiades and Hyades (qq v) two of its constituent star clusters, being possibly referred to in the Old Testament; while Aldebaran, its brightest star, is mentioned by Hesiod and Homer The Greeks fabled this constellation to be the bull which hore Europa across the seas to Crete, and was afterward raised to the heavens by Jupiter. Aldebaran is the principal object in the Hyades, named after the seven daughters of Atlas and Aethra. Many of the Hyades (but not including Aldebaran) form an associated group of stars with a common motion. The measurement of the motions of these stars permits an accurate determination of their distance; they are situated at approximately 130 light years from the sun. Aldebaran itself is a reddish giant star, located at a distance of about 80 light years from the sun constellation contains the "crab nebula," a gaseous mass which has been shown fairly conclusively to have originated in the outburst of the new star, or nova, of A.D. 1054. Photographs indicate that the nebula is expanding in size from year to year The structure of the Milky Way in Taurus is complex, with dark, almost starless lanes and bright nebulosity.

TAUSEN, HANS (1494-1561), the protagonist of the Danish Reformation, was born at Birkende in Funen in 1494. The quickwitted peasant lad ran away from the plough at an early age, finally settling down as a friar in the Johannite cloister of Antvorskov near Slagelse. After teaching for a time at Rostock and Copenhagen, he was again sent abroad by his prior, visiting the newly founded University of Leyden and making the acquaintance of the Dutch humanists. He was already a good linguist, understanding both Latin and Hebrew. Later he translated the books of Moses from the original. In May 1523 Tausen went to Wittenberg, where he studied for a year and a half, when he was recalled to Antvorskov. In consequence of his adherence to Lutheran doctrines he was first imprisoned in the dungeons of Antvorskov and thence transferred, in 1525, to the Grey Friars' closter at Viborg in Jutland, where he preached from his prison to the people assembled outside, till his prior, whom he won over to his views, lent him the pulpit of the priory church, Several young men in Viborg had studied at Wittenberg, and

the burghers had already expelled their youthful bishop Jorgen Friis Tausen no longer felt safe among the Franciscans, he discarded his monastic habit, and placed himself under the protection of the burgesses of Viborg At first he preached in the parish church of St John, then in the market-place from the church When the Franciscans refused to allow him to preach in their large church, the mob broke in by force A compromise was at last arranged, whereby the friars were to preach in the forenoon and Tausen in the afternoon. The bishop sent armed men to the church to arrest Tausen, but the burghers drove them back In Oct 1526 King Frederick I made Hans Tausen one of his chaplains, and charged him to continue "to preach the holy Gosto the citizens of Viborg, who were to be responsible for his safety Tausen found a fellow worker in Jorgen Viberg, better known as Sadolin, whose sister, Dorothea, he married. He was the first Danish puest to marry He was also the first to use Danish instead of Latin in the church services.

On the death of King Frederick, Tausen, at the instance of Ronne, was, at the Herredag of 1533, convicted of blasphemy and condemned to expulsion from the diocese of Sjaelland, whereupon the mob rose in arms against the bishop, who would have been murdered but for Tausen's intervention. Ronne then permitted Tausen to preach in all his churches on condition that he moderate his tone On the final triumph of the Reformation Tausen was appointed bishop of Ribe (1542), an office which he held for 20 years

See Suhr, Tausens Levnet (Ribe, 1836); Danmarks Riges Historie, vol ii (Copenhagen, 1807-1005).

TAUSSIG, FRANK WILLIAM (1859-1940), American economist, was born at St Louis, Mo, on Dec 28, 1859. He was educated at Harvard university (A.B., 1870, Ph.D., 1883), where he started teaching in 1882, becoming professor of political economy ten years later He made a particular study of finance and was during 1917-19 chairman of the U.S. tariff commission March 1919 he was called to Paris to advise in the adjustment of commercial treaties He was in 1904-05 president of the American Economic association and from 1896 to 1937 edited the Quarterly Journal of Economics He wrote Wages and Capital (1896); The Tariff History of the United States (1888); Principles of Economics (1911), Some Phases of the Tariff Question (1915), Inventors and Money Makers (1915); and Social Origins of American Business Leaders (1932).

TAUTOMERISM: see Isomerism.

TAVERNER, JOHN (c. 1495-1548?), English composer, was born in Lincolnshire, possibly at Tattershall, and according to some accounts became organist of Boston church. In Nov. 1526 he was made master of the children at Cardinal college, Oxford (now Christ Church), and also acted as organist During this period he wrote his church music. Taverner was then convicted of heresy but it appears that he was not sent to prison because his offence was slight Taverner resigned his post at Cardinal college in April 1530 and some time during this year contributed three songs to Wynkyn de Worde's Song Book ("My Harte, my Minde," "Love wyll I" for three voices, and "The bella" for four voices), published in Oct. 1530 Having secured a lucrative post from Thomas Cromwell, he was concerned in the suppression of four friaries at Boston in Aug. 1538, later being given two of them. He died and was bursed at Boston, probably in 1548

A two-part song, "In Women no Season is Rest or Patience," is in the British museum, but, apart from this and the Wynkyn de Worde the British museum, but, spart from this and the Wynkyn de Worde specimens, only Tweneris's church music has been preserved. Of this there is a complete collection, with blographical notes, in the Carnege (come moromplet); 3 Magnificats and a Te Deum; a Kyrie known as the "Levoy", and shorter pieces.

See "Taverne" by E. H. Fellowes in Grove's Dictionary, and education, 1925 and W. H. Grattan Flood, Early Tudor Company of the Carnege (Cardon, 1925) and W. H. Grattan Flood, Early Tudor Company of the Cardon, 1925 and W. H. Grattan Flood, Early Tudor Company of the Cardon, 1925 and W. H. Grattan Flood, Early Tudor Company of the Cardon, 1925 and W. H. Grattan Flood, Early Tudor Company of the Cardon Company of the Cardon C

TAVERNIER, JEAN BAPTISTE (1605-1689), Freiten traveller and pioneer of trade with India, was born in 1605 at Paris, where his father Gabriel and uncle Melchior, Protestants from Antwerp, pursued the profession of geographers and engravers He had already travelled much in Europe and was well acquainted with the principal European courts, when he started

from Regensburg with two French fathers, M de Chapes and M de St Liebau, for the Levant In their company he reached Constantinople early in 1631, where he spent 11 mo, and then proceeded by Tokat, Erzerum and Erivan to Persia His farthest point in this first journey was Isfahan, he returned by Baghdad, Aleppo, Alexandretta, Malta and Italy, and was again in Paris in 1633 In Sept 1638 he began a second journey (1638-43) by Aleppo to Persia, and thence to India as far as Agra and Golconda His visit to the court of the Great Mogul and to the diamond mines was connected with the plans realized more fully in his later voyages, in which Tavernier traded in costly jewels and other precious wares, among the greatest princes of the east. The second journey was followed by four others. In his third (1643-40) he went as far as Java and returned by the cape, in his last three journeys (1651-55, 1657-62, 1664-68) he did not proceed beyond In 1669 he received letters of nobility and in 1670 purchased the barony of Aubonne, near Geneva

Tavernier's narratives of his travels are Nouvelle relation de l'intérieur du sérail du Grand Seigneur (4to, Paris, 1675), based on two visits to Constantinople in his first and sixth journeys; Les six voyages de J B. Tavermer (2 vol , 4to, Paris, 1676) and Recueil de plusieurs relations (4to, Paris, 1679).

The closing years of Tavernier's life are obscure. He left Paris for Switzerland in 1687, in 1689 he passed through Copenhagen on his way to Persia through Muscovy, and in that year he died at Moscow.

See Chailes Joret, Jean Baptiste Tavermer d'après des documents nouveaux (1886, bibliography), and an English translation of his account of his travels in India, by V Ball (1889).

TAVISTOCK, a market town and agricultural centre in the Tavistock parliamentary division of Devon, England, 15 mi. N. of Plymouth by road. Pop. of urban district (1951) 5,889 Area 3 3 sq mi. It lies in a deep valley below the western edge of Dartmoor where one of the main routes into Cornwall crosses the Tavy. It was once the centre of an important mining district for tin and copper and is one of the four stannary towns of Devon. Its mediaeval importance owes much to the magnificent Benedictine abbey of St Mary and St. Rumon founded in 961 by Orgar, earl of Devon. After destruction by the Danes in 997 it was rebuilt, and among its famous abbots were Lyfing, friend of Canute, and Aldred, who crowned Harold II and William and died archbishop of York. At the time of the Conquest it ranked as the wealthiest house in Devon, including the hundred and manor of Tavistock among its possessions. Most of the abbey was demolished at the dissolution and the lands given to the dukes of Bedford; in 1912 the council acquired some of this land from the duke. Remains of the abbey include the gateway which now houses the Tavistock library The church of St. Eustachius dates from 1318 and possesses a lofty tower supported on four open arches; the "clothworkers' aisle" (1445) witnesses to the importance of the town as a wool centre. Kelly college, near the town, founded by Adm, B. M. Kelly and opened in 1877, is now a public school for boys.

Henry I granted the abbots a market in 1105 and the famous Tavistock goosey fair in 1106. This takes place annually on the second Wednesday in October. In 1513 the abbots were granted a seat in the house of lords. Tavistock is a borough by prescription and returned two members to parliament from 1295 until 1867; in 1885 it was disfranchised.

TAVOY, a town and district in the Tenasserim division of Burma. The town is on the left bank of the river of the same name, 30 mi, from the sea. Pop. (1931) 29,018. It carries on a considerable coasting trade with other ports of Burma, and with the Straits Settlements whither is sent the bulk of the tin ore for which the district is important, as well as much of the rubber. The chief industry is salk weaving, but there are also rice and

The district has an area of 5,390 sq.mi. It lies between Siam and the Andaman sea of the Bay of Bengal, enclosed by mountains on three sides, viz., the main chain of the Bilauktaung on the east, rising in places to 5,000 ft, which, with its densely wooded spurs, forms an almost impassable barrier between Burmese and Siamese territory; the Nwahlabo in the centre, which takes its

name from its loftiest peak (5,000 ft ), and a third range, under the name of Thinmaw, between the Nwahlabo and the sea coast The Tavoy is navigable for vessels of any builden. It is interspersed with many islands, and with its numerous smaller tributaries affords easy and rapid communication. The climate is on the whole pleasant 
The annual rainfall averages more than 200 in. Pop (1941) 211,729, showing an increase of 31,765 in the decade. The staple crop is rice Forests cover an area of nearly 5,000 sq mi, of which considerable areas are "reserved." The leading industries of the district are rubber planting and tin mining, both of which are of recent development

Tavoy, with the rest of Tenasserim, was handed over to the

British at the end of the first Burmese war in 1826.

TAXACEAE, a small family of the Gymnospermae consisting entirely of evergreen shrubs and trees, containing only three small genera, Taxus including the yew (q v ) in Eurasia and various subspecies and varieties in North America, Torrya with five species in eastern Asia and North America, and Austrotaxus in New Caledonia As thus restricted to three genera, see R Pilges, "Taxaceae," in Engler and Prantl, Die Naturlschen Pflanzenfamilien, ed. 2, vol. 13, pp. 199-211, fig 113-115 (1926), and for a monographic treatment, including what is designated as the Podocarpaceae, see R. Pilger, "Taxaceae," in Pflanzenreich, no. 18 (iv, 5), pp 1-124, fig 1-24 (1903) (E. D. ML)

TAXATION. Taxes are compulsory government levies on

private units imposed for general public purposes, not as a direct charge for special services rendered. They are thus differentiated from borrowing, gifts, reparations, fees imposed to defray the costs of licensing and other special services, public prices like postal rates charged for goods and services sold by the government, and special assessments levied to pay for street paying and similar

specific improvements to real estate.

Clear-cut lines among the various types of public revenue are hard to draw, and each type shades into adjacent classes For example, in a twilight zone between taxation and borrowing are the compulsory loans levied by Canada, Great Britain and the United States during World War II (in the form of refundable income taxes) and by Denmark and Israel in the 1950s. Also difficult to classify are social insurance contributions (not generally designated by law as taxes, except in the United States); they progressively take on the character of taxes as the link weakens between the size of the individual's contributions and the scale of his benefits

Though generally thought of as an instrument of revenue, taxes are recognized also as a major instrument of national economic policy. In war and in armed peace, nations call on tax increases to subdue inflation, and in depression they grant tax reductions to stimulate private markets and employment. Especially when government spending equals one-fourth to one-third of the national product, as in western Europe and North America, taxes play a crucial role not only as a source of revenue but as a balance

wheel in the economy.

History.-Only late in human history did governments come to rely on taxes, especially on taxes levied equitably and with the consent of the governed, for the bulk of their revenue. For centuries, the public domain was the chief source of public revenue, and taxation consisted largely of excises on domestic consumption and customs duties on foreign trade. It was the duty of the unprivileged classes-slaves, vassals, peasants, colonists and conquered peoples-to support the ruling classes, be they the free citizens of Athens and Rome, the lords and nobles of the feudal barony or the courts of the Louis. Taxes as a badge of freedom rather than a mark of bondage are a modern phenomenon.

In ancient Greece and Rome, income from mines, tribute from subjugated countries, gifts from wealthy citizens and taxes on trade and consumption filled virtually all revenue needs. Except for Rome's famed inheritance and capitation taxes (both foreshadowed by ancient Egyptian taxes) and certain emergency levies in Greece, direct taxes on income and wealth were unknown.

Taxes of any kind had little place in the agrarian feudal system of the middle ages. The king, the duke, the count, the baron -each in turn derived income from the land he held directly and levied rentike dues on those who held land at his pleasure, e.g., on those beneath him in the feudal hierarchy. From the 14th century on, as the feudal system was gradually broken up by dissipation of the public domain, by growth of industry and commerce and by centralization of government, these patrimomal revenues

slowly gave way to taxes

Land, as the primary source of wealth, also became the primary source of traction during this period. Both local and central governments in England turned to land taxes, bissing them at first on area (the old hadage and carriage) but later on annual retails value. The French counterpart was the arbitrary annual taille on estimated iram income. The early American colones broadened the British type of land tax into a property tax whose base metisded land, bouses, personal property and faculty (the rated eaning capacity of one's trade or profession). With the great growth of foreign and domestic commerce between the 14th and 19th centures, import and export duties and internal excises became important, especially in France, Spain and other commercial centres. Poll taxes and such presumptive levies as the hearth tax and window it axis flourished in this period

Rebellion against arbitrary and oppressive taxation played a major role in modern history. Such milestones in Brutah constitutional history as the Magna Carta (12x5) and the Bill of Rights (1689) helped establish the principle of consent and representation in taxation. Failure to apply this principle to the colonies played no little part in the American Revolution Much of the desperation that exploded in the French Revolution grew out of one of the most oppressive and inequitable tax systems of all time

The establishment of representative democratic government, the advent of the industrial revolution and the development of modern ideals of social justice and equality left their imprint on both the principles and the forms of taxation. The 19th century saw exceptioncy and oppression in taxation gradually make way for equity and uniformity. With the unfolding of new forms and differentiated sources of wealth, taxes on incomes and inheritances were adopted and sefined, and property taxes were further broadened.

Great Britam adopted an income tax in 1798 and a death transfert ax in 1796, broadened both measures (after setting the income tax aside from 1816 to 1841) midway through the 19th century, and brought them to something like their modern form near the turn of the century. Although customs and excises contuned to be an important source of revenue, the central government during the first half of the ooth century greatly intensified its use of direct taxes on income and estates. "Local rates" on real estate continued to be the mainstay of local tax systems

Modern and effective use of income and death taxes was not made in the United States until about the time of World War I. Earlier, customs, excess on liquor and tobacco, and sales of land furnished the bulk of federal revenues. The peculiarly American state and local levels. But during World War I and in the interwar period, the federal government adopted an estate tax, developed its corporate and individual momen taxes, expanded its excises and introduced social security pay roll leves. The states meanwhile tapped such new sources as gasoline taxes, retail sales taxes, motor vehicle levels and net income taxes, largely abandoning the property tax to the local units.

Under the pressure of World War II, central government taxes everywhere were brought to new peaks, both in their seventy and in their adaptation to such nonrevenue ends as curbing of inflation and prevention of war profiteering. After the war, most behignerate granted only modest tax reductions in the face of large debts, continued inflation and deteriorating relations between the Soviet and western worlds. Outbreak of the Korean War in 1950 touched off. a new wave of tax increases, but within three or four years, such countries as Australia, New Zealand, the United States, Canada, Great Britain, the Netherlands and Germany were again reducing taxes.

Modern Forms.—As modern economic society progressively exposed new facets of wealth, income and transactions to tax planners and legislators, they responded with a bewildering array of

levies The production and receipt of income, the ownership and transfer of wealth, the sale and use of commodities and services, the carrying on of a business and a host of other economic factors all became bases of objects of taxation

The versatility of income as a tax base can be visualized by observing the gantlet of taxes it may have to run as it flows into, through and out of a corporation. At the point of entry, income may be subject to (r) taxes on gross receipts or gross income (often classed as consumption taxes because they are largely passed on to consumers in higher prices), (2) taxes on the net profits remaining after all expenses are deducted, (3) taxes on excessive profits, especially in waitime. Once inside the corporate walls, net income which is not distributed to stockholders may run athwart taxes on undistributed profits like the 1936-38 tax of 7%-28% in the United States or the British standard rate on retained earnings At the point of exit, income paid out as dividends may encounter a distributed profits tax like the post-World War II British tax of 221% As it reaches the stockholder, dividend income may be subject to (1) a progressive personal income tax applying a uniform schedule of rates to net income regardless of source (as in prevailing United States practice); (2) a schedular income tax applying different rates to different sources of income (as in Massachusetts), (3) a special tax or surtax on investment income (as in Canada), (4) special credits or allowances under the regular income tax (again, as in Canada) To this galaxy of income taxes should perhaps be added the low-rate levies on business pay rolls and individual wares so widely used to finance oldage and unemployment insurance programs

Property remains the principal local tax base in the Englishspeaking word Broadest of all property taxes is the US general property tax, an impersonal levy on both real estate and personal property, measured by exchange value and levied against owners. Narrower and more personal is the British system of local rates, confined to real estate, measured by annual rental value, and part levied as a tax on occupants Even narrower are the rural land taxes of Asia, the middle east and much of Europe

Most personal of the taxes on property ownership are the progressive taxes on personal net worth (assets minus habilities) levied in the form of (1) annual net worth taxes, as in Scandinavia, Germany and the Netherlands, and (2) one-time capital levies, as in many European countries in the wake of both World Wars I and II In the United States, constitutional barriers stand in the way of a national net worth tax

Transfers of wealth by death are taxed in most western countries under both estate taxes (levied on the decedent's estate as a whole) and inheritance, succession or legacy taxes (levied on the heirs' distributive shares). Comparable taxes apply to transfers by efft

Another major tax family are the consumption taxes, those which are generally passed on to consumers in higher prices even though initially levied on producers or distributors. The term hiden taxes ordinarily refers to this group of levies. In their more general forms, they are levied as turnover, gross income or valueded taxes at several stages of production, as sales or purchase taxes at the manufacturing, wholesale or retail stages; as use taxes on the consumer; and as tariffs or customs duties on imports and exports. In their more limited forms, they appear as selective excess on liquor, tobacco, gasoline, luzuries and many other commodities and services; or as profits from government monopolies of salt, liquor, matches, tobacco and the like.

Business taxes, in the broadest sense of the term, refer to all taxes arising out of the ownership and operation of businesses. More narrowly and usefully, it refers to a separate category of taxes applicable only to business entities as such and bearing on relation to the personal status of the owners or operators of the business. In this sense, it includes on one hand such genal privilege taxes as incorporation fees, capital stock taxes, the occupational taxes popular in the southern United States, the occupational taxes popular in the southern United States, the occupational taxes which single out certain types of business for special taxation, e.g., in the United States the state taxes on insurance companies, usually measured by gross premiums, and on

public utilities, measured by gross earnings or property Corporate income and profits taxes are also often labelled business taxes

Not readily classifiable as income, property, transfer, consumption or business taxes are such miscellaneous levies as poll taxes, prohibitory taxes like the United States levy on state bank notes, taxes on increments in wealth or land values and proposed graduated taxes on individual spending

(For further details on the various types of taxes and their use, see Taxation, Local, Capital Levy, Corporation Tax; ESTATE DUTIES, EXCESS PROFITS TAX; INCOME TAX; LAND TAXES, and SALES TAX)

General Classifications.-Tax literature and usage abound with general classifications Apart from groupings by tax base or source, one of the most useful classifications is by type of effective rate structure, se, progressive, proportional and regressive types The distinction depends upon the ratio of tax hability to net income (or net worth). If the ratio rises as income rises te. if the tax takes a greater percentage of a person's income, the larger that income-the tax is progressive If the ratio is constant, the tax is proportional If it declines as income rises, the tax is regressive The terms are applied both to particular taxes and to tax systems as a whole For example, studies by Gerhard Colm for 1941 and Richard Musgrave for 1948 indicate that the pattern of total tax burdens in the United States is regressive for incomes up to about \$2,000, roughly proportional for incomes between \$2,000 and \$7,500 and progressive for incomes above \$7,500 Among specific taxes, the personal net income, net worth, and death and gift taxes are almost universally progressive Most sales and excise taxes are levied at proportional rates but are regressive in effect; for example, a 5% sales tax takes a larger percentage of a small income than of a large income because the taxed items represent a larger percentage of the small-income than of the large-income budget.

Another widely used distinction is that between direct and indirect taxes Commonly, the term direct denotes a tax which tends to be borne by the persons upon whom the government levies it. Indirect denotes a tax which tends to be shifted, s.e., passed on to others in the form of higher prices received or lower prices paid by the taxpayer Since it is difficult to determine precisely who bears the final burden of a given tax, the line between the two is not easy to draw Customarily classed as direct are net income, net worth, death, gift and land taxes. Consumption taxes, many husiness taxes, pay roll taxes and taxes on realty other than land are ordinarily considered to be indirect. Relative emphasis on direct versus indirect taxes as thus classified varies greatly from country to country Of total tax revenues (excluding social insurance levies) at all levels of government in 1950, direct taxes accounted for 56% in the United States, 52% in the United Kingdom, 32% in Germany and 26% in France, indirect taxes, for 29%, 40%, 53% and 67% respectively; and property and wealth taxes, for 15%, 8%, 15% and 7%, respectively.

Another useful distinction, encountered particularly in discus-

sions of custom duties, is that between specific and ad valorem taxes. A tax or duty is specific when it is based on some physical measurement or quantity, e.g., so much per pound, per yard or per gallon. It is ad valorem when it is based on value and levied as a percentage of that value, e.g., 15 mills per dollar (1.5%) of property value.

Objectives and Criteria .- The pervading objective of taxation, in concert with other government policies, is to maximize the general welfare. Taxes contribute to this end by providing the financial foundation for the substantive functions of government and at the same time serving as an engine of social and economic betterment which nations can call upon to reduce excessive inequalities of wealth, to check inflation and war profiteering and to promote economic stability.

How can the broad welfare objectives of taxation be translated into guideposts for tax policy? In the search for an answer, the maxims propounded by Adam Smith in his Wealth of Nations in 1776 provide a traditional point of departure. He set forth the tests of equity, certainty, convenience and economy as follows:

I. The subjects of every state ought to contribute towards the

support of the government, as nearly as possible, in proportion to their respective abilities, that is, in proportion to the revenue what they respectively enjoy under the protection of the state.

If. The tax which each individual is bound to pay ought to be certain, and not arbitrary. The time of payment, the manner of payment, the quantity to be paid, ought all to be clear and plain to the quantitutic, and to every other person.

the contributor, and to every other person

III Every tax ought to be levied at the time, or in the manner, in which it is most likely to be convenient for the contributor

to pay it

to pay it Every tax ought to be so contrived as both to take out and to keep out of the pockets of the people as little as possible, over and above what it brings into the public treasury of the state

Appropriate as they were in his day, both as standards and as reform slogans in taxation, Smith's canons depend for their present-day validity largely on what is read into them For example, Smith directed his maxim of certainty against the evil of lodging power over the amount and terms of taxes in the "tax-gatherer, who can either aggravate the tax upon any obnoxious contributor, or extort, by the terror of such aggravation, some present or perquisite to himself" In its modern context, the demand for certainty is usually a protest against too-frequent changes in tax laws, regulations and court decisions. Moreover, the unfolding of the principle of progression in taxation has infused new meaning into Smith's maxim of equity. Even with modernized content, however, his canons furnish little more than three common-sense rules of tax administration and one basic principle, that of equity, for the distribution of tax burdens

That this set of guides is no longer adequate is hardly surprising in view of the sweeping economic, social and political developments since Smith's day. Concepts of justice have changed profoundly. Methods of measuring economic strength have been refined Democratic control of taxation has been won. Tax administration has vastly improved. Economic systems have become enormously more complex and interdependent. The sense of social responsibility and, with it, the role of government have steadily grown. In response to these changes, it was inevitable that the functions of taxation should be broadened and its standards recast. As adapted to modern circumstances, the canons may be 1e-exammed under four major headings (1) social justice, (2) consistency with economic goals; (3) ease of administration

and compliance; and (4) revenue adequacy.

Social Justice - That taxes should be just is a self-evident first principle of taxation. But in taxation, as in other fields, justice is a product not of scientific analysis but of a people's value judgments. As reflected in contemporary tax systems, the value decisions modern societies have made regarding social justice appear to require (1) that taxes be impartial in their application—the "equity" test; and (2) that taxes, on balance, be designed to reduce economic inequalities-the "equality" test. Unfortunately the precise meaning and the practical dictates of these tests are not readily definable and have, in fact, been the subject of extended controversy

It is, to be sure, widely agreed that equity in taxation requires impartial (not identical) treatment, i.e., equal taxes on persons in like circumstances and reasonably differentiated taxes on persons in units circumstances. Thus, the equity criterion sets up the presumption that even when taxation is asked to serve such external ends as redistribution even used taxation as assect to serve such external ends as redustribution of income or recepture of excessive war profits, the internal structure of the taxes levide should adhere to the principle of reasonable classification and impartial treatment. But the nub of the problem is. What is reasonable classification in taxution—what characteristics of a person identify him with or differentiate him from other persons for taxing identify him with or differentiate him from other persons for taxing classified and one acceptable criteria have been developed for classified people, what relative tax burdens should the different classes have a considerable criteria and the proposed of the considerable criteria have been developed for classified people, what relative tax burdens should the different classes

For a limited group of levies on the border line of taxation, it has been deemed equitable to classify people and tax them according to the been deemed equitable to classify people and tax them according to the quantity of benefits received from government. Where such benefits to the control of the control of the control of the control of the does not demand a subsidy to the individual to rind the social interest does not demand a subsidy to the individual to rind the social interest reasonable to apply the benefit principle. Gasdine taxes and social security employment levies are commonly justified on the ground that special benefits—the use of the highways and protection against inspecial cenents—the use of the nignways and protection against missecurity—accurate the taxpayer in more or less direct proportion to his in-payments. But the difficulty of measuring most government benefits and the desirability of providing many services on the basis of need narrowly limit the application of the benefit principle. And the day when "taxation according to benefits received" was a battle cry in the struggle to shift the yoke of taxation from the overburdened masses to the exempt nobility has long since passed.

Accordingly, the principle of ability to pay is generally invoked as a basis for classifying and differentiating among people for tax purposes bass for classifying and differentiating among people for tax purposes Deceptively simple in appearance, this concept involves many difficulties that the contract of the co but the amount of net income is only one element in the measurement of ability. Individual income tax laws also take into account (?) family obligations, recognized in marital and dependency exemptions and (?) less universally, the source of the income, recognized in differential treatment favouring "earned" over "unearned" income Even after this yardstok, propely to substrated, valuks induviduals according to

after this yardstuck, propelly calibrated, innks individuals according to their income, the question remains as to how much more the person of high rank should pay than the one of lower rank. The person of high rank should pay than the one of lower rank and the person of the person

"To make the burden of taxes equal . . . is not effected by a mere numerical proportion. The man who is taxed to the amount of one-

"To make the burden of taxes equal ... is not effected by a mere numerical proportion. The man who is taxed to the amount of one-seveley than the man who is taxed to the amount of one-seveley than the man who is taxed an equal proportion of an income of 1,000 rupes, and to a producious bigness more severely than the man who is taxed an equal proportion of 10,000 rupes per amnum" the "scrinfe" footnings have played a major role. An offshoot of hedonstic or utilitatan economics, these doctrines find their most refined expression in a C F good seat-secrifice theory. It bodds that progression is necessary to manimize the aggregate direct burden of the same of the second lightly on the more important units found at the margin of small in-comes. Modern welfare economists question the stated assumptions, pointing out that they cannot be verified until a way is found not only

is based on sacrifice doctrines. is bised on scenfec doctrons.

Not astisfied with attenuated translations of "ability to pay" into "progression," many noted thinkers have rested their case for progressive textuon might be a single progression of the bass of ability and scenfec become meaningful only in terms of greater economic equality. In this view, reducing inequality of incomes increases the general welfare by enabling more unger needs to be satisfied at the expense of less urgent

to measure satisfactions but to compare them among different peop

They are therefore disinclined to accept a defense of progression which

Taussig's later use of the equality criterion was based mainly on his

needs.

In the result of the squality criterion was based mainly on his interpretation of the democratic commensus that "1", such great degrees of inequality as the modern world shows are regarded as not commant with cannot of ustice." Hearty Simons, writing in the 1950, stated also that the case for sharp progression rests on the case against "Consistency with Economic Goods—The importance of harmonisms the control of the

 $db_{M_{\alpha}}$ 

capable of producing when fully employed. Whether that demand wills be forticoming depends on the supergate spending of consumers, bulanesses and governments. When income is withdrawn from the spending stream by individuals who netther spend it nor inventiones, plant and equipment), the eat result is to dry up duamed and employment equipment, the eat result is to dry up duamed and employment and augment their spending by boirowing money or drawing on assets, the result is to inflate demand and employment. Left to testle, the private economy will experience cyclical alumps and booms, aggravated perhaps by secular stagnation or inflation in this setting, it becomes vital that central government—avong taxes as part of a co-ordinated has sevultar balance wheels in the exponsibilities is cyclical and perhams sevultar balance wheels in the exponsibilities as cyclical and perhams sevultar balance wheels in the exponsibilities. capable of producing when fully employed Whether that demand will haps secular balance wheels in the economy

anga secular dualnes workes in the economy usalf, first of all, with the cycleal stability of total spending. Fletable taxes serve as one means of restants or correcting its instability, of restricting total spending in a boom period and expanding it in a slump. This approach calls for a boom period and expanding it in a slump. This approach calls for the compensation of the control of th contract more than in proportion to the ups and downs of national income, current collection and withholding magnify this stabilizing impact by making tax revenues respond instantly to changes in income Contracyclical tax policy also enlists short-term changes in tax rates Contracyclical tax policy also enhists short-term changes in tax rates to impound or free purchasing power. The British White Paper on Employment Policy (1944) stated that "the ideal to be aimed at a major of the theorem of the properties of the properties of the properties of the properties of the properties of the properties of the properties of taxation and the incorporation of some system of deferred coulds (repayable in bad times) as a permanent feature of national tavation

Unless contracyclical tax measures are already imbedded in the law. the necessary tax increases to combat inflation and tax decreases to toe necessary Law increases to compat innation and tax decreases to counter deflation may be unduly delayed in the legislative and administrative process. This is especially likely in the United States, where tax proposals by the executive branch do not have the thrust provided by the British and Canadian parliamentary systems, under which vioco by the British and Canadian parjiamentary systems, under winch the government in power stands or falls on the acceptance or rejection of its program. Under the US system, the executive proposes but the congress disposes—often slowly and only after successive modifications by the house of representatives through its ways and means committee, by the senate finance committee, by the senate itself and finally by the joint conference committee Nonetheless, in severe economic fluctuations, it may not be possible to generate the required deflationary surpluses or expansionary deficits unless automatic fluctuations in revenues are reinforced by discietionary changes in rates In contrast with the wide area of agreement among economists on the

Perenties are reminitors of which the wide area of agreement among economists on the broad principles of anticyclical tar policy, there is no consensus on the properties of anticyclical tar policy, there is no consensus on of the properties of th of the mature or stagnant economy, beste with persistent unemployment, weak markets, redundant savings and lagging investment. It may be a subject of the stagned of the saving source of the saving source of the saving with government expenditure should seek to activate over coupled with government expenditure should seek to activate over the saving saving the saving savi

after the war suggested that, at reast under conditions or armed peace, the problem of containing chronic inflation might replace the problem of sustaining aggregate demand. If this proved to be the case, advocates of progression would find little comfort in the economic argument. The more progressive the tax rates, the higher the level of tax revenues.

The more progressive the tax rates, the higher the level of tax revenues would have to be to achieve a given counternalismonary effect. As taxes rose to new heights during and after the war, their distinctive affects became a source of increasing concern. Colin Clark developed the thesis that beyond levels of z/5% to z/5% of antonia income, but the control of the

Taxation is often called upon to serve economic ends other than

those concerned with aggregate spending and saving. Taxes are emthose conceined with aggregate spending and saving "Lares are employed to subsidize the production of certain items, eg, protective tariffs, and to penalize the production of others, eg, the heavy taxes levied by dairying states on oleomargarine. In World War II, high exiles were imposed on goods like automobiles and radios to divert

exists were imposed on goods like automobiles and ridios to divert resources from their production into war production. The chimatation of unwarianted economic gain from war has been a pramey objective concession in the contract of the concession in their contract of the concession in their contract of the concession in their contract of the contra both government and taxpayers and without large-scale evasion by illegal means and avoidance through legal loopholes and subterfuges, the promes unworkable no matter how laudable its economic and social objectives. The sense of equity is as surely violated by a tax which applies unequally to taxpayers in identical circumstances because of lax administration as it is by a tax which is basically unfair in its statutory administration as it is by a tax which is basically unfair in its statutory provisions. From the standpoint of administration and compliance alone, taxes should be simple to compute and easy to understand (undestanding being a matter, not of the wording of the law, but of the concepts and tax returns which confront the taxpayer). assessed on an obvious base easily arrived at, levied at moderate rates and pay-

on an obvious base easily arrived at, levice at moderate rates and pay-able in a convenient manner.

But the degree of simplicity required or of complexity permissible is not an absolute. Much depends on the nature of the tax, for example, the minimum complexity required to bring about tolerable equity in the minimum complexity required to bring about tolerable equity in an excess profits tax is much greater than that required in a tobacco tax. Much also depends on the scope of the tax—how widely it applies and how deeply it cuts. The demands for ease and simplicity of the United States individual income tax were far less piessing in 1939, United States individual income tax were far less piesang in 1930, when it applied at moderate rates to 4,000000 people, than in 1944 on 1954, when it applied at heavy rates to more than 5,000,000. Factors external to a given tax must also be taken into account. The lack of co-ordination of federal, state and local tax systems, for example, imposes costs and irritations arising not out of a particular tax but out of the conflict and duplication among taxes and taxing jurisdictions. Even more important are the factors external to the tax system as

The general level and standards of the civil service establish a boundary beyond which taxes cannot go in the direction of refinement and complexity Administrative techniques and competence, in turn, depend in good part on the stage of development of society A country that is sparsely settled and industrially undeveloped is likely to have that is sparsely settled and industrially undeveloped is likely to have very simple administrative mechanics and their force to rely heavily on on imports and exports. In more advanced countries, the machinery and the economic data on which it depends are better geared to direct, personal taxes like those on income and mheritances. The levels of public education, the attitudes toward government and the prevailing concepts of justice in taxation similarly condition tax forms and practices They are vital in determining how complicated and refined a tax may be without jeopardizing its success in practice. As these limits of tolerance are broadened, the frontiers of taxation are automatically

extended

retunded.

Revenue Adequacy —The recipits of government must be sufficient to commandeer for the state that part of society's real resources which to commandeer for the state that part of society's real resources which to commandeer to the state that part of society's real resources which to the state of the state o

national economic budget.

In this conception, taxes are not levited for revenue alone. The test of adequate yield as applied to the tax system is not that it cover a predetermined level of government expenditure but rather that, to-gether with borrowing if necessary, it raise the required funds in the manner best calculated to further the end of full and stable employ-The quantitative role of taxation becomes interlocked with its

qualitative role.

qualitative role. This reasoning applies primarily to central governments Their facat policies may appropriately be designed to offset tendencies toward economic matability in the private sector of the conomy. But offset to the conomy is to the conomy to the conomy. But the private sector of the conomy. But the private sector is the private sector to the conomy and the private sector to the conomy and the private sector to the the private sector to the priva budgets remain valid.

Shifting, Incidence and Effects.—To know only who bears the

impact of a tax, i.e., who turns the money over to the government or its agents, is to know very little indeed about the social and economic consequences of that tar. The tax may set loose forces which enable the original payer to obtain higher prices for the goods or services he selfs or pay lowen prices for those he buys, the property of the prop governmental consumption and investment and help to the come of pass final judgment on a tax, one needs to know how it affects the distribution of teal income available for private use, called its incidence, and what repercussions it has on the level of national income, called its effects

income, called it effects .

Unfortunately, the way in which a tax affects the distribution and level of meome cannot be soluted for precue statistical study. Since conclusions must perfore be reached to the solution of the conclusion of the property of the solution of the sale was solved to the conclusion of the solution of the sale was solved to the solution of the sale was solved to the sale was solved to the sale was solved to the sale with the sale was solved to the sale was sale was solved to the sale was solved to the sale was solved to t lines indicated above in the classification of taxes into direct

lines indicated above in the classification of taxes into direct and Comparative tax statistics centre on (i) distributions of tax burdens among fineness groups, (2) relative relatance on difficient forms of taxes, and (3) international and intertemporal burden comparative tax statistics centre on (i) distributions of the tax of (3) international and intertemporal burden comparations for total and (5) international and intertemporal burden continual content of the comparation of the control control content of the control and the comparative stability of tax structure in Great Britain

Comparison of Central Government Tax Revenues and Sources in the

Taxes	Un	ited Sta	tes	Unit	ed King	dom	Canada			
	1939	1944	1953	1939	1944	1953	<b>2939</b>	1944	1955	
Total (billions) .	\$5.5	\$42 X	\$6/5	£10	£3 5	£49	\$04	\$27	84 2	
Individual income Corporate in-	18 8%		44 4%	39 7%	38 0%		13 1%	31 7%		
come, profits	23.3	36 2	31.4	22	151	78	195	294	300	
Death and gift		12	13	77	30.	31		6	9	
Excise	320	104	148	17.2	160*	17 68	20 Q	167	128	
Sales							28 9	128	168	
Customs	5.8	10	9	226	160	210	181	6.3	100	
Employment	135	4.2	72	107	4.4	T2 3		2 3	١.	
Muscellaneous	1				66	I	7	- 1	3	
Total	100%	100%	100%	100%	100%	100%	TOOP	100%	700	

Sources United States Budget Documents, United Kingdom Financial Statemerit, Figures rays not add to totals because of rounding "Includes purchase tax" [Estimated]

By itself, this table says little about the comparative burden of taxes in different years or in different countries. To give some indication of this, revenues are usually related to some measure of national income o output. In the three countries, total tax revenues (including income or output. In the three countries, total tax revenues, (anothering those of all local governments, which comprised about \$\$\frac{1}{2}\$\$ of total taxes in the United States and Canada in 1039 but only \$\$\frac{1}{2}\$\$ in 1053, in construction of the United States and Canada in 1039 but only \$\$\frac{1}{2}\$\$ in 1053, in construction of the United States, from 1050, in Canada.

1044 and 13% in 1053, in the United States, from 15% to 44% to 40% in Great Britain, and from 12% to 13% to 50% in Canada.

The raties of total tax collections to total output of goods and Great Britain, and from 12% to 13% to 50% in Canada.

The raties of total tax collections to total output of goods and Great Britain Learneous 1000 was in 1038 Titley 14.5%. Greece 10.7%, Demmark 11.0%, Italy 23.9%. United States 36.7%, Norresco 10.7%, Bellionia Learneous 103%, Notherhands 1.0%, Firance 31.4%, Valid Jinternational companisons of tax burdens of 1000 for capital for the control of the United Lto make. Companisons of tax burdens of 1000 for capital for the control output difficult to make. Companisons of tax burdens or 1000 for capital for the control output difficult to make. Companisons of tax burdens or 1000 for capital for the control output difficult to make. Companisons of tax burdens or 1000 for capital for the control output difficult to make. Companisons of tax burdens or 1000 for capital for the control output difficult to make. Companisons of tax burdens or 1000 for capital for the control output difficult to make companisons of tax burdens or 1000 for capital for capital for the control output difficult to make companisons of tax burdens or 1000 for capital f

Valid jnfernational companions of tax burdens or tax rates or per capita taxes are especially likely to be misleading because of marked differences in purchasing power of money (not reflected in exchange ratios), in purchasing power of money (not reflected in exchange ratios), in rate of taxes to national income or product—most wide power taxes of taxes to national income or product—most wide power taxes of taxes to national income or product—most wide power taxes of taxes to national income or product—most wide power taxes of taxes to national income or product—most wide power taxes of tax

BIBLIOGRAPHY.—Harold M. Groves, Financing Government, 4th ed. (New York, 1954); Roy Blough, The Federal Taxing Process (New

York, 1952), W. J. Blum and H. Kalven, The Uneasy Case for Progressive Taxatom (Chuago, 1953), O. H. Blownke and E. D. Allen, Economic of Public Finance, and ed (New York, 1954), Richard Goeth, The Corporation Income Tax (New York, 1951), Alvin H. Hinsen, Taxata Thoirs, and Bissiness Cyclest New York, 1951), Alvin H. Hinsen, Taxata Thoirs, and Bissiness Cyclest New York, 1943, London, 1947). Ursula K. Hicks, Public Finance (London, 1947), J. M. Keynes, How to Pay for the War (New York, 1962); A. C. Piguo, A. Study in Public Finance, 3rd rev ed (New York, 1962), Henry C. Simons, Personal Income Taxation (Chuago, and London, 1958), Josah Stamp, The Pandamental Principles of Prastion (New York, 1963), Tax Institute, The Limits of Taxable Capacity Chuecoon, 1953, Walliam (Rev. York, 1964), Tax Institute, The Limits of Taxable Capacity Chuecoon, 1953, Walliam (New York, 1964), Tax Institute, The Limits of Taxable Capacity Chuecoon, 1953, Walliam (New York, 1964), Taxable Capacity Chuecoon, 1953, Walliam (New York, 1964), Taxable Capacity Chuecoon, 1954, Walliam (W. W. W.)

TAXATION, LOCAL. The proportion of government costs that falls on the local and central authorities, respectively, near widely from one country to another In general, the local share is a larger proportion of the total in the federal states than the unitary states. (For taxes levied by the central national authority, see TAXATION)

All tax powers in unitary states rest with the central authority, local divisions have only delegated powers. In consequence, the local authorities are usually quite restricted in their chore of taxes. In federal states, on the contrary, the central government's powers of taxation have ordinarily been restricted, and the states or provinces have usually had under independent powers of taxation than the central government itself in the beginning

Over long penods of time, however, the central government's tax powers have been extended to meet their ever-increasing obligations, until they have senously encroached on the tax powers of the underlying authorities. There is a tendency for federal taxes to overlap and ultimately to supersede state or provincial taxes.

This centralization of taxes is apparent in both federal and unitary states 11 is the result of the growing centralization of most government activities that has come with improved facilities for transportation and communication. Few functions continue to be of strictly local concern, and few taxes can be successfully

Table I —Percentage of Government Revenues from Local Sources an Selected Countries Before World War I and After World War II

Country	Year	Local per cent	Year	Local per cent
Unitary States United Kingdom France Federal States	1913-14	43 7	1951-52	7 8
	1913	20 I	1950	19 3
United States	1915	60 0	1952	23 8
Canada	1913	51 2	1948	30 7
Australia	1913-14	70 0	1951-52	25 9
Germany	1913-14	50 7	1951-52	38 8

administered by a small local jurisdiction. The same tendencies are at work for the different local levels of government, the larger jurisdiction growing continually at the expense of the smaller

The percentage of government revenues from local sources for several countress green in Tuble 1. This shows both the greater centralization in the unitary states and the increasing centralization over a period of approximately acy years. The two period selected are periods in which the proportions were not distorted by the extraordinary demands of the financing of the two wars

# STATE AND LOCAL TAXATION IN THE UNITED STATES

State and local governments in the United States have a larger share of governmental functions than local governments in unitary states, and a proportionately larger share of governmental revenues and expenditures. There are at least three layers of government throughout the country—federal, state and local—each with its own tax powers. And except for a few combined city and county governments, there are at least two layers of local government. There are at least two layers of local governments phase to townships or towns. These in turn are usually divided into school districts. Incorporated cities and villages sometimes replace these subdivisions and sometimes are in addition to them. Often there

are special districts besides. All these have independent tax

There is no shaip division of functions among the different levels of government. In general, schools are the responsibility of local governments, with some aid from the states. The highway system is a composite of state and local roads, often with state aid to the latter and federal and to the former. Welfare activates originated as a purely local matter, but by degrees state and federal authorities assumed increasing responsibility for them. Police and fire protection were still primarily local duties, but by mid-oth century the same centralizing tendencies were beginning to be apparent here, also. The same forces that house centralization of government activities in other countries were at work likewise on the Hunter States.

There are as many state and local tax systems in the United States as there are states. The only restrictions on state tax powers are that states may not tax interstate commerce. In consequence, only customs duties are not available to state authorities. Every other important form of taxation employed by the federal government is at the disposal of the states and is used by some of them, although excises, with the exception of higher theorem of them are the consequence of the disposal of the state of the state of the state of the disposal of the state and is used by a state of the st

The local subdivisions have only delegated tax powers. In The major part of their income Consequently, the wide diversity found among state tax systems does not extend to the tax systems of the smaller units of government.

The moving mean of the systems in the United States is flown in Table 11 and of the systems in the United States is flown in Table 11 and of the systems of

General Property Tax—The characteristic tax of the state and local tax systems of the United States is the general property tax Property taxes began in colonial days as levies on specific forms of property, especially land and houses. The taxes were levied on capital value rather than rental value, but values were often determined by arbitrary measures. Land was often classified, for example, as woodland, pasture or arable land, and the value per acre was the same for all land of a given class. Houses were vulued according to the number of doors, windows or chimneys. In the course of time, various classes of personal property were subjected to taxation. The items selected—e.g. slaves, carriages, watches and clocks and money—were those that indicated

TABLE II -II.S. Federal, State and Local Tax Reserves

Aut	hora	ty		1902	1925	1952		
Federal State . Local		:	:	\$525,000,000 155,000,000 905,000,000	\$3,137,000,000 1,282,000,000 4,054,000,000	\$65,587,000,000 13,243,000,000 0,500,000,000		
Total	Total			\$1,387,000,000	\$8,473,000,000	\$88,330,000,000		
Federal State Local .	:	:	٠	37 9% 11 2 50 9	37 0% 15 2 47 8	74 2% 13 0 10.8		
Total				700.00%	100.00%	Ton off		

Source Various publications of the Bureau of the Census

Table III.-U.S. State and Local Revenues From Specific Taxes, 1902 (In millions of dollars)

Ta	ĸ				State	Local	Total	
Property					82	625	707	
Alcoholic heverage Corporation	•		*		10	45 10	55 54	
Inheritance		•			7	=	7	
Miscellaneous				•	12	26	38	l
Total								

Source: Bureau of the Census, Wealth, Debi, and Toxalion, 1902 (1903).

Source	State	Local	Total
Taxes Property Proper	346 805 687 196 2,001 1,450 430 1,710 791 2,002 1,422	7,580 68 7 3 100 40 10 11 20 478	7,926 \$73 694 199 2,401 1,500 4 10 1,725 813 2,002 1,000
Total taxes Nontax revenue (excluding grants)	11,892 1,214	8,621 2,475	20,473 3,689
Total revenue	13,066	11,006	24,162

Source Bureau of the Census, Reports on Government Finances Local revenues partly

unusual taxpaying ability When these levies became numerous, they were combined in a single general property tax

The general property tax is a levy on all property real and personal, tangible and intangible Valuation for tax purposes is made by local assessors The rate of the tax is determined annually by the different taxing authorities, usually by the process of dividing estimated expenditures that are not provided for through other revenue sources by the value of taxable property In other words, the property tax is usually the elastic element in the tax system, varying with expenditures

Up to the time of the American Civil War the tendency was, as indicated above, to combine various special levies into a general property tax After the Civil War this tendency was reversed One by one, various classes of property were withdrawn from the general property tax base, either to be taxed in other ways or to be exempted entirely. This tendency went so far in some states

that only real estate remained subject to the tax

The principal reason for this change was the increasing difficulty of reaching personal property, particularly intangibles The difficulty arises partly from the ease with which such property can be concealed from the tax assessor, or even removed from any tax jurisdiction where taxes are heavy Intangibles, in particular, so regularly evade the tax assessor that in many states the tax on this property is nominal only The fact that one owner of stocks, bonds and mortgages may be subject to a heavy tax and another escape entirely makes the taxation of intangibles grossly unequal. Moreover, in so far as such property is reached there is double taxation. No taxpaying ability is created by placing a mortgage on a farm, yet the mortgage is added to the full value of the farm in the local tax base

Tangible personalty, also, offers difficult problems of assessment Household furniture and clothing, no longer new, have no real market value Also, they are readily concealed from assessors who rarely cross the threshold Inventories in shops and factories are more readily valued, but they can easily be reduced to abnormally low levels on assessment day Consequently, personal property, as a result of evasion or legal exemption, has become

a declining proportion of the property tax base

Real estate, on the contrary, is both visible and immobile, and consequently bears the brunt of the property tax levies Real estate assessments for the entire United States amounted to fourfifths of the total by the 1950s Valuation of real estate is an expert's job, and local assessors have not always been chosen for their technical competence. This, together with political pressures, has resulted in serious inequalities in the distribution of the property tax burden.

In general, small properties are assessed at a higher percentage of true value than are large properties, principally because the assessor is better able to value a small house and lot than a large estate or department store. Also, there is a tendency to encourage new building through underassessment, and to compensate by leaving values unchanged on the older, deteriorating properties. (See also LAND TAXES.)

Much real estate is exempt. The larger part of this is government property, and large state or federal holdings in small local taxing jurisdictions have often created serious financial problems.

TABLE IV — U.S. State and Local Revenues from Specific Taret, 1951 However, there has been some effort to compensate such local (In millions of dollars) Nonprofit or units through special state or federal assistance Nonprofit organizations for educational, religious or philanthropic purposes have regularly been encouraged by tax exemption, and there has been a tendency to extend exemption to small home owners, through homestead exemptions, and to tenants, through the exemption of low-cost housing projects These exemptions made serious inroads on the local tax base.

States endeavoured to assist their local subdivisions by obtaining their own revenues increasingly from other sources Property taxes supplied 53% of state tax revenues in 1902 and only 3% in 1051 Even this assistance, however, left real estate taxes at high levels Property owners have sought protection from excessive taxes through state legislation fixing the maximum rate that can be levied by the local authorities These tax limits have been widely used but they have often proved arbitrary and have led to unbalanced local budgets or undesirable curtailment of local government services as well as to low tax rates.

Much of the hardship suffered by property taxpayers arises from inequalities in the tax. If real estate were assessed equitably, the tax would not be unduly burdensome in most areas Equitable assessment would not, of course, make the tax a satisfactory measure of ability However, approximately half of local expenditures are for street improvements, police and fire protection and other services bringing direct benefits to the property owners Welfare activities, education and other functions which would not benefit property owners as such are supported in increasing measure by federal and state governments

Consumption Taxes.—A variety of consumption taxes pro-

duce a large share of state tax revenues. The most important of this group of taxes are the motor fuel tax, taxes on alcoholic beverages and tobacco and the general sales taxes The revenues from these different consumption taxes are given in Tables III and IV for 1902 and 1951, respectively; and the number of states employing

such taxes is given in Table V. Motor fuel taxes are levied at varying amounts-ranging from

three to seven cents a gallon in 1952. They are quite regularly earmarked for highway construction or maintenance, and the states often share them with the local subdivisions for highway use In isolated instances local governments have been authorized to levy independent taxes. The first motor fuel tax was levied in 1919 It spread to all other states in the course of the following decade, and by 1952 only the general sales tax produced more state revenue In so far as the revenues of the motor fuel tax are used for highway purposes, it can be classified as a benefit tax, since the taxpayers contribute roughly in proportion to their use of the highways A tendency developed to use a disproportionate share of the proceeds for rural highway systems and to give relatively

Table V-Number of US States (Including District of Columbia)

Tax	1902	1912	1922	1932	1942	195
General property .	46	46	45	42	20	22
Personal income	- 1	2	11	19	31	33
Corporation income		1 2	11	20	33 48	33
Death and gift	. 27	38	45	47	Ã8	33 48
General sales .		1 -	1	6 (	2.2	32
Alcoholic beverage* (gallonage or		i	1	-		,,,,
monopoly)	- 1		1	l .	49	49
Tobacco	1 1	3	1 11	20	30	41
Motor fuel	1		10	49	49	40
Motor vehicle licence	1 1	42	40	49	40	46
Pay roll	1 '	l "	1 "	. "	40	1 46

"Before promining liquor taxes were in the form of hiences. Source Senate Doc. no 69, 78th Cong 1st sess Federal, State, and Local Government steel Relations (1943), and publications of the Bureau of the Census.

little to the cities for their streets, but more and more states are recognizing the claims of urban highways Alcoholic beverage revenues from gallonage taxes and the profits

of state liquor monopolies became an important source of state income in most states after the repeal of prohibition in 1933, and tobacco taxes spread rapidly after the beginning of the 20th century These are comparatively easy taxes for the states to administer, and are usually defended as luxury taxes, although the cigarette taxes unquestionably fall heavily on the low-income General sales taxes also produce large revenues Most of these taxes were introduced in the 1330s, when relief expenditures were growing, and existing revenue sources were shinking. The nature of these taxes, and the dates of their introduction into state tax systems are given in Table VI. These taxes are regressive, particularly when food is included in the base, but they seem to be accepted with comparatively little protest

Consumption taxes as a whole produced about two-fifths of all state revenues in 1952 and about 4% of local revenues in this same year.

Personal Taxes.—State personal income taxes originated with a Wisconsin levy beginning in 1911. Other states followed until, by 1952, 32 were levying such a tax. This form of state taxation would probably have spread even more rapidly if the "equal and uniform" tax clauses in many state constitutions had not prevented

TABLE VI -Sales, Gross Receipts, Gross Income and Use Taxes on Effect as of Jan. 1, 1953

State	Basss of Tax	Effects Origin	ve Date al Law	Rate of
State	pass of Tax	Sales, etc	Use	Tax
Alabama	Retail sales of tangible personalty			_
Anzona Arkantes	and amusement admissions Retail sales of tangible personalty, Retail sales of tangible personalty, room reptals, admissions and	1936	none	1/1%-2%
Califorma Colorado	utility services Retail sales of tangible personalty Retail sales of tangible personalty	1935 1933	1949	3%*
Connecticut	and some utility services Retail sales of tangible personalty	1935	1936	2%
District of	Retail sale or rental of tangible			, , ,
Columbia Florida	personalty Retail sales of tangible personalty,	1949	1949	2%
Georgia	rentals, admissions Retail sales of tangible personalty	1949 1951	1949 1951	3%
Illinois Indiana	Retail sales of tangable personalty Gross income of individuals; whole-	1933	none	2%
	sale and retail sales	1933	none	14%-114%
Iowa	Retail sales of tangible personalty, admissions, some utility services	1934	1937	2%
Kansas	Retail sales of tangible personalty, admission, some utility services	1017	1037	2%
Louisiana	Retail sales or rental of tangible	1016	1018	
Maine .	Retail sales of tangible personalty	1951	1951	3%
Maryland	Retail sales of tampble personalty and some utility services	1949	none	1%
Michigan	Retail sales of tangible personalty and some utility services	1011	1937	3%
Мізанаррі	Gross income from various businesses	1014	1938	36%-2%
Musomi	Retail sales of tangible personalty.			
New Mexico	utility services, admissions Gross business income	1935	none	25%-2%
New York	Ontional local taxes on retail sales	1034	1934	
North Carolina	Wholesale and retail sales	1933	1937	1/20%-2%
North Dakota	Retail sales of tangable personalty, admissions, some utility services	1935	1930	2%
Ohio	Retail sale or rental of tangible	1935	1936	3%
Oklahoma	Retail sales of tangible personalty and certain services	1933	1937	2%
Rhode Island	Retail sales of tangable personalty			
South Carolina	and some utility services Retail sales of tangible personalty	1947	1947	2%
South Dakota	Retail sales of tangible personalty.			
Tennessee	admissions, some utility services Retail sales of tangible personalty	1935	1937 none	2%
Utah	Retail sales of tangible personalty;			
Washington	admissions; some utility services	1933	1937	3%
West Virginia	Retail sales of tangible personalty Retail sales of tangible personalty;	1035	1951	
Wyoming	gross income of business. Retail sales and rentals of tangible	1934	none	2%‡ .
	personality, admissions; some	1935	1937	3%

\*Additional local taxes at option of municipality Taxes vary with locality, 3% in New York city. Egress income taxes vary from 11% to 6%.

the imposition of progressive rates. This tax became an important source of revenue—in some states the most important tax in the system; but states were deterred from levying highly progressive taxes, partly through feat that wealthy residents would move to other states and partly because the federal government was well established in the field hefore most states had turned to it for new TEVENDER.

Local income taxes are found in a few large cities including, in 1952, Philadelphia, Pa.; Washington, D.C.; Louisville, Ky.; and Toledo, and Columbus, O. Also a number of smaller municipalities in the state of Pennsylvania levy such taxes. Except for Louisville, these taxes are in areas where there is no state tax.

All have low rates The revenues are substantial, and in Toledo in 1952 they exceeded property tax collections However, few states have permitted such levies.

Inheritance, estate and grft taxes are long-established sources of state revenue, but wide variations in yield from one year to the next make them undependable, and they are rarely one of the larger revenue producers. Here, as in the case of personal income taxes, interstate competition for wealthy residents has tended to keep rates low, and the federal tax has become much heavier than those imposed by the states. These taxes have rarely been used

by municipalities Business Taxes.—One of the earliest forms of taxation to be developed by the states was the corporation tax. The first taxes of this sort were mostly designed to replace or supplement unauccessful efforts to tax intangibles under the general property tax since corporations obtain their charters from state authorities, the states have unquestioned right to levy privilege taxes in exchange printer charter. Moreover, the case of assessment and collection of capital stock taxes,  $e_{\mathcal{E}}$ , on corporations which are already expisited with state officials, simplified administrative problems

Corporation taxes have taken many forms. Some are for the privilege of obtaining a charter, and others are for the annual privilege of domaining a charter, and others are for the annual privilege of domes and sometimes to a specific class of corporations, such as banks, insurance companies, railroads, power companies or business corporations. The base may be capital stock, the value of physical assets, gross receipts, net income or any other measure that the state can reach.

There is a tendency to replace earlier forms of corporation taxes with corporation net income taxes, but most of the states adopting corporation income taxes have continued to levy a variety of other corporation taxes. Local governments have had little opportunity to levy corporation taxes, but both counties and cittes have commonly imposed a variety of business incences. These are a more important source of revenue in the south than elsewhere, but they are to be found throughout the United States. They are rarely important sources of revenue. State pay roll taxes are important revenue produces, but they are earmarked for unemployment benefits and make no contribution to general state expenditures.

Other Sources of Revenue.—The only other important tax is the motor-webice become, employed by all states and some mumicipalities. This form of motor-vehicle taxation preceded the gasoline tax and has, for the most part, been retained at fairly high levels, although a few states have greatly reduced their licence taxes when they have introduced or increased gasoline tax.

There are many fees charged for special services, and other mome collected in the course of administering various state and local functions. Also, municipal public-service enterprises are for the most part self-supporting, although they incur deficits more frequently than do such enterprises in England. They rarely yield surpluses that can be contributed to the general revenue funds. Public-service enterprises are not responsible for either as large a share of municipal expenditures or revenues as in England They are even less important in state finance.

Grants-in-Aid.—Crants-in-aid from federal and state to state and local governments had become an important factor in state and local financing by the time of World War II. Federal grants were of little unportance until the federal government adopted the social security system and began to participate in relief financing in the 1930s These were, however, more than emergency assistance, and became a well-established method of financing state functions.

State aid to local governments has a much longer history; in fact it antestates the English grant system. Most of the earlier grants were for the development of the school systems. In 1902 nearly four-fifths of the total was for this purpose. Highway and welfare, however, received steadily growing assistance from state funds after the beginning of the 20th century, and many other local functions came to receive state assistance. Table VIII gives the distribution of federal and state grants-in-aid according

TABLE VII -US Federal and State Grants-in-And to State and Local Governments, 1951 (In millions of dollars)

Function	Tostates	To local subdivisions
Education Welfare Highways Other spacial functions General purposes Total aid	129 1,185 130 564 2,508	2,260 974 676 270 513 4,702
Total revenue for own functions Percentage from aids	15,574 10 I	15,/08 29 8

Source Bureau of the Census, State Government Finances in 1952

to functions The total of state aid grew from \$65,000,000 in 1902 to \$5,000,000,000 in 1952, and from less than one-tenth to about three-tenths of all local funds in the same period

The reasons for state aid are various Most of the earlier grants were to stimulate local activity and improve local standards of performance This was particularly true of the early school grants which were usually in the form of matching grants. Duiing the 20th century, however, school grants were made more and more to assist the poorer districts to achieve minimum standards The equalization grant grew at the expense of the matching grant. The same development became apparent in highway and welfare aid Highway aid more often took the form of sharing the motorfuel tax than grants from general revenues, but welfare grants were normally made from general revenue funds.

The effect of state aid was to improve local services greatly. Where equalization went so far, however, as to provide local districts with 80% or 90% of their revenues, difficult problems of control arose to prevent misuse of funds. For the most part, states did not extend controls over local governments to the extent that England did Even with generous grants local governments were

left comparatively free

Evaluation of the State and Local Tax System.—The outstanding developments in state and local tax systems after 1000 were the rapid development of new sources of state revenue, and the tendency for states to assist local governments by leaving the property tax for their exclusive use, by sharing state taxes or increasing grants from general revenues, and by taking over formerly local activities for state administration and support. This is the same centralizing process apparent in other countries. In spite of this, local governments continued to struggle with unbalanced budgets and excessive property tax levies, while state governments usually found revenue sources adequate for their needs.

Many authorities suggested that the remedy probably lay, in some measure, in speeding up the process of state assistance, but there was danger that local authorities would lean too heavily on the state The alternative was to improve administration of the tax on real estate, and reduce rather than continue to increase the properties exempted from this levy. Only thus could any substantial measure of local self-government be retained.

BIRLIOGRAPHY—The best general description of state and local taxes and tax systems in the United States as to be found in H M. Green, and tax systems in the United States as to be found in H M. Green, prehensive work on the general property tax as [1. P. Jensen, Property prehensive work on the general property tax as [1. P. Jensen, Property prehensive work on the general property is a property of the prehensive tax systems of specific states are wealingle for many states in various intories of state tax systems.

histories of state tax systems. Current developments and discussion of special problems will be found in the publications of the National Tax association, both the annual Proceedings and the National Tax Journal. The publications of the Tax institute, including Tax Policy and an annual Symposium on some specific current tax problem, are also invaluable for this

Statistics of state and local tax systems are to be found in a series Statistics of state and local tax systems are to be found in a series of publications of the ceasus bureau of the department of commerce. The series includes decembal reports on Wealth, Debt., and Tevation, Statistics of Clerks. Occasional studies have been published by the National Industrial Conference board on the Cost of Government is the Institute of Test Pidals, Individual to the Institute of Test Pidals, Individual States, and by the Tax Institute on Test Pidals, Individual States, and by the Tax Institute on Test Pidals, Individual States, and the Commerce of the Commerce of the Commerce Clearing House, Inc. The 13th edition of this was published the In 1932 and is entitled Test Systems are published decembally by the Davies of the Commerce Clearing House, Inc. The 13th edition of this was published in 1932 and is entitled Test Systems are 1932 and its entitled Test Systems are 1932 and its entitled Test Systems are 1932 and its entitled Test Systems are 1932 and 1932 an

# LOCAL TAXATION IN ENGLAND AND WALES

The sphere of local government in England and Wales, measured in terms of revenues and expenditures, is far more limited than is that of the national government. It is more limited, also, than the sphere of local government in federal states, and in many other unitary states In 1931-32 less than one-third of government expenditures in England and Wales was incurred by local authorities, and an even smaller proportion of revenues came from independent local sources

There are a variety of local authorities, and most areas are subject to overlapping local jurisdictions. The large cities are organized as county boroughs and, except for the parish, normally comprise a single local government. The area outside these county boroughs is divided into administrative counties, and these in turn are subdivided into municipal boroughs, urban districts or rural districts. The smallest unit of local government, the parish, is found throughout England and Wales, but by the 20th century it

no longer exercised important local powers.

There was constant pressure to transfer functions from the smaller to the larger jurisdiction. Until the middle of the 19th century the parish was the most important area of local govern-In the early years of the 20th century 1t had become purely nominal in urban areas, and even in rural areas its activities had become few and unimportant. Parish expenditures declined to a fraction of 1% of all local expenditures. The total number of local units, excluding the parishes, declined from about 1,900 in 1929 to approximately 1,600 in 1944

This centralizing tendency resulted in the transfer of functions from parish to district, from district to county and from county to central government Poor rehef, for example, was originally the responsibility of the smallest unit of government, the parish. In 1934 it became primarily a national function and in 1948 the entire responsibility for public assistance was transferred to the national government. In 1946 health, also, became the responsibility of the national government.

The county is principally responsible for education, police and highways. Housing, minor roads and trading services are largely the responsibility of the districts and boroughs

The local revenue system is very simple. All local units are supported largely from two sources-rates and grants The first is the only tax the local authorities are permitted to levy, except for a few small county licences that produce only a fraction of 1% of local revenues Grants come from the general revenues of the national government.

The development of local rates and grants, and their relation to national tax revenue, is shown in Table VIII It is apparent that in the century preceding World War II, there was a clear trend toward sharing an increasing proportion of national tax revenues with local governments through the system of grants. This trend was reversed with World War II.

World War II increased national obligations, rather than local. The increased tax revenues were necessitated by war expenditures; but greater central government participation was required also for civilian functions such as housing. In 1950-51 local rates were less than 10% of national and local tax revenue, and grants had risen to more than half of all local revenues.

Rates .- History and Development .- Local governments derived their authority to levy rates; the one important local tax,

Table VIII -British National and Local Revenues, 1842-43 to 1951-52

	Unite	d Kingd	om	England and Wales								
	Million Pour	ns of ids	Per cent	М	fillions o pounds	d		ei cent from				
Year	National tax revenue	Grants	revenue	Local rates and grants	Rates	Grants	Rates	Grants				
1842-43 1872-73 1913-14 1928-29 1939-40 1951-52	50 2 65 9 163 0 685.3 1,017 0 3,738.1	0.6 2 4 27,1 108.3 217.2 413.8	1 3 3 7 10 6 15.8 21 4 11 1	0.1 19 7 94.4 259 8 383.2 059.0	8.0 18.6 71.3 166 0 201 3 201 0	0 2 1 1 23 1 03.8 181 0 368.0	97 3 94 4 75.5 64 I 52 I 44.2	2 7 5.6 24.5 35 9 47 9 55 8				

Source. Statistical Abstract of the United Kunsdom

from the Act for the Relief of the Poor of 1601. It had been common practice, however, long before the law of 1601, to levy comparable rates. The act of 1601 provided that every inhabitant of the parish should be taxed for the support of the poor "according to the ability of the same parish." No measure of ability was specified, and the tax developed into a personal tax levied in proportion to the iental value of the property occupied Personal property was sometimes included in the assessment in the early history of the rates but had been definitely exempted by the middle of the 19th century. Thus rates became levies on those persons occupying land or buildings, designated as "rateable hereditaments," within the jurisdiction of the local rating authority

Vacant property is exempt from the rates in England and Wales. In Scotland, half of the tax is levied on the owner and half on the occupier. The owner's share is levied on his property whether it is occupied or not

The occupier is assessed on rental value, which is usually determined by the actual rent paid for the specific property or similar

According to the Rating and Valuation act of 1925, sec 58, "gross value means the rent at which a heretatment might reasonably be expected to let from year to year if the tenant undertook to pay all usual tenant's rates and taxes, and if the landloid undertook to bear the cost of the repairs and murance, and other expenses, if any, necessary to maintain the hereditament in a state to command that rent."

Specialized ownen-occupied properties must receive special treatment. These are mostly business properties and the valuation is related to profits Machinery is exempted. Provision was made for quinquenail valuations under the Rating and Valuation and of 1925, but actual changes in value became comparatively infrequent. This act did not change methods of valuation materially, but attempted to secure uniform valuations throughout

The base of the local rates was reduced from time to time by successive "directings". The Agricultural Rates act of 1896 exempted one-half of the rental value of agricultural land from local rates. In 1923 this exemption was increased to three-fourths and in 1920 the total rental value of agricultural land was exempted. Agricultural buildines were exempted in 1023.

The Local Government act of 1929, which derated all agricultural land, also derated industrial properties and railroads, reducing the "net annul value" to which the rates apply to 25% of full value. As early as 1848, the land used for the actual railroad line, but not including the property used for stations, had been derated by this same percentage. Complete exemption was provided for the property of educational, religious and other nonprofit orgamzations. This left as the most important ratepayers the occupiers of houses and commercial buildings. The proportion of the total valuation attributable to these by mid-zoth century was approximately oxy5%.

Administration of Rates and Distribution of the Burden.—The valuation areas after 2032 were the boroughs and districts. The elected councils of the horoughs and districts were made responsible for the valuation. To ensure some degree of uniformity among valuation districts these were grouped into larger assessment areas, each with an assessment committee appointed by the rating authorities and the county council. The function of these committees its to supervise valuations, hear complaints and equalize.

Most counties also have full-time country valuation officials, to ensure uniformity withm the country. A Central Valuation committee for all of England and Wales serves in an advisory capacity, Railroad property, formerly valued piecemeal by local officials, was valued as a unit after 1930 by a national Railway Assessment authority. The valuation is based on revenues.

Each local tax authority fixes its own rates, but all the rates leved in a given area are levied as a consolidated rate. Collections are also combined. In case of delinquency, the local authorities have recourse only to the occupier's estate, which may be only personal property. If the delinquency is dehiberate the taxpayer may be impressed. The administration is largely the responsibility of boroughs and districts,

According to the early legislation authorizing rates, they were to be apportioned according to taxpaying ability. Later, however, this conception of taxpaying ability was modified in recognition of the fact that rentals are not closely related to incomes and tend to take a laiger proportion of small rather than large incomes. This makes the levy regressive. Moreover, rates vary considerably from one district to another, whether such variations are measured in terms of the taxable valuations or per capita. This is the tresult of wide differences in per capita wealth in different areas and the tendency for local needs to be in inverse proportion to wealth.

In so far as the rates are used for services, bringing direct benefits to the ratepayers, a case can be made for regarding rates as benefit taxes. If the occupiers receive benefits from local government roughly in pioportion to rates paid, the test of ability is inclevant. The original poor rates obvoosyly do not bring any such direct benefits to ratepayers. But many of the costs of local government met from the rates, are of direct henefit to the ratespayers.

Consequently there was a tendency to classify the rates as benefit taxes. Some authorities even took the position that rates are not strictly taxes at all, but charges for special services. However, the national government did not subscribe to this theory. Since the first half of the 19th century it had been assisting local authorities through an expanding system of grants, which was directed increasingly to the rehef of ratepayers, and especially to the equilabation of rates in different areas.

Grants-in-Aid.—The national government introduced grantsmead to local authorities early in the tyth century. The eathest of these went to individual local governments for specific and unusual expenditures. The first grant for an entire class of local authorities was introduced in 1835, with the reimbursement of counties by the central government for half the costs of criminal prosecutions and transportation of prisoners. This and many of the succeeding grants were made specifically for the relief of local ratepayers. The functions aided were those regarded as of national importance. Another important reason for the growth of grants was the desire of the central government to improve the standards of local services.

By the end of the 19th century the national government was assisting local governments by grants for police, education and various welfare and health activities Highways, for which grants had been provided intermittently during the 19th century, were given regular and beginning in 1908. Housing grants began in 1919.

Practically all the earlier grants were for specific functions and were usually fixed at a given percentage of approved local expenditures. The percentage met from national funds was substantial, usually amounting to from 25% to 75% of costs. Thus they tended to stimulate expenditure for the activities added, and to raise the level of local administration through the setting of national standards for these services.

The guiding motive in the development of the grant system prior to 1939 was the desire to stranulate local authorities to expand services for certain functions and to improve standards of local administration. In some instances relief to local ratepayers, as a consideration, but only for school grants was any effort made to equalize resources

Some indirect equalization was achieved through the enlargement of local districts and through national assistance with the workers burden. Unemployment insurance and old-age benefits, particularly, gave local ratepuyser relief. The total rate burden was probably not excessive in 1926, but inequalities in rates were very great. Moreover, the heaviest rates tended to fall on depressed areas. Rates for poor relief tripled between 1916 and 1927, and the increases were greatest in the areas with the greatest unemployment. This was the principal reason for the 1920 changes.

The Local Government act of 1929 was part of the government's recovery program The aim was to reduce local rates, particularly for agriculture and industry. There was no thought of simulating new and improved local government services. The block gram provided by this act was partly compensation for derating, partly a substitute for specific grants abolished by the act and partly additional funds for general rate reduction

Greater equalization was attained under this act, partly through the transfer of certain local functions to large local districts, and partly through the block grant. This giant was distributed according to an elaborate formula which weighted population is accordance with the proportion of children under five years of age in the population and with the proportion of the unemployed. It was also weighted to favour those districts with a low per capita rite base and relatively few inhabitants per mile of hierbows.

The formula was never completely satisfactory At first, however, the large sums available afforded real relact. The total of rates declined from £166,000,000 in 1928 to £146,000,000 in 1938. Rates increased after that, however, and exceeded the 1938 level in 1936. In 1948 the block grant was replaced by "exchequer equalization grants" which increased the total distributed and were designed to achieve greater equalization. Changes in the amount of grant revenue as a result of these acts are given in Table IX

The tendency for the national government to increase its assistance to local governments continued after the Local Govern-

TABLE IX -Local Government Grants, England and Wales, for Sciented

Periods

(In multi-second content of the co

(In	millions of	pounds)		
Purpose	1928-29	1930-31	1936-37	1950-51
Education Highway Housing Police Other specific Equalization Total	41 7 14 3 10 7 10 3 16 8	43 9 19 2 11 9 10 4 8 3 45 0*	44 8 9 7 14 0 11 8 14 1 45 3	243 0 27 1 60 8 28 4 

\*For derating losses 22 3, for loss from discontinued grants 16 3, additional revenue 3 o, supplementary grants for special hardship 14 Source Ministry of Health, Answal Report

ment act of 1929 New housing subsidies were introduced in 1920 and 1931 In 1935 the national government took over the entire administration of able-bodied poor relief, instead of increasing grants for this purpose. It did not, however, assume the whole cost, requiring local authorities to contribute 60% of their 1932—33 expenditures for this purpose. This ensured local government authorities of no increase in these costs but also prevented decreases

In 1938-39, £3,300,000 out of £44,000,000 spent for relief was contributed by local authorities. The 1940 Olid Age and Widows Pensions act transferred a large number of people from local public assistance to unemployment aid, and an act of 1948 transferred all important public assistance costs to the national government. During World War II the national government financed a variety of emegancy costs through grants or direct expenditure; and in 1946 it assumed full responsibility for the health function.

Trading Services and Miscellaneous Sources of Taxation.
—The third important source of British local revenue, fart sonal and grants-in-aid, is the earnings of trading services. These municipal industries comprise water supply, gas and electricity, tramways, buses, docks, harbours, canals and private street improvements

There is no tendency to use the trading services as a source of net income or to subsidize them from rates. For the most part charges cover the costs of the services in question. Sometimes, however, there are deficits to be met from rate funds, or surpluses that may be apouhed to rate reduction.

Other sources of net income are of very minor importance. There are a few county licence taxes, including dog licences, that bring in small revenues. Minor revenues are derived from various administrative fees. Special assessments are rare.

Local authorities can obtain money for capital improvements through loans. Local debts more than doubled in the decade from 1900 to 1930, largely because of the rapid development of municipal housing projects. They increased relatively little in the decade from 1930 to 1940. In 1940, however, the net debt of local authorities exceeded ±1,500,000,000. About one-third of this

sum was for trading services, an even larger share for housing and the remainder for miscellaneous local activities

Evaluation of the Local Revenue System.—The local revenues as the system of England and Wales is like that of most countries in the system of England and Wales is like that of most countries in the system of the

The need for extensive equalization seems not to have been apparent before World War I, although some effort was made from time to time to use grants at least partly for this purpose. In the years following that war, the decine of some of England's basic industries led to acute need in certain areas, together with commarkive affluence in other areas where industry was examidus.

The national government attempted to meet this situation by assuming a larger share of the cost of support for the unemployed, by widening the area of charge and by providing larger grants distributed on equalization bases

These measures proved of genuine assistance, but senous ficqualatuse contuned Complete equalization would result in the national government's contributing three-fourths, and in some areas even nun-tenths, of the revenues for a large number of local authorities. This increased the danges—always present when the spending authorities are not directly responsible to the tarpayers—of wasteful use of funds. One of the ments claimed for the block grant was the removal of central government controls. But, while many minor restrictions were withdrawn, important controls remained.

For the most part, the national government extended central supervision and control along with the grants-in-and, but if the controls were adequate for a system in which the larger share of the income took the form of grants, the freedom of local self-government, which is the principal virtue of independent local authorities, would be greatly curtailed. Moreover, there was some danger of maintaining the status quo in depressed areas, where emigration of workers might better be encouraged.

The gams of derating were also questioned In so far as local rates were benefit taxes it was difficult to justify the withdrawal of industrial and agnoultural values from the tax base. And the decrease in the local tax base decreased local independence somewhat in proportion. These, however, were tendencies to be found in local revenue systems in all industrialized countiles. The centralising trend is apparently irresistible

tralizing trend is apparently irresisting. Binizonasari.—An excellent account of the local revenue system is to be found in Herman Finer, English Local Government, part v (London, 1933, New York, 1934). Edwin Cannan, History of Local (London, 1933, New York, 1934). Edwin Cannan, History of Local case of the latest the local case of the latest the local case of the latest the local case of the latest the latest account of the history of grants—and is only formats in High, two ed (Boston, 1930). A later, comprehensive study of the grant system is Mabel Newcomer, Central and Local Finance and Granasy and England (New York, 1937). If and U. K. W. Hicks, or Granasy and England Chew York, 1937) is and London, 1935) is an excellent analysis of the distribution of the burder of local expenditures among ratepayers and others

excellent analyses of the distribution of the burden of local expenditures among ratepayers and others

Official statistics of local revenues appear in vanious government. On the statistical distribution of the statistical

neuth, Annual Local Taxaton Returns: England and Walts.

There are many speals reports of government committees and royal

There are many speals reports of government committees and royal

these are the Royal Committee on Local Taxaton, Find Riv.

port, Cd 538 (1901), Department Committee on Local Taxaton, Find Riv.

port, Cd 7315 (1914) (Committee on Local Expenditure for England
and Walts, Report, Cd, 4200 (1931).

#### LOCAL TAXATION IN OTHER COUNTRIES

The characteristics of the diverse local tax systems found throughout the world cannot be summarized briefly Instead, some of the more important deviations from the English and U S patterns have been described below

France.-The French system has many characteristics that are typical of European countries It differs from that of England or the United States in its high degree of centralization. France, before World War II, was a unitary state that did not delegate to local governments the degree of independence that English local authorities acquired It is divided into departments, which are in turn subdivided into communes Administration is highly centralized, with commune authorities, for the most part, responsible to department authorities, and these responsible to the national authorities. In consequence, local revenues and expenditures are a comparatively small part of the total

The second important difference between the French system on the one hand and the English and American on the other is that a large proportion of local revenues come from centimes additionnels. These are local levies on national tax bases, a form of taxation unknown in England and the United States Before the introduction of the income tax in France, in 1917, the national government had four direct taxes to which departments and communes could add centimes The taxes in question were on rental value of real estate, doors and windows, presumptive income (determined mostly by rentals) and business. After the income tax was introduced the national government gave up all these except for a modified real estate tax The old bases were retained, however, for local use, except for the door and window tax, and the commune taxes were continued as additional levies on department tax bases.

Local governments did not share in the national income tax, but the national government made substantial grants to communes for various purposes. These became an increasing proportion of

TABLE X .- Local Revenues in France, 1934 and 1950

				In 000,000	,000 francs	ooo francs Per	
Source				1934	1950	1934	1950
Contributions Director . National grants . All other revenue		:	•	59	104 3 125 7 224 6	39 3 13 3	22 Q 27 6 49 5
Total revenue	:	:	:	150	454 6	200 0	190 0

Source Annuaire Statistique (1938 and 1951).

local revenues, exceeding one-fourth of the total in 1950 In addition, communes and departments have substantial independent tax sources. These include a variety of consumption taxes, amusement taxes and direct taxes for roads and other purposes. The amount of revenue from grants and local sources is given in Table X.

Germany .-- Before Hitler, Germany was a federal state and as such developed independent federal and state tax systems; or rather, the federal system was superimposed on existing state systems with relatively few changes in the latter. The state systems presented much the same diversity as did those of the United States.

Prior to World War I, the personal income tax was the central tax of most state and local systems. This tax was commonly supplemented by a true of taxes on land, buildings and trade. The land and building taxes were usually levied on owners, and the trade tax on occupiers. The base of these taxes was determined by the state; and local taxes took the form of additions to state taxes.

Local authorities were permitted to determine, within limits, the rates they wished to levy on the state tax base for income, land, building and trade taxes. These rates were added to state levies. In this respect the German system resembled the French system closely. It differed in the variety of taxes from one state to another and in the greater independence of Kreis and commune authorities. In some states the local authorities were permitted to levy independent taxes on income or property, and commonly did so in preference to using the state tax base. In others the local governments depended almost entirely on additions to state taxes, having few independent tax sources at their disposal. These direct

taxes produced more than three-fourths of all state and rocal revenues, the income tax alone producing more than half of all state and local revenues in 1913-14. There were, however, a variety of stamp, beverage and entertainment taxes that produced substantial income

Under the Weimar constitution, after World Wai I, the national government took over personal and corporation income taxes and shared these and other central government taxes with the states The states in turn redistributed part of the proceeds to local goveinments The result was to circumscribe state and local tax powers materially and to unify tax systems for the entire Reich By 1934, more than half of state tax revenues and more than onefourth of local tax revenues came from Reich taxes This use of shared taxes was found in other countries, but Germany developed it much further than any other important nation. Nevertheless, direct taxes on land and buildings and trade and a variety of consumption taxes remained at the disposal of state and local governments The larger share of state and local costs fell on local governments in 1932-33. Their expenditures were almost double those of the states State expenditures exceeded local for police and education, but other important functions were primarily the obligation of local authorities

configuration or local authornies

Centralization increased with the Nazi government. The federal

Centralization increased with the Nazi government. The federal

discovernment of the state became mere subdrustons of the central authority of the state and contained the

treatment of the yattleance. Thus the German yorkem became more

highly centralized than the French. Following World War II, state

taxes were restored, and in western Germany the state and local shane

of the total was 39% in 1951-52

Other European Countries.—Other European countries offer many deviations from the French and German patterns The limited local additions to central taxes are however, a very common form of local taxation Shared taxes are much less common They usually appear when the central government takes over a formerly local tax

source. Local consumption taxes and other indirect levies are found in varying degrees. In some countries they play a more and common waying degrees. In some countries they play a more mortant part than in dither France or Germany. There is a tendency, however, for national governments to obtain a larger share of their laxes from indirect levies than for local governments. In come taxes tend to be primarily national levies, but real estate taxes are almost universally primarily national levies, but real estate taxes are almost universally a local source of revenue

The local authorities of continental Europe have a much greater variety of taxes at their disposal than either the English or US local governments, but they have less freedom in determining the amount of the level.

## BRITISH COMMONWEALTH

Canada.-The Canadian tax system resembles that of the United States in many ways Both are adapted to the federal form of government, and in both the different levels of government have wide

ermment, and in both the different levels of government have wide powers of transition with substantial overlapping in the taxes of dif-rent estate taxes and state or provincial governments get large revenues from liquor, gasoline and motor vehicle hence taxes. Also, there is wide variation in the tax systems of the different provinces wide variation in the tax systems of the different provinces property tax differs both from the general property tax of the United States and from the English rates. The tax is levied on capital value as in the United States, but it is usually hunted to real estate and often has exempted improvements entirely or has assessed them at a lower value than land. The rapid rise in land values, especially during the opening years of the 20th century and the desire to encourage settle led to the attempt, in the western provinces especially, to place the en-tire burden of local taxation on land alone

the burden of local taxation on land alone. This proved to be a very unstable tax base. Land booms were followed by collapse. In some cities the tax base was cut in half in a short space of time. The result was frequent crises in municipal financing, and after World War I there was an effort to broaden the tax base. Improvements were generally included in assessments for

Table XI.—Canadian Provincial and Municipal Revenues, 1947

		. (4	n:	ши	OHS	01	donars)		
Reven	Revenue source							Municipalities	Total
Real and personal pro Liquor taxes and prof Gasoline tax		y ta	x	:	:		125 111	104	308 125 111
Corporation taxes Other taxes and fees		:	:	:	:	:	76 145	57	76 902
Total taxes, profits Dominion grants Other revenue	and	fees	:	÷	:	:	461 146 73	361 2 52	822 148 125
Total revenue			÷				680	ATS	7,005

Source. Canada Year Book, 1051.

local taxes, although often at a fraction of full value Personal propeity was exempted but the real estate tax was often supplemented by a tax on business rentals

The provinces enjoyed a much wider variety of tax sources, but beginning with World War I, the Canadian government tended to encloach on provincial sources, even going so far as to conscript the personal income tax at the time of World War II The federal govpersonal monne tax at the functor world war it. The federal gov-ernment, however, follered the provinces generous compensation in the form of substantial grants for specific functions and general purposes in 1940 these amounted to mote than one-fourth of provincular eventues from taxes and grants. The largest were for old-age pensions and un-employment benefits, but there were also substantial sums that the provinces were free to spend as they chose

provinces were tree to spend as they chose my agreement with all the provinces excepting Quidec, these are ply agreement with all the provinces excepting the war. The more important local tax revenues are given in Table XI. Australia.—Australa, lake Canada, has a feederal government. The states have independent and widely yarying tax systems, and munica-phities here, as elsewhere, obtain their principal revenues from real

estate taxes
The local rates, as they are called, differ from the English rates and vary somewhat in the different states. In most states there are two separate levies—one on the unimproved capital value of land and one on the improved value

In some states the latter is on rental value and thus resembles the English rates In other states this, also, is on capital value Real estate is assessed for these levies by a state official The amount of the levy is, however, determined by local officials and varies with needs from one municipality to another and from one year to the next. Personal property is not subject to these taxes.

Municipalities have no other important independent some in-obtain substantial grants from state governments and obtain some in-obtain substantial grants from state governments and obtain some inrevenues from all sources for 1946-47 are shown in Table XII

Because of the sparse population in much of Australia the states
undertook many functions ordinarily left to local governments, in-

Table XII —Australian State and Municipal Revenues, 1946-47 (In millions of pounds)

Source				State	Municipal	Total
Rates Inheritance tax Motor vehicle taxes Land tax All other taxes Total taxes Grants Business undertakings Other revenue Total revenue	:	:	:	8 I 7 5 1 3 11 5 28 4 58 7 78 4 7 I	15.6   15.6   15.0	15 6 8 1 7 5 1 3 11 5 44 0 58 7 78 4 22 1

\*State grants to municipalities have been omitted to avoid double counting Municipal revenues parily estimated Source Official Year Book of the Commonwealth of Australia

cluding education, health, welfare and much of the cost of highways.

Municipal expenditures are largely for public-service enterprises and public improvements

States obtain revenues from a large variety of taxes, as shown in Table XII. They no longer have at their disposal, however, the income taxes that provided them with more than half of their revenues in the period prior to World War II. Their largest single source is the inherit-The states also obtain exceptionally large revenues from land sales

and from public-service enterprises.

The Australian commonwealth, like the Canadian government, assisted the underlying governments with an extensive senes of grants, Some of these were in compensation for tax sources transferred to the federal government, and some were for aid to specific functions. Also some were special grants to particularly needy states. Beginning with World War I, the commonwealth began to encroach seriously on state sources of revenue. With the outbreak of World War II, the commonwealth appropriated the income tax in spite of vigorous protests from the states. State revenues from this source were replaced by a common-wealth grant of the same amount. This arrangement was continued after the war. Thus the centralizing tendencies apparent in other countries appeared in Australia, also.

BIBLIOGRAPHY.-The best summaries of the tax systems of the different countries of the world are to be found in Tax Systems of the deferent countries of the world are to be found in Tax Systems. Thirteen editions of this have been published up to and including the 1952 edition. An excellent account of the Canadian system is to be found in tion An excellent account of the Canadan system is to be found in the series of reports of the Royal Commission on Dominion-Provincial Relations, published in 1930 and 1930; J. Harvey Perry, Teastions is the Second Report of the Royal Commission on Taxation, 1938 (1934), A good account in English of the French system is to be found in R. Millag. The Public Framesco 1918-War France (New York, 1939), An account of the German system is to be found in M. Newcomer, Configuration of the Commission of Teach of the Second Public London, 1937).

Detailed statistics for all countries are to be found in their official government reports

TAXICAB: see TAXIMETER

TAXIDERMY, the art of lifelike representation of animals (and especially mammals and birds) by means of their prepared skins, has, by a natural association of ideas in museum practice come to include the making of habitat groups, in which animals are exhibited with their naturally associated plants, with or without a painted landscape background. Zoological collecting is related to taxidermy in origin and in the techniques of preparation of bird and mammal specimens (see ZOOLOGICAL COLLECTING)

History.-Taxidermy, like museum collecting of animals in general, evidently has its origins in the preservation of skins, horns and skulls as hunting trophies or as travel souvenis. The early perfection of tanning methods made possible the use of skins as clothing, rugs and bed coverings. The introduction, in the 18th century, of chemical poisons for protection of skins, hair and feathers from destructive insects, made possible the accumulation of great private and royal collections of mounted birds and mammals that preceded the development of modern museums. Taxidermy as an art is now carried on almost entirely under the auspices of larger museums. As a more or less skilled trade, the mounting of game buds, fishes and especially the heads of horned mammals continues in the hands of commercial establishments Great numbers of privately owned specimens of this sort gravitate to taverns in the United States; but the continued popularity of mounted heads of record deer or other native and even exotic animals as home decorations is by no means confined to the "trophy room" of the wealthy sportsman The skins of the West African gorilla brought by Hanno to Carthage in the 5th century B.C represent trophies of an early voyage of exploration.

The origins of a more ambitious taxidermy may be seen in the report of skins of the European bison and aurochs having been set up by the Austrian Baron Siegmund Herberstein, in the great hall of his residence, over a framework of boards, some time before the year 1550. Perhaps the oldest existing mounted skin of any animal is that of an Indian rhinoceros preserved in the Royal Museum of Florence, dating apparently from some time in the 16th century. The stuffed skin of a Nilotic crocodile in the Museum of St. Gall in Switzerland dates from the year 1627, and has thus survived for more than three centuries Such exotic or rare creatures, preserved with an educational purpose rather than pumarily as trophies, exhibit the beginnings of museum preparations of exhibits; and indeed, their collection and preservation represent the beginnings of museums of natural history

Early crude attempts to fill out skins of animals to lifelike size consisted in merely stuffing the sewed-up skin with hay or straw, or, at a later date, with excelsior Such specimens might have shown the hair or plumage well, but could only crudely represent lifelike form. There seem to have been critical attempts to improve methods of taxidermy, and even to supply vegetation and painted backgrounds early in the 19th century. Thus an account of the larger African mammals in Bullock's Museum, published in 1815, states that:

Various animals, as the lefty Giraffe, the Lian, the Elephant, the Rhinocrous, set, are exhibited as ranging in their native wilds and forests; whist exact Models, both in figure and colour, of the races and most invarint plants from every clims, give all the appearance of the control of th

The effort to mount large mammals in natural positions and even in positions representing great activity appears in the work of the Maison Verreaux, a commercial establishment in Paris under the direction of Jules Verreaux. Verreaux combined the roles of naturalist, explorer, taxidermist and business man, and the Maison Verreaux formed the prototype of Ward's Natural Science Establishment in the U S. For the International Exposition in Paris in 1867, the Maison Verreaux created the group showing an Arab courier on a camel attacked by two lions, and this group was purchased for the American museum in New York city in 1869.

The subsequent history of taxidermy is mainly American, and

centres to an extraordinary degree in the group of active young men who gravitated to Ward's Natural Science Establishment at Rochester, New York This unique business, evidently modelled on the example of the Maison Verreaux, was founded by Professor Henry A Ward of Rochester It engaged in the supply of museum materials, from minerals to mastodons and from birds of paradise to orangutans, to the schools, colleges and universities

The cartoons below, which date from 1883, illustrate the turning point in the history of taxidermy from "stuffing" to "modelling," and emphasize also the influence of the Ward group in the development of modern methods.

#### THE PRINCIPLES LAID DOWN

The triumphs of the art of Taxtdermy, displayed in Bird-stuffers' windows and in the museums of many of our institutions of learning,

windows she in the museums of many of our institutions of nearming, have ever had a facunation for our joint part of the fact of the state of the fact and his lotty praise or his own genuis, quite convinced him that this Professional who had, for fifty years past, blessed New York with his interesting productions, might give him some clue to the above mentioned mystery, S. therefore followed him down to Broadway to his sanctuary, saw his work and heard his discourse.



Fig. 1,—"All animal forms," said the Professional, "were intended by Nature to be allike, though a series of blunders and accidents have irreparably merred the design, it therefore rests with the Taxidernist to restore the universel similarity. All animals are composed of a head (A), a body (B), legg (C), and a cast (O) is a fost incontrovertibly proving our theory. Bone



"Touching the similarity theory, take the dog: add antiers



me, is always engaged in or

of the U.S., whose origin or development fell in the era from 1860 to about 1890 These decades were likewise the period of active growth of museums in the U.S., which supplied an additional market to Professor Ward

William T. Hornaday and his fellow taxidermists at the Rochester establishment, William Critchley, Frederick S Webster, George B Turner, Henry E Denslow and later Carl E. Akeley. seem to have been in extraordinary agreement in the hope of raising taxidermy to the status of an art. The accompanying cartoons from a set in the Ward's Natural Science Bulletin (1883) illustrate the feeling of the Ward group against the crude effects obtained by their colleagues who "stuffed" animals. The realization that natural positioning of animals depends on knowledge of their habits in life and on their anatomy, and in turn on a sculptural process to produce the manikin on which the skin was to be applied, was by no means new, but the Ward taxidermists experimented more actively with clay and plaster of Paris and with various techniques for making manikins than had any other group Their interest in themselves as a group with professional ambitions is illustrated by their leadership in a short-lived "American Society of Taxidermists," whose exhibitions were held in 1880, 1881 and 1883 The failure of the society to continue seems traceable to a peculiar secretiveness of commercial taxidermists. which still persists It may be well to point out that the struggle between the commercial point of view at Ward's and the ideals of the younger and more idealistic members of the staff could only he resolved by the development of preparation staffs under the auspices of great museums in the United States

Among the young men who came to Rochester to practise taxidermy by working at the Ward institution was Carl E. Akeley Akeley, benefiting especially by the advice of Critchley, the bird taxidermist, and with great native mechanical and artistic ability hit upon the process that represents the greatest single advance in the taxidermy of large mammals. This, briefly, consists in a method of transfer of the form of a model in clay to a light. strong and permanent manikin on which to mount the skin. The animal is modelled in the attitude desired for exhibition, in clay The armature over which the clay is placed may to advantage include the skeleton of the animal and should at least have the limb-bones to ensure basic correctness of the length of the limbs The clay model is sculptured to represent the muscular surface of the animal, with attention to the forms of the muscles involved in the particular posture chosen. The clay form is then converted into a plaster of Paris mould in such a way as to form a waste mould in three pieces By the application of burlan. composition (originally papier-mâché) and, in large animals, a layer of wire cloth, to the inside of the mould, there results (after removal of the mould) a light, strong, durable form, the manikin, with a surface well adapted to hold the skin of the animal it is to represent, while it is at the same time a satisfactory copy of the clay model So successfully does this process meet the requirements of scientific and artistic taxidermy, that with only minor changes it remains in use at all larger museums

Pupils, associates and colleagues using Akeley's methods, with occasional improvements, filled the large museums of the US with fine representations of the mammalian and bird life of the world. The Akeley tradition was capably carried on by his associate at the Chicago museum, Julius Friesser. Among Akeley's pupils in Chicago, Leon L. Pray may be mentioned for his experimentation with the technique of carved manikins, and, indeed, with the techniques of taxidermy in general. Carving of wooden limbs to represent correct muscular anatomy was suggested by the American artist, Charles Willson Peale for the "Peale Museum" of 1802. The use of balsa wood for this purpose retains the desirable quality of lightness in such manikms, which are almost always used for small mammals and birds, displacing the tow or excelsior manikins widely used for mounting such small creatures in the past. After working with Akeley in Chicago, James L. Clark continued as an associate of Akeley in New York and became one of the leaders in the field of artistic taxidermy

General Taxidermy Methods .- The emphasis on techniques in the above account may somewhat obscure the factors most es-



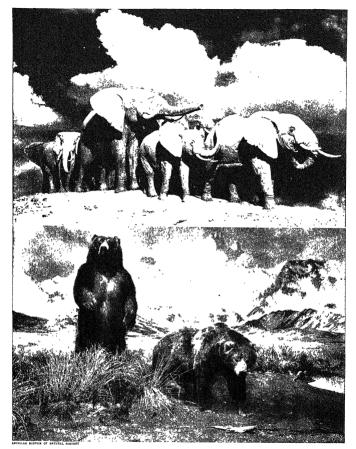
# VARIOUS TAXIDERMY TECHNIQUES USED IN A MODERN NATURAL HISTORY MUSEUM

- 2. Tanned skin of a large bird being fitted into place over the manikin.

  Legs, bill and the glass eyes have been set in place

  3. Plaster of-Paris place mould being removed from hollow burlap manlkin The animat's tanned skin will be fitted over this form
- Restile posed in position before being moulded A plaster-of-Paris
  and is then made over the body
  Tanned kin of a large birt beang stid nits place over the manikin.

  Tanned kin of a large birt beang stid nits place over the manikin.
  - Celluloid reproduction being removed from the plaster-of-Paris mould, it is then cleaned of all plaster still adhering to the zurface and completed for exhibition



MAMMAL HABITAT GROUPS IN THE AMERICAN MUSEUM OF NATURAL HISTORY

1. Africain elephants, taxifermy by Carl E Akeley and Robert H. Rockwell, foreground and beckground blown in

2. Alaskan brown bear, Aghlleen Pinnacles, Alaskan Peninsule; taxifermy by Robert H. Rockwell, background by Balmore Brown, foreground by G. Frederick Mason

sential to the new taxidemy, namely that its practitoner must combine the naturalist and the artist, with the naturalist's knowledge of the naimal in life, the scientist's critical attitude toward the shortcomings of his work and the artist's eye for form and composition If the taxidemist then be also a skilled carpenter, mechanic and inventor, he may hope to find employment in a museum or to succeed with an establishment of his own

The importance of bird taxidermy in museums and in commercial shops is next only to that of large mammals. The study of birds began with the collecting of specimens for their accunate description, and the specimens mounted in museum galleries are still essential for the development of an adequate acquaintance with the birds of a local region as well as for knowledge of birds of the world

# WARD 'ANTI STUFFING" CARTOONS, CONTINUED

## AN UNAPPRECIATED TRIUMPH

"The skins of animals," continued S—'s instructor, "were originally intended by Nature to be filled out to their fullest extent, though the failures in carrying out this principle are many and glaring Among such the greyhound is a painful example"



Fig. 4—"A gentleman possessed one of these animals, which died, and its



Fig. 5 —"The result was a great success; yet the owner was dissatisfied 'My deer, sir,' said i, 'we can't stuff it any tighter—human strength cannot do it' However, to please the genitleman, we promised to try"



Fig. 6.—"Well, sir, I invented a powerful air-pump, and blow that skin out until the result was a married of perfection in canine form. Would you believe it, sir? the owner granuloid more than before! Well, sir, we byfully took the specimen off his hands, are which tied it is an example of what of the form the National Museum!"

The critical examination of mounted skins of snakes, hazards and other reptise led Leon L. Walters, at the Chicago Natural History museum, to the conclusion that the tirdike representation of these creatures, as of amphibians and of many fishes, was impossible by the ordinary methods of taxidermy. The fundamentally important qualities of colour and translucence were lost in tanning reptile skins; and if the mounted skin, or indeed a model, was pannted to restore the colours, the resulting appearance was highly artificial. These difficulties led to the preparation of cold-blooded animals for museum exhibition as plaster or wax casts. By the Walters process, celluloidlike meterial is subskituted as the ma-

ternal of the cast, cellulose nutrate or cellulose acetate dissolved in a suitable solvent to form a thick liquid has the correct of pigments added to it for each element of the pattern in the animal to be reproduced, and these patts of the pattern may then be painted on the inner surfaces of a plaster mould made from the freshly-killed animal. Artistic ability to make a lifelike pose with the dead animal, and no hitle ingenuity in plaster moulding are requisate. The celluloid material dries as a thin layer, which may be reinforced by any suitable composition. When the plaster is removed, the resulting "celluloid" model combines the correct colours with the natural appearance of translucence, and the preservation of the scale detail of the mould avoids any appearance of being painted

Walters' critique of museum techniques applies also to many of the haules or thinly-harred mammals, to the coloured bills and feet of birds and especially to the fleshy base skin of birds (like a turkey gobble head), which can also be made lifeliek by reproduction in cellulord. The Walters hippopotamus, made as a cellulose acetate model, is thus the only existing lifelike representation of a hippopotamus whose inch-thick skin has a deep fleshy translucence A group of narwhals prepared by this technique 18

equally noteworthy

It is possible to combine models of soft pasts or of scaly pasts with the skin, as was done most notably in a cassowary and in a group of emperor pengiums. Most novel of all is the possibility of transfer of hair or feathers to the celluloid "skin". In a mould made from a fresh skin, after a few days of maceration, the hair "slips," ie, pulls out of the skin by the roots! Thus the plaster of the mould will include the hairs (or feathers) down to the skin suiface, and painting the liquid celluloid into the mould to form the new skin will hold the root of every hair in exactly its original place. The removal of plaste is accomplished by extended soaking in water and combing remaining particles out of the hair Such processes obviously form an important supplement to the ordinary techniques of museum taxedemy.

The extension of the term taxidermy to include life-size models in general is especially desarable in the case of the pieparation of museum exhibits of fishes. Fishes were at first quite simply skinned out and "stiffed". Such speciments newtably tended to be ill-shaped, and a great improvement was made by naking a plaster mould of one side of the fish (the side to be exhibited) before skinning out the specimen, and then fitting the skin into the mould and drying it before removing the plaster. When it was discovered that such skins crack in the course of 20 o1 gyers, the logical step was to make plaster casts in moulds of the original fish, and to paint them to represent the colours of the hiving fish, as, of course, was necessary for the skin itself, the natural fins of the fish, spread and prepared, were set into the plaster model. Further experimentation with fins carved from

sheet celluloid indicate that such fins are preferable to the natural fins and they are certainly more permanent; thus by degrees, the mounting of fish skins was entirely displaced by a process of modelmaking.

It comes as a considerable shock to many museum vistors that the hippopotanus they are admiring, or the brilliantly coloured parrot fish on the screen before them, is a model and not the original animal; there is much of the trophy collector's instinct in most human beings, but it is clear that museum tech-



AMERICAN MUSEUM OF MATURAL HISTORY Fig. 7 — "The Akeley Doe," modelled by James L. Clark under the direction of Carl E. Akeley, 1902

niques must aim at the most effective and lifelike representation of animals and plants, and must disregard the human failing that values a scrap of cloth from the Wright aeroplane above a completely accurate working model. The difficulty lies, perhaps, in a confusion of the quite incompatible aims of historical and scientific museums.

### TAXIDERMY TECHNIQUES

All the early books published on this subject, such as R. A. F. Redamurs' Treatuse (1749) and the guides and instructions on collecting and preserving natural history specimens, by E. Donovan, W. Swaisson and Capitan Thomas Bisown, are quite out of date, and are interesting only from a historical point of were for work in the field, the instructions issued by the different nuseums in their publications are of great assistance to the sportsman and collector. As regards the actual mounting, the work is so intricate and requires such special training that it is rarely undertaken with successful results by amateurs. A few works have been published dealing with this branch of taxdermy and the reader will find much that is helpful in John Rowley's Taxdermy and Museum Exhibition, an account of American taxidence methods.

Taxidermy may be considered under two separate headings (1) the skinning and preserving of specimens and (2) the mounting of such specimens in as lifelike attitudes as possible. It should be noted that only a very small number of the animals skinned and preserved are set up, or mounted; the great majority go to swell the large study collections maintained in museum.

and private collections, as so-called study skins

Birds .-- As soon as the specimen is collected, wine off all blood and dirt on the feathers, then plug up the mouth and nostrils with cotton to keep the blood and body juices from running out and staming the feathers Colour notes of all fleshy parts should be made, also a notation of the colour of the eyes, bill and legs The skinning of birds is accomplished by first making an incision along the breast, starting at the tip of the breastbone to the vent. The skin is worked down each side of the body to the legs, which are detached at the knee joint, the tail is next severed close to the body and the skin worked down over the back to the wings. Wings are disjointed where they join the body, and the skin is then worked down over the neck to the base of the skull, turning it inside out as you work. The skull is skinned out, first cutting away the ears, close to the head, then the eyes and down to the bill. The body is severed from the skin at the base of the skull, where the skull joins the neck; the skull is cleaned of all muscles, and the eyes and brain are removed Wing and leg bones and the base of the tail are cleaned of all flesh, muscles, etc. The skull, wing and leg bones and the base of the tail are left attached to the skin and are used in the mounting of birds. On some of the larger headed birds, whose skulls are too large to allow the neck skin to be turned over, it is necessary to make an incision along the top of the head, large enough to skin the skull through; also a cut will have to be made on the underside of the wings to allow the muscles of the wings to be removed The tendons found in the feet and legs will also have to be pulled out Powdered borax is used as a preservative on the skin. It is sifted on as soon as the opening incision is made, and the skin is allowed to absorb as much as possible throughout the entire skinning operation. The skin is prepared for mounting by removing all tissue and scraping the inside along the feather tracts. separating each feather at the base. It is then washed thoroughly with soap flakes and warm water, degreased in alcohol and benzine. To preserve the skin, it is immersed in a saturate solution of borax water, allowed to drain and the feathers dried and

Measurements from the natural body are taken, the specimen is sexed and the condition of the body noted. The artificial body is made of balsa wood, it being carved and shaped to the exact size of the natural one. The artificial neck, made of fine tow, is built on the balsa body, with a wire to hold it and the skull in position. Composition is placed in the eye sockets and the skin turned rightside out. Legs, tail and wings are wired, then cotton or tow is wrapped around the wire and bones to represent the muscles which were removed. The artificial body and neck are placed in the skin. The wings, legs and tail are anchored securely in their proper positions, and the moiston is sewed together.

The bird is now "set up" on its base, or a natural branch, and is held there by the wires extending from the feet. It is shaped

146

into a natural and lifelike attitude and the feather pattern is adjusted into place. Glass eyes of the proper colour and size are set in place and the feathers are arranged in position with wires, pins and thread. After the bud has dired for several weeks, depending upon the size and climate, all thread and portuding wires and pins are removed. When the faded parts are restored with oil paints, the specimen is completed.

Mammals—After a mammal is collected, many different measurements from all parts of the body must be recorded before the animal is skinned the total length, length of tail, of each foot and leg, distance from the up of the nostrit to the eyes and ears, crumference of different parts of the body and legs,

In skinning smaller mammals, only one incision is made, from a point between the front legs to the vent. The skin is then worked down each side of the body, cutting away the flesh close to the skin, when the legs are reached, they are disjointed from the body in much the same manner as in the skinning of birds. The tall is removed in one piece by pulling it from the skin Then, by turning the skin inside out, the body and skull are removed, the skull being cut away from the skin where it joins the guins or teeth.

With the larger mammals that are to be mounted, the skinning operation is somewhat different After all detailed measurements are taken, the opening cut, on all the horned mammals, is made from a point between the front legs, down the middle of the belly to the tip of the tail Another cut is made up the back of the neck, starting at a point between the shoulder blades to the base of the horns, or antlers An incision is next made up the inside of each leg, starting at the bottom of the foot, joining the belly cut, the skin is then removed as cleanly as possible, leaving no flesh or fat on it. It is skinned down over the body, legs and tail, then over the head, cutting away the ears, eyes and nostrils close to the skull and, on the horned mammals, loosening the skin from around the base of the horns. Attention must be given to the feet, eyes and lins, splitting them open so that these parts will not spoil and let the hair slip. The skin is then thoroughly salted, folded fleshside in and allowed to dry in a cool, dry, shady place. The skull, leg bones and pelvis are cleaned of all flesh and muscles, then dried and kept for future use in the mounting of the mammal. Sometimes the entire skeleton is cleaned and saved, especially if the anatomy of the mammal is not too well known.

Before mammal skins can be mounted, they must be tanned or leathered, which is a complicated and detailed process (see LEATHER). After the skins are tanned and properly poisoned, they will not crack, nor will the hair ever fall out

In the mounting of smaller mammals, the process is somewhat similar to the mounting of birds. An artificial body is built, the legs and tail are wired, and the body is placed misde the skin. Legs, tail and skull are anchored in place, the skin is sewed together and the mammal is given a lifelike stitlude.

The mounting of larger mammals requires a thorough knowledge of anatony Before the taddermis attempts to mount any specimen—bird, mammal, fish or reptile—he must be familiar with its habits and the different attrudes it assumes under various conditions. As a guide and help when modelling mammals, as soon as the animal is collected, plaster-of-Paris casts are made, in the field, of all important parts of the body before and after removing the skip.

An armature or framework is first constructed, following all measurements taken and using the skelcton, "setting" it up in the shape desired in the finished mount. Over this armature, modelling clay is applied in working out all anatomy and details; each muscle is put in its proper place and the clay model is built up to the correct lifelike size and shape. A plaster-of-Paris piece mould is then made over this clay model, in sections, so that it will come apart after the plaster has set The mould is removed, and a "manikin" is then built into each section of the mould by glueing in several layers of burlap. Iron rods are anchored up the inside of each leg in the manikin to support the animal after it is completed. The different sections of the mould are then

wired together, and the burlap manikin is allowed to dry inside the mould for several days After wetting the mould with water. it is broken up, leaving an exact copy of the animal's body in this light, hollow, burlap form. The manikin is covered with composition, the tanned skin is fitted, glued and adjusted into place, and the skin is sewed together. Glass eyes are set in and all details and anatomy of the nostrils and lips are modelled directly, the composition taking on the form and holding the expression of the face as modelled Antlers and hoofs are cleaned and oiled, the han is combed and brushed in its proper place, and the mammal is allowed to dry Colour is restored to the faded parts of the skin around the eyes, nostrils and hps.

Fish.-Several methods are used in the mounting of fish, one in which the skin is mounted over a modelled form, another (used by many museums), called the casting method, in which the fish is reproduced in plaster of Paris, using the natural fins and tail In fish taxideimy, one of the most important steps is to restore the correct colours of the living specimen to the mount. As soon as the fish is taken from the water, accurate colour notes are made, and the measurements and outline of the body are recorded In skinning the specimen, it is laid out on its "show" side and the opening incision is made on the reverse side. Only one cut is needed, down the centre from a point back of the gill coverts to the tail The skin is carefully separated from the body so as not to disturb the scales, as they are easily worked loose, until the fins and tail are reached These are cut loose and the skin is worked down to the head, which is cut from the body. The head is cleaned and the eyes and cheek muscles are taken out. The gills are also cleaned but are left attached in the skull. The skin is cleaned, washed, dipped in alcohol and the preservative and it is ready for mounting.

Working from the measurements and other data, an artificial body is built over a centreboard; then this is modelled in the shape and form with excelsior and finally covered with composition After the cheek muscles are filled out with composition, the skin is pulled over this form and adjusted in position. Composition is also used at the base of each of the fins and tail and the skin is then sewed together. The specimen is laid out on a board to dry, the head, gills, fins and tail being held in position with wires and strips of cardboard, this giving them their proper spread and shape After the specimen has dried for several weeks, all wies, cardboard, etc, are removed, glass eyes of the proper colour are set in and any depressions in the body are filled out with modelling wax. The fins and tail are reinforced with cloth and tissue, the specimen is shellacked, then painted, following the colour notes taken. The casting method gives a more natural reproduction and will remain a truer mount in years to come, as to form and colour. After the colour notes have been taken, the fish is opened in the "off" side and filled in with clean sand or corn meal to "build-out" the sunken belly. It is then posed sand or corn mear to "pund-out" the sunsen peny. It is shall possed in position and sponged off with alum water to remove the mucus which covers all fish. A mould is carefully made by pouring plaster of Pans over the specimen and removing the plaster as soon as it has Fins and tail are cut from the body, spread and dried into the shape in which they are later used

After the plaster mould has dried, a separator is painted on the inside, over the detail, and a thin layer of the plaster is poured in inside, over the detail, and a thin layer of the plaster's popured and backed with fine-cut tow. This plaster is allowed to set, the mould is soaked in water and is then broken away from the case in their natural positions, and the back of the cast is about up with when the back of the cast is built up with we mesh and libre, mixed with plaster, Glass eyes are set in place, and any rough spots found on the cast are "pointed up", the original colours are then restored to the cast with oil paints.

Reptiles.-Great advances have been made in the preparation of reptiles. No other method has been so revolutionary in its technique replies. No other memor has been so revolutionary in secunique since the dermoplastic method was developed for the mounting of mammals. There are still many museums and all the commercial taxidermists who mount the skms of reptiles, but the reproduction method has been outstanding in its results.

Where the skin is used, it is first removed from the body, cleaned of all the flesh, washed and poisoned. An artificial body is built which conforms to the natural one. The skin is then pulled and a justed over this artificial form. It is allowed to dry, glass eyes are set in and the natural colours are restored with oil paints.

In the more modern reproduction method, colour notes must be taken as soon as the reptile is collected, they must be accurate, as a great deal of the success in the finished specimen depends upon these notes. The reptile is posed in position and plaster of Paris is poured and brushed over it to make a true and accurate mould, transferring

all the detail, contour and anatomy of the original body to the plaster. A great deal of care must be exercised in making this plaster mould, which is sometimes in sections so that it will come apart. After the plaster has set, the reptile is removed and the work of making the reproduction takes place inside this mould

The reproduction is made of clear plastic, it is celluloid dissolved in one of its solvents—acetone, butyl acetate, anyl acetate—to form the body material. Oil pigment is then added For each colour ecoded when the notes were taken, a separate batch of coloured liquid celliquid must be made for the reproduction

Following carefully the colour notes and the preserved body of the rollowing carefully the colour notes and the preserved body of the repulse, which is saved for compareson and study, the undermust paints or the saved for compareson and study the undermust paints or the "lop" or pattern colour is painted in first, then the body or base colour is added This coloured collular material, as it is painted into the mould, takes on not only the colour and pattern of the repulse, but also the form and all details contained in the mould. Laying in these different colours requires a great deal of experience, time, care and patience. After all the colours are painted in, a backing of several different materials is worked into the mould for ing of several different materials is worked into the modul of stength, then the modul is land away to dry After thorough drying, which may take several weeks or months, the specimen is immersed in water and the plaster is broken away from the reproduction. It is then cleaned with water, brushed with a wire brush. Glass eyes are set in and the reproduction is oiled and placed on its base

This method of reproducing reptiles not only gives a truer form and anatomy, but preserves the translucency of colours found in the scales of all reptiles (J W M)

Bibliomaphy — William T Hornaday, Taxidermy and Zoological Collecting (1891), R W Shifeldt, "Scientific Taxidermy for Musemin," Rep US Nat Mus., 1892 (1894), Oliver Dave, Methods in the Art of Taxidermy (1894), Montagu Browne, Artistic and Scientific Taxidermy and Motelling (London, 1896), John Rowley, Taxidermy and Misseline (London, 1896), John Rowley, Taxidermy and Misseum Erichtstein (1915), Carl E Akeley, In Englistic Africa (1914), Leon L Walters, "New Uses of Colluidst and Similar Africa (1924), Leon L Walters, "New Uses of Celluloid and Similar Material in Taxidermy," Technique Ser Field Mus, No 2 (1925); Leon L. Pray, Tavidermy (1943)

TAXIMETER, a registering apparatus used on taxicabs to compute the fare for riding and waiting time and for the recording of extras In addition it includes a series of counters that accumulate the fares that were recorded, and the paid and total mileage for the taxicab owner's information

The fare-indicating device in the meter is operated by a flexible shaft to record distance travelled and a clock to record waiting time, but only one of these means can operate on the fare drums at one time. The meter is put into operation by the movement of the flag which has three positions: vacant, hired, not recording, the not recording position meaning that waiting time is not recording and is used when the passenger is paying his fare or when a tire is being changed, etc. A fourth position known as double tariff is sometimes used in Europe and South America. In this position it will record at a higher late of fare and is used as a night rate. The meter is driven by a flexible shaft from the speedometer outlet at the transmission, and a reduction box is provided that reduces the flexible shaft speed to approximately 60 revolutions per mile Change gears are provided under the meter to compensate for difference in tire diameters.

Meters are also built that issue a receipt to the passenger for the fare paid and print a record of the fare and mileage on each trip for the owner's information. (B, C, P.)

TAXONOMY. The science of classification in a broad sense, usually restricted to biological classification and specifically to the classification of plants and animals. Taxonomy is thus the methodology of systematic botany and zoology, and sets up systems for the arrangement of the kinds of plants and animals in the form of hierarchies of superior and subordinate groups. Plant life as a whole and animal life as a whole are referred to as the plant and animal kingdoms; the subordinate groups are successively the phylum (the phyla are the main subdivisions of the kingdom), class, order, family, genus and species, each such cate-gory including one or more of the groups next subordinate to it. The more elaborate further subdivisions within this hierarchy are employed only when a comprehensive classification of a group of animals or plants is drawn up to express all that is known about the degrees of relationship of the component groups Such an elaboration of the system may result as shown on the following page (after G. G. Simpson, 1945).

```
Kingdom
  Phylum
    Subphylum
      Superclass
        Class
           Subclass
             Infraclass
               Cohort
                 Superorder
                   Order
                      Suborder
                        Infraoider
                          Superjamily
                            Family
                              Subfamily
                                 Tribe
                                   Subtribe
                                     Genus
                                       Subgenus
                                          Species
                                            Subspecies
```

The purpose of taxonomy is to develop a convenient and precise method of classifying human knowledge, and thereby preserving knowledge and making it accessible A classification based on extended examination, description and comparison of the forms of life, becomes in fact a short expression of a vast amount of the data of animal and plant structure (See articles Botany and Zoology)

The necessity for naming the systematic categories (many of which are recognized in common speech), and for establishing a comprehensive and accepted nomenclature for the kinds or species of animals and plants produces an initiate relation between taxonomy and zoological and botanical nomenclature (see Zoo-LOGICAL NOMENCLATURE).

Taxonomy depends on descriptive biology for its materials, but most descriptions of plants and animals, and most alterations of the system of classification, are now need with a little work set up by the taxonomists of the past. This work set up by the taxonomists of the past. This considerable with the slow growth of some two centures of proposal and critique in the pre-Darwanna era, the categories of the classification of the past of the pre-Darwanna era, the categories of the classification of organisms tends toward a more and more exact reflection of organisms tends toward a more and more exact reflection of their natural relations, s.e., of their phylogeny (see Animals, Phylogeny or the control of

The basic method of taxonomy is to compare and weigh the characteristics of the structure of plants and animals by the methods of comparative anatomy, and to interpret the major subdivisions in the light of comparative physiology and embryology. Systems of classification based upon a single set of characters, or drawn up from a single viewpoint, must be reinterpreted by the study of all available knowledge of the forms concerned. At the level of the species and subspecies every type of variation requires examination

Classification may begin purely as a matter of convenience, as was the case with early botanical classifications, which developed on account of the use of herbs and plant products in medicine Such classification may be entirely "articlal," being bissed on the more readily observable distinctions rather than on the more fundamental differences. Indeed, the distinction between an artificial and a natural classification was necessarily obscure in the calcular before C. Darwin With general acceptance of the theory of evolution, it became more and more "convenient" to have the classification reflect the natural (i.e., phylogenetic) relations of the organisms concerned. Systematic zoologists and botanists are still often driven to the identification of animals by means of "artificial keys," in which the features employed for the distinction of groups, and for the distinction of one form from another may be quite arbitrary, and be limited to the supericlical and read-

aly observable characteristics (referred to by taxonomists as "characters". Oute unnatural juxtaponitions result from the use of such characters Artificial keys are a necessary device for rapid identification, but are not to be regarded as classifications. The results of the control of the control of the control of the control (evident in much popular birdstudy) in which animals are referred to as if they had evolved into distinct species solely in order to be identified by taxonomists

The basic units of the classificatory system are the readily recognizable kinds or species of plants and animals. Some of these are contrasted as distinct in common knowledge, like the hoise and the ass, or white oak and red oak. These instances also illustrate the first step in the process of classification, the grouping together of the various single-hoofed animals related to the horse (horse, ass and zebra) as the horse genus, and similarly the grouping of acorn-bearing trees into the oak genus. By the simple device of combining the name of the genus with that of the species, the resulting names carry with them this much information as to the relationship of the animals named, and allow for additional species to be named if any remain to be discovered. This is done in the vernacular of many languages when a series of species is as readily recognizable as a group as are the oaks, the horse tribe or the common squirrels, but for the less familiar animals, and to establish a critical and international nomenclature, the technical scheme of generic and specific names in Latin, established by C Linnaeus in the 18th century, has proved satisfactory and has in fact greatly stimulated the exploration of the world for the distinguishable kinds of plants and animals

The merit of the Limnean system lay and hes in uts sutability for continued emendation as well as expansion in the light of increasing knowledge, without loss of its essential character. A large proportion of our knowledge of plants and animals comes to be correlated with the system of classification. The amplification and correction of the classification is a continuing active function of taxonomic research, and this is essentially the method of science as applied to any field of investigation.

The thoughtful definition of species by A. E. Emerson ("Taxonomy and Ecology," Ecology, vol. 22, p. 213 [124], Ecological Society of America) as "an evolved (and probably evolving) genetically distinctive, ieproductively solated, natural population requires only the extension of practical use, and becomes more understandable by the examination of the existent diversity of plant and animal life.

As the knowledge about the variability of species increased, and when species began to be studied as populations, it was realized that the collecting of specimens constitutes only a method of sampling. A subordinate category for series of animals that had been thought of as species, but which were found to be connected by transitional (or intergrading) populations—the subspecies—was found to be essential.

Geographic gradients of variation, eithei uniform or separated by "steps" as topographic, climatic or other harriers, form an important aspect of variation within species to be considered in atxonomy. A classical example as afforded by the Bergmann rule that warm-blooded animals become larger to the north and smaller to the south, essentially in association with the temperature gradient. Such gradients of variation are termed climes (Julian Huxley), and those in which there are interruptions or irregularies are referred to as step-clines. To distinguish as named subspecies the segments of a uniform variation gradient appears to be fallacious. The segments of a step-cline, however, may correspond exactly to a series of subspecies defined on other grounds.

The "subspecies" of zoological systematics is defined essentially on a geographic basis, and is derived from the Linnaen concept of "variety" subordmate to the species. The term variety has been used to cover so great a diversity of variation, including equally mutation, phenotypic variation and geographic form, as to be useless in a precise taxonomy. The transition to the subspecies concept in botanical nomenclature has lagged behind that m zoology. A great variety of infraspecies terms has been proposed, and is useful in the analysis of variation (cf. G. C. Robson and O. W. Richards).

Turning again to the species level, a most important clarification of the concept lies in the recognition that purely morphological definition must be subordinated to the insight that the species is composed of populations in which variability is inherent. The "closet naturalist" was (on is) exposed to the fallacy of describing variant individuals as species. Much of modern taxonic investigation is occupied in the essential re-evaluation of the work of earlier taxonomists, bringing to beat on classification on timerely the information from more adequate collections and anatomical study, but drawing upon embryology, physiology, genetics, psychology and geography

Re-examination on the basis of larger collections (i.e., a better sample) may unite a whole series of supposedly distinct forms into one, or may distinguish forms that had long been regarded as a single variable subspectes. A few species have now been subjected to exhaustive genetic analysis, especially among the fruit files of the genus Drosophida, and such analysis throws much light on the problem of definition of species, though it is obviously impossible to extend detailed genetic examination to more than a few forms.

The morphological characteristics distinguishing genera are ordinarly (but not necessarily) more sharply defined than those distinguishing species, and the distinctions between genera are to be thought of as having an origin more remote chronologically and those between species. Thus the concept of the genus comes to have essential importance to nalecontology.

So many genesa are familiar in ordinary thought and language, like the oaks (Quercus), the maples (Acer), the cats (Fex), some of the squirrels (Scurus), etc., that there should be no difficulty in the wider application of the concept of the genus as a natural group of related species. Definition of genera by means of characters thought to be of "generic value" may bead or arbitrary and unnatural assortment of species. The synthetic assortment of known species into their evident groups, as if they were building blocks, thus becomes an extremely important check on generic dassification. It is found that characteristics suitable for the definition of genera in one group may be useful only in the distinction of species in another.

When the number of species of a genus is large, these may fall min subordinate groups, which are referred to as subgener as business of the subgeneric group may be merely an artificial assemblage of species, serving to break a long series of forms into more convention smaller ones, when the subgeneric group is a natural one, the distinction from the genus may be mainly that between the used of the "splitter" and the "lumper". The splitter focuses his attention on differences, and emphasizes or overemphasizes then, while the lumper attends mainly to resemblances, and may overemphasize these in his turn

The study of fossi remans of both plants and animals obviously introduces the dimension of time into variation, and this affects all of the categories, and would complicate the distinction of the groups of lower rank even more were it not for the study that the gaps in the palaeontological record supply convenient agaps between the species and genera. As palaeontological accumulate, important modifications of the classification of the huber groups become necessary (see below)

The recognition that the geographic series of subspecies, comnected by intergradation where they meet, or simular series with overlapping variation (as on chains of islands) are matched by such as led to the concepts of the "Formenkreis," "Rassenkreis" and "Artenkreis" The component forms of such series may be thought to have originated by parallel rather than by divergent evolution. Ernst Maye clarifies this problem by the distinction of species as sympatric, if their areas of distribution overlap, and allopatric, for the series of forms, or "Kreise," if their geographic ranges are distinct

### THE HIGHER GROUPS

Just as such sharply defined species as man, the lion or the peacock, and such readily recognizable genera as those of the oaks, the maples, the cats or the common squirrels, serve to in-

troduce the words "species" and "genus" in the more precise sense of taxonomy, common knowledge is found to be reflected in the language for some of the larger divisions at the other end of the system of classification The primary division, into the plant and animal kingdoms, appears in various languages as well as in English Except for a few groups like the sponges, birds and ferns, the ordinary words for the phyla and classes usually fail to correspond precisely with the more exact zoological and betanical definitions

The taxonomy of the higher groups may be pursued analytically, beginning at the top and searching for the successive subdivisions of the two kingdoms, or it may be studied by the synthetic method, beginning with the mote factually defined groups nearer the bottom of the scale, and especially with the genera The arrangement of the groups above the species level has involved all of comparative anatomy and embryology, with much involved and of comparative anatomy and embryology, with much malasentology.

The difference between an artificial and a natural classification of the higher groups rests primarily on the distinction between analogy and homology The discernment of both homology and analogy in the structures of animals closely or remotely related forms the contribution of comparative anatomy to taxonomy The fundamental distinction of the homologous from the analogous may be far from simple, and even the definition of the terms becomes obscure in the light of embryology and genetics. As wings, the wings of a bird and of a bat are analogous, and not homologous, and must be presumed to have arisen independently and not one from the other As fore-limbs, the wings of a bird and those of a bat are plainly homologous, as they are also with the arm of a man or the fore-leg of an elephant, and support other evidence as to the relation of these several forms as "Vertebrata" In a broad sense, homology may be of quite a different type, like the correspondence between the alternating generations of ferns and flowering plants so brilliantly demonstrated by W F. Hof-

Homology of structures, essentially, predicates the common unheritance of the characters under consideration, while independently derived structures that resemble each other are said to be convergent or parallel. "Structural similarity is indicative of common phyletic origin, and as a rule its degree is proportional to the nearness of the common ancestry" (G. G. Simpson). The exceptions to this rule, and the reinterpretations made necessary by such exceptions, afford the major problems of phyletic comparative morphology.

The successive addoctination of the series of groups, with steadily increasing number of the lower categories in most types (not in all) is reflected in the familiar companison with a branching fire, with it is reflected in the familiar companison with a branching fire, with it is reflected in the familiar companison with a branching fire, with visit to the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the control of the principal groups of animals, the phylin, appear in the carliest known fossil-berning string.

The exact relations of branch to branch or of branch to trunk are unknown, being for the most part lost in the imperfections of the palseontological record; there are accordingly numerous groups at every level in the classification that are regarded as equivalent, and much effort has been expended to make them reasonably so. It may be pointed out that much difference of opinion over taxononic groups in general applies to their rank in the hierarchy rather than to their validity as definable groups.

It may be pointed out that many of the intermediate group, especially the orders and families, are essentially the estimate of evolutionary specialization in a single direction (like the orders for the inchirposium sor whales, or the family of sea sunkey). An entirely included the control of the control o

gories under the same names is evident in the difference between the grades "order" and "family" in an ancestral group like the Reptilia, and a derived group such as the Mammalia.

An essential problem is introduced by palaeontology in groups in which the evidence of ancestral approximation (at the point of dvergence of the branches of the phylogenetic tree) has been discovted by the problem of the problem of the problem of the prosecond with their lister dereved and more distinctive descendent, in a "vertical classification," or with the primitive forms of the other branches to which they may be more closely striller in actual morphism of the problem of the problem of the problem of the genetic and morphological definition of groups is notably exemplified by the early Tertary smastery of horses, shonceroess and tapris

Since some classification is executal for the establishment of scientific botany and coology, taxonomy in its organs is the most elementary of disciplines. The record-keeping function of taxonomy affords an essential continuing service to all of the related belongical sciences Assembly and the second of the continuing service to all of the related belongical sciences Assembly to the second of the continuity of the second of the continuity of the second of the

this amply justifies Hunley's tulte of 1949 "The New Systematics Buttleonarys —Alfred E. Emerson, "Taxonomy and Ecology," Reloley, vol 2x, p 213, (1941), Julian Huvley, The New Systematics (1940), Ernst Mayry, Systematics and the Origin of Species (1942), G. C. Robson and O. W. Richards, The Variation of Animadis in Nature (1945), George Gaylord Simpson, "The Principles of Classification and a Classification of Mammals," Bull. Amer. Min. Nat. Hist, vol 38 (1943).

TAY, the longest river in Scotland. From its source in Ben Lui (3,708 ft), a mountain on the borders of Perthshire and Argyllshire, it flows northeast to Logierait, where it curves to the south by east as far as Dunkeld; there it turns southeast to the mouth of the Isla, where it bends southwest to the vicinity of Scone. From this point it makes a sharp descent southeast beyond the county town, where it sweeps to near Newburgh in Fifeshire; here it faces the northeast again as far as Broughty Ferry, whence it flows straight eastward into the North sea, off Buddon Ness in Forfarshire, after a total run of 117 mi. During the first 11 mi. it is known as the Fillan and discharges into Lock Dochart. From the lake it emerges as the Dochart (13 mi.), which enters Loch Tay at Killin. Flowing through the loch for 144 mi. it issues at Kenmore under its proper name of Tay. With its tributaries it drains all Perthshire and portions of Forfarshire and Argyllshire, having a catchment basin of 2,400 sq m1 In many parts the current is impetuous, and in flood has occasionally wrought much havoc. Its mean discharge of water every minute is estimated to be larger than that of any other stream in the United Kingdom.

Vessels make Dundee at all stages of the tide, and the estuary is navigable to Newburgh by vessels of 500 tons, and as far as Perth by ships of 200 tons. The navigation, however, is seriously obstructed by shifting sandbanks. The estuary varies in width from ½ mi. at Cairniepser Ferry to full 3 mi. at its mouth. The first railway viaduct across the firth, opened in 1877, was blown down along with a train in 1879. The second bridge, 2 mi. and 73 yd. in length, was erected 50 ft. higher up stream and opened in 1887. The Tay is famous for salmon

TAY, LOCH, the largest lake in Perthshire, Scotland. It is situated about the middle of the county and has a flatened oges form, with a general trend from northeast to southwest. It is rad, mi, long from Killin at the head to Kemmore at the floot, from \( \frac{1}{2} \) mit to fully r mi, wide. It receives at Killin the rivers Lochay and Dechart and discharges by the Tay at Kemmore. Ben Lawers (3,984 ft.) rises near the left blank. There are piers at Killin, Ardeonaig, Lawers, Ardelnaig, Farnan and Kemmore, at which the steamers call during the tourists season. At the foot of the lake is an island containing the ruins of the priory which was founded in 121 by Alexander 1 in memory of his wife Shyllad, daughter of Henry I. She was buried there. Loch Tay enjoys great repute for its salmon fishing.

TAYABAS, a municipality (with administrative centre and 46 barries or districts) of the province of Tayabas, Luzon, Philippine Islands, about 8 mi. north of Lucena, the provincial capital. Pop.

(1939) 18,172 (a gain of 3,189 aften 1918) of whom 9,182 were males and five were white Tayahas, which was the provincial capital from the middle of the 18th century until 1901, is situated on the slope of the extinct volcano, Banájao, and commands a fine view of the surrounding country. The chief agricultural products are palay (race) and conounts. Hatmaking is a household industry which has attained considerable importance. Tagalog and Bikol are the principal vernaculars. Of the inhabitants aged 6 to 19 inclusive, 41.4% attended school in 1939, and 66.2% of the population 10 years old and more was literate. (C S  $\upmu$ )

TAYGETUS, the highest mountain in the Peloponnesos, separating Laconia from Messenia, and traversed by the steep Langada pass The highest point is Hagios Elias (7,897 ft).

TAYLOR, ANN (1782-1866) aftervard Mrs Joseph Gilbert and TAYLOR, JANE (1783-1824), English writers for children, daughters of Isaac Taylor (1759-1829), were born in London Jan. 30, 1782, and Sept. 23, 1783, respectively. In 1786 the Taylors went to live at Lavenham in Suffolk, and ten years later removed to Colchester Jane was a lively and entertaining child, and composed plays and poems at a very early age Their father and mother held advanced views on education, and under their guidance the girls were instructed not only in their father's art of engraving, but in the principles of fortification. Ann introduced herself to the publishers Darton and Harvey by a rhymed answer to a puzzle in the Minor's Pocket Book for 1799, and Jane made her first appearance in print in the same periodical with "The Beggar Boy." The publishers then wrote to Isaac Taylor asking for more verses for children from his family, and the result was Original Poems for Infant Minds (2 vols, 1804-05), by "several young persons," of whom Ann and Jane were the largest contributors The book had an immediate and lasting success They followed up this success with Rhymes for the Nursery (1806), Hymns for Infant Minds (1808, 2nd ed 1810), Rural Scenes (1806); City Scenes (1809); a less-known collection, Signor Topsy Turvy's Wonderful Magic Lantern; or, The World Turned Upside Down (1810), and Original Hymns for Sunday School (1812). In 1813 Ann married a Congregational minister, Joseph Gilbert, and Jane went to live at Ilfracombe with her brother Isaac. In 1816 Jane returned to Ongar, where the family had been settled for some years, and died there on April 13, 1824 Ann Gilbert died at Nottingham on Dec. 20, 1866. Both sisters wrote after their separation, but none of their later works had the same vogue

The best edition of the Poetical Works of the sisters is that of 1877 There is an excellent edition (1903) of the Original Poems and Others, by Ann and Jane Taylor and Adelaide O'Keeffe, edited by E V. Lucas, with illustrations by F. D Bedford (1903).

with illustrations by F. D. Bedford (1991).

Abundant information about Ann and Jane Tyylor as to be found.

Abundant information about Ann and Jane Tyylor as to be found.

1874), cellied by her soil Josiah Gilbert, Memorra and Positical Remains.

of Jane Taylor ed by her brother, Jane Taylor (a vols, 1835), and the collection by the same cellier entitled The Family Period (1991), and the collection by the same cellier entitled The Family Period (1991), and the collection by the same cellier entitled The Family Period (1991), and the collection of the American Charlest (1991), and Taylor (1991), and the collection of Protes and Poetry by Jane Taylor was published, with introd. by F. V. Darry, in 1992 in the Charlest (1991), and the Char

TAYLOR, BAYARD (1825-1878), U.S. author, was born of English and German stock in Chester county (Pa ), Jan 11, 1825. He published at Philadelphia in 1844 a little volume. Ximena; or The Battle of the Sterra Morena, and Other Poems Remuneration for his poetry on a scale generous for the time and advance payments for travel letters by the publishers of the Saturday Evening Post and the editor of the United States Gazette, as well as a conditional engagement by Horace Greeley. made it possible for him to take (1844-46) the coveted trip to the old world which was his university education. His study in Germany and his happy roaming through Scotland, England, France and Italy are described in his Views Afoot (1846), which went through a number of editions. After a brief period of country journalism Taylor moved to New York city. The year 1848 brought him several lucrative magazine and newspaper offers, the most important of which was with the New York Tribune. The excitement of the gold rush at this period was responsible not only for his passionate Californian ballads but for his trip to the Pacific

Eldorado (2 vols , 1850) The wanderlust was in his blood His trips to almost every part of the globe continued until the end of his life, and, although the popularity of his narratives of travel has diminished, his vivid pictures of remote places, such as A Journey to Central Africa (1854) or Northern Travel (1857), in their day won many readers

For several years his lectures were equally in demand Quiet was afforded him in his country home. Cedarcroft, in which he entertained hospitably and read and wrote copiously Some of the works of his later period are The Poet's Journal (1862), The Picture of St John (1866), the translation of Faust (1870-71), Home Pastorals (1875), and the novels Hannah Thurston (1863), Joseph and His Friend (1870) and The Story of Kennett (1866) As a novelist Taylor is undistinguished, as a poet he is at his best in the Poems of the Orient (1854) or his rich and sonorous rendering of Faust in the original metres

In 1862 Taylor had entered the diplomatic service as secretary of the legation at St Petersburg, and in the following year he became chargé d'affaires at the Russian capital His disappointment at not being made minister there, which caused him to leave the service, was atoned for by his being made minister to Germany

early in 1878 He died on Dec. 10, 1878

Taylor's Studies in German Literature (1379), and Critical Risays and Latery Novies (1880) were published positionarily Gollected editions of his Postscal Works and of his Dramatic Works appeared in 1880. Bendes co-operating with H. S. Endder in the publication of works and the proper of the property of the Continuity of the Continuity of the Continuity of the Continuity (1995). All Smyth has a good biography (1896), with bibliography

TAYLOR, BROOK (1685-1731), English mathematician, son of John Taylor of Bifrons House, Kent, was born at Edmonton in Middlesex on Aug 18, 1685. He was educated at St. John's college, Cambridge, and studied mathematics under John Machin and John Keill He obtained in 1708 a remarkable solution of the problem of the "centre of oscillation," which, however, remaining unpublished until May 1714 (Phil Trans, vol. xxviii, p 11), his claim to priority was disputed by John Bernouilli

Taylor's Methodus Incrementorum Dwecta et Inversa (London, 1715) added a new branch to the higher mathematics, now designated the "calculus of finite differences," Among other ingenious applications, he used it to determine the form of movement of a vibrating string, by him first successfully reduced to mechanical principles.

The same work contained the celebrated formula known as "Taylor's theorem" (see Calculus, Differential and In-TEGRAL), the importance of which remained unrecognized until 1772, when J. L Lagrange realized its powers and termed it "le

principal Jondement du calcul différentiel"

In his essay on Linear Perspective (London, 1715, revised ed 1719) Taylor set forth the true principles of the art in an original and more general form than any of his predecessors; but the work suffered from the brevity and obscurity which affected most of his writings

Taylor was elected a fellow of the Royal society early in 1712. sat in the same year on the committee for adjudicating the claims of Newton and Leibniz, and acted as secretary to the society from 1714 to 1718. From 1715 his studies took a philosophical and religious bent Taylor died on Dec. 29, 1731, at Somerset House, and was buried at St. Ann's, Soho. See also Taylor's Theorem.

TAYLOR, FREDERICK WINSLOW (1856-1915), U.S. engineer, was born March 20, 1856, at Germantown, Pennsylvania. In 1875 he was apprenticed as patternmaker and machinist in a small Philadelphia shop. As early as 1880 or 1881, while gang boss in the employ of the Midvale Steel company, controversy with workers led him to realize the necessity of accurate measurement of what constituted a day's work on any operation. This in turn led to a series of careful experiments resulting in important achievements in two fields; in mechanical engineering, the discovery with Maunsel White of a new method of tempering tool steel permitting metal-cutting operations at high speed (1898); and in the field of management, perfection of that system of shop management which later came to be known as scien-

coast as correspondent for the Tribune, which he recounted in tific management. The remainder of his life was spent in forwaiding the principles of this system, by practising the new profession of consulting engineer in management for many plants (1893-1901), lecturing and writing

(1603-1901), secturing and writing.

He died March 21, 1915, in the city of Philadelphia.

Taylor's writings include Notes on Belling (1801), The Adjustment Of Wags to Effective (1805), The Principles of Scientific Management (1906), The Principles of Scientific Management (1904), Car Brompoon, The Taylor, Father of Scientific Management (1931), C. B. Thompson, The Taylor, System of Scientific Management (1932), C. B. Thompson, The Taylor, System of Scientific Management (1932), C. B. Thompson, The Taylor, System of Scientific Management (1932), C. B. Thompson, The Taylor, System of Scientific gement (1917)

TAYLOR, SIR HENRY (1800-1886), English poet and political official, was born Oct. 8, 1800, at Bishop-Middleham, Durham After a few months' service in the navy he obtained a clerkship ashore. From 1824 to 1872 he held important appointments in the colonial office, where he rendered active assistance to Sir James Stephen in drafting the Act of Emancipation He died at Bournemouth March 27, 1886 Taylor was the author of several plays, of which Philip van Artevelde was the most famous His dramatic poetry is generally better than his lyrical work, but some of his lyrics, notably "If I Had the Wings of a Dove" have found a place in many anthologies.

Taylor's Autobiography (2 vols 1885) should be supplemented by his Correspondence (1888), edited by Edward Dowden. His Works

were collected in five volumes in 1877-78.

TAYLOR, JEREMY (1613-1667), English divine and author, was baptized at Cambridge Aug. 15, 1613. His father, Nathaniel, a barber, was a man of some education, for Jeremy was "solely grounded in grammar and mathematics" by him before he became a pupil of Thomas Lovering, at the newly founded Perse grammar school. Lovering is first mentioned as master in 1619, so that Taylor probably spent seven years at the school before he was entered at Gonville and Caius college as a sizar in 1626. He was elected a Perse scholar in 1628, and fellow of his college in 1633. He took holy orders in 1633, and took the place of Thomas Risden for a short time as lecturer in St. Paul's Archbishop Laud sent for Taylor to preach before him at Lambeth, and took the young man under his special protection. Taylor retained his fellowship at Cambridge until 1636, for Laud desired that his "mighty parts should be afforded better opportunities of study and improvement than a course of constant preaching would allow of," but he seems to have spent much of his time in London In November 1635 he and been nominated by Laud to a fellowship at All Souls, Oxford, where, says Wood (Athen Oxon., Ed. Bliss, iii, 781), love and admiration still waited on him. He seems, however, to have spent little time there He became chaplain to his patron the archbishop, and chaplain in ordinary to Charles I. After two years in Oxford, he was presented, in March 1638, by Juxon, bishop of London, to the rectory of Uppingham, in Rutlandshire In 1642 he was appointed to preach in St. Mary's on the anniversary of the Gunpowder plot, and apparently used the occasion to clear himself of a suspicion, which, however, haunted him through life, of a secret leaning to the Roman Catholic communion. This suspicion may have arisen from his intimacy with Christopher Davenport, better known as Francis a Sancta Clara, the learned Franciscan chaplain of Queen Henrietta; but was probably strengthened by his known connection with Laud, as well as by his ascetic habits. More serious consequences followed his attachment to the royalist cause. The author of The Sacred Order and Offices of Episcopacy or Episcopacy Asserted against the Aerians and Acephali New and Old (1642) could scarcely hope to retain his parish, which was not, however, sequestrated until 1644. Taylor probably accompanied the king to Oxford. In 1643 he was presented to the rectory of Overstone, Northamptonshire, by Charles I. There he would be in close connection with his friend and patron Spencer Compton, and earl of Northampton. Taylor seems to have been in London during the last weeks

of Charles I's life, and is said to have received his watch and some jewels which ornamented the ebony case in which he kept his Bible. He had been captured while besieging Cardigan castle on Feb. 4, 1645. He found refuge, as private chaplain, with Richard Vaughan, 2nd earl of Carbery (1600-1686), whose hospitable mansion, Golden Grove, Carmarthenshire, is immortalized in the tulle of Taylor's great manual of devotion, and whose first wife was a constant friend of Taylor. The second Lady Carby was the original of the "Lady" in Mitton's Comus. Mis. Taylor died early in 1651. His second wife was Joanna Bridges, said on very doubtful authority to have been a natural daughter of Charles I. She owned a good estate, though probably impoversished by parliamentariane exactions.

From time to time Jeremy Taylor appears in London in the company of his friend Evelyn, in whose dury and correspondence his name repeatedly occurs. He was three times imprisoned in 1654–55 for an injudicious preface to his Golden Grove, again in Chepstow castle, from May to Oct 1655, on what charge does not appear; and a third time in the Tower in 1657–58, on account of the indiscretion of his publisher, Richard Royston, who had adomed his "Collection of Offices" with a print 1epresenting Christ in the attitude of prayer

Much of his best work was produced at Golden Grove In 1646 appeared his famous plea for toleration, Θεολογία Έκλεκτική A Discourse of the Liberty of Prophesying In 1649 he published the complete edition of his Apology for authorized and set forms of Liturgy against the Pretence of the Spirit, as well as his Great Exemplar . a History of . . . Jesus Christ, a book which was inspired, its author tells us, by his earlier intercourse with the earl of Northampton Then followed in rapid succession the Twenty-seven Sermons (1651), "for the summer half-year," and the Twenty-five (1653), "for the winter halfyear." The Rule and Exercises of Holy Living (1650), The Rule and Exercises of Holy Dying (1651), a controversial treatise on The Real Presence . . (1654), the Golden Grove; or a Manuall of daily prayers and letames . . . (1655), and the Unum Necessarum (1655), which brought upon him the accusation of Pelagianism In reply to a request from Katherine Phillips (the "matchless Orinda"), he wrote his Discourse of the Nature, Offices and Measures of Friendship (1657). His Ductor Dubitantium, or the Rule of Conscience . . . (1660) was intended to be a standard manual of casuistry and ethics for Christian people.

He probably left Wales in 1657, and his immediate connection with Golden Grows seems to have caused two years earlier. In 1658, through the kind offices of his friend John Evolyn, Taylor was offered a lectureship in Lisburn, Ireland, by Edward Conway, second Yosount Conway At first he declined a post in which the duty was to be shared with a Presbyterian, or, as he expressed it, "where a Presbyterian and myself shall be like Castor and Pollux, the one up and the other down," and to which also a very meagre salary was attached He was, however, induced to take it, and found in his patron's manison at Portmore, on Lough Neigh, a congenial retreat

At the Restoration, instead of being recalled to England, as he probably expected and certainly desired, he was appointed to the see of Down and Connor, to which was shortly added the small adjacent diocese of Dromore. He was also made a member of the Irish privy council and vice-chancellor of the University of Dublin. None of these honours were sinecures Of the university he writes, "I found all things in a perfect disorder . . . a heap of men and boys, but no body of a college, no one member, either fellow or scholar, having any legal title to his place, but thrust in by tyranny or chance." Accordingly he set himself vigorously to the task of framing and enforcing regulations for the admission and conduct of members of the university, and also of establishing lectureships. His episcopal labours were still more arduous. There were, at the date of the Restoration, about 70 Presbyterian ministers in the north of Ireland, and most of these were from the west of Scotland, and hated episcopacy. The new bishop had nothing to offer the Presbyterian clergy but the bare alternative-submission to episcopal ordination and jurisdiction or deprivation. Consequently, in his first visitation, he declared 36 churches vacant; and of these forcible possession was taken by his orders. At the same time many of the gentry were won by his undoubted sincerity and devotedness as well as by his eloquence. With the Roman Catholic population he had no success. At the instance of the Irish bishops Taylor undertook his last great work, the Dissuasive from Popery (in two

parts, 7664 and 7667), but, as he himself seemed partly conscious, he might have more effectually gamed his end by adopting the methods of Ussher and Bedell, and inducing his clergy to acquire the Irish tongue He died at Lasburn on Aug 13, 1667, and was buried in the cathedral of Dromoie

Of a genuine poetic temperament, fervid and mobile in feeling, and of a prolific fancy. Taylor had also the sense and with at come of varied contact with men. All his gifts were made available for influencing other men by his easy command of a style rarely matched in dignity and colour. With all the majesty and stately elaboration and musical rhythm of Milton's finest piose, Taylor's style is relieved and braphtened by an astomishing variety of felicitous illustrations, ranging from the most homely and terse to the most dignified and elaborate

terse to the most digmified and elaborate

The whole works of . Jeremy Trylor with a life of the author and a critical examination of his workings was published by Bushole Regmaid Hebre in 1822, resulted after careful revision by Charles Regmaid Hebre in 1822, resulted after careful revision by Charles Frophetaying, Holy Liviug, and Holy Dying have been often reprinted by Dr. A. B. Grosait in vol. 1 of the Miscellanies of the Fulley Workshop to the Forms and Versa-transitions of Jeremy Trylor were edited by Dr. A. B. Grosait in vol. 1 of the Miscellanies of the Fulley Workshop the Fulley Workshop to the Fulley Workshop to the Fulley Workshop to the Fulley Workshop to the Fulley Workshop to the Fulley Workshop to the Fulley Workshop to the Fulley Workshop to the Workshop t

TAYLOR, JOHN (1580-1653), English pamphleteer, commonly called the "Water-Poet," was born at Gloucester Aug. 24, 1580. After fulfilling his apprenticeship to a waterman, he served (1596) in Essex's fleet, and was present at Flores in 1597 and at the siege of Cadiz On his return to England he became a Thames waterman, and was at one time collector of the perquisites exacted by the lieutenant of the Tower. He was an expert in the art of self-advertisement, and achieved notoriety by a series of eccentric journeys. With a companion as featherbrained as himself he journeyed from London to Queenborough in a paper boat, with two stockfish tied to canes for oars. The Pennyles Pilgrimage, or the Moneylesse Perambulation of John Taylor . . . how he travailed on foot from London to Edenborough in Scotland . . . 1618, contains the account of a journey perhaps suggested by Ben Jonson's celebrated undertaking, though Taylor emphatically denies any intention of burlesque. He went as far as Aberdeen. At Leith he met Jonson, who good-naturedly gave him 22 shillings to drink his health in England. Other travels undertaken for a wager were a journey to Prague, where he is said to have been entertained (1620) by the queen of Bohemia, and those described respectively in A very merry, wherry ferry voyage, or Yorke for my money, and A New Discovery by sea with a Wherry from London to Salisbury (1623). At the outbreak of the civil war Taylor began to keep a public house at Oxford, but when the royalists surrendered the city he returned to London, where he set up a similar business at the sign of "The Crown" in Phoenix Alley, Long Acre. He was buried in the churchyard of St Martin's-in-the-Fields on Dec. 5, 1653

Staty-three of Taylors' "works" appeared in one volume in 150. This was reprinted by the Spenner society in 1868-69, being followed by other tracts not included in the collection (1879-18). Some of his more amusing productions were edited (1872) by Charles Hindley as The Works of John Praylor. They provide some very entertaining reading. Mr Hindley edited other tracts of Taylor's in his Macciones Antique Angleson (1873).

TAYLOR, JOSEPH (c. 1586-1652), English actor, is mentioned in the follo Shakespaere of 1623 as one of the 26 who took principal parts in all of these plays. He was with the duke of York's company in 167c, but involved himself in a lawsuit with John Heming, by leaving them to join the Lady Elizabeth's in the next year. He appeared in the actor list of the latter company in The Honest Marks Fortune (1613) and The Coxcomb (1613). From 1636 he was one of the prince's company, but left they to join the king's men in 1619. He remained with them until he retired, playing several of Burbage's parts, including Ferdinand in The Duchess of Malfi, and Hamlet There is a legend that he was trained by Shakespeare to play Hamlet In many of F Beaumont and I Fletcher's plays he had a leading role, and he is one of the ten actors who signed the dedication of the first tolio of these dramatists (1647) He led the king's men, with J Lowin, after Heming and H Condell, and in 1630, after Heming's death, obtained two shares in the Globe, and one in the Blackfriars theatres. In 1630 he was appointed veoman of the revels. He died at Richmond, where he was buried Nov. 4, 1652.

TAYLOR, TOM (1817-1880), English dramatist and editor of Punch, was boin at Bishop Wearmouth, on Oct 19, 1817 He was a fellow (1837) of Trinity college, Cambridge, and for two years professor of English literature at University college, London He was called to the bar (Middle Temple) in Nov 1846, and went on the northern circuit until, in 1850, he became assist-ant secretary of the Board of Health On the reconstruction of the board in 1854 he was made secretary, and on its abolition his services were transferred to a department of the Home Office He retired on a pension in 1876. Four burlesques of Tom Taylor's were produced at the Lyceum in 1844. He made his first but with To Parents and Guardians (Lyceum, 1845) He also wrote some burlesques in conjunction with Albert Smith and Charles Kenny, and collaborated with Charles Reade in Masks and Faces (1852) Before the close of his life his dramatic pieces numbered over 100. amongst the best known of which are Our American Cousin (1858), produced by Laura Keene in New York, in which Sothern created the part of Lord Dundreary; Still Waters Run Deep (1855), Victims (1857), and the Ticket of Leave Man (1863).

Taylor wrote leaders for the Morning Chronicle and the Daily News He was on the staff of Punch until 1874, when he succeeded Shriley Brooks as editor He was a good amateur actor, an artist, and an art critic of The Times. He died at Lavender

Sweep, Wandsworth, on July 12, 1880.
TAYLOR, ZACHARY (1784-1850), twelfth president of the United States, was born in Orange county, Virginia, Nov. 24, 1784 Within the year his father, Richard Taylor, an officer in the Revolutionary War, made a new home for his family in Kentucky where Washington appointed him collector of the port of Louisville, then on the border and Spaniards and Indians were still a menace In this environment Zachary Taylor spent his youth, and gained what little schooling he was to enjoy from Elisha Ayres, a New England tutor, who was employed by the elder Taylor to ground his numerous family in the rudiments. In 1806 he volunteered during the difficulties caused by Aaron Burr's southwestern schemes and saw brief service. Two years later through the instrumentality of his relative, James Madison, and others, Zachary Taylor was given a commission by Jefferson as first lieutenant in the seventh infantry

In 1810 he married Margaret Smith (1788-1852) As captain and major he served through Harrison's Indian campaign and the War of 1812 in the northwest territory and at the close of the war temporarily left the army because reduction to peace-time strength had lowered his rank. However in 1816 President Madison reappointed him to his old rank and there ensued twenty years of garrison life at various posts, varied in 1832 by an expedition against Black Hawk. The outbreak of the Seminole War in 1837 found him an infantry colonel in the Northwest and soon orders came for him to take his command to the Everglades. In this bewildering warfare he spent three years gaining promotion to the rank of brigadier-general by brevet for his service in the battle of Kissimmee on Lake Okeechobee and receiving command of operations. He was able to make little impression against these Indian foes and in 1840 asked to be relieved. He was given command of the first department with headquarters in Louisiana, which enabled him to acquire a plantation at Baton Rouge and establish a home where he spent many intervals between tours of inspection. When Texas was acquired in 1845 it fell to him to protect the new possession and he was ordered by the War department to occupy the borders of Texas, by the spring of 1846 he

over 3,000 men and established Ft Brown The Mexican army was concentrated across the river with orders to drive the Ameiicans out of the contested area, the result was a skirmish on the American side of the liver, April 24, and war was immediately declared Taylor found himself in a precarious situation because of the exposed position of his base of supplies at Pt Isabel and while manoeuvring to protect this base he fought the Mexican army winning two victories at Palo Alto (q v ) and Resaca de la Palma (qv) on May 8 and 9, 1846 These victories sent the Mexicans across the river to Matamoras Taylor was unprepared to follow up his advantage so when he finally crossed the river and occupied Matamoras (May 18), the enemy had gone The news of these victories was received with great appreciation throughout the country and various persons including Whig editors and politicians began to see the possibilities of a presidential candidate in the victorious general Thereupon, because Gen Winfield Scott, commander of the army, was so slow in preparing to take active charge, President Polk placed Taylor in command of the invasion of Mexico and appointed him major-general at first by brevet and then in full rank. After slow preparations at Matamoras he moved in August to the head of navigation on the Rio Grande where he established a depot at Camargo and then set out for his first objective, Monterey September 21-24 witnessed a senes of vigorous skirmishes, heroic assaults and grave errors Taylor with little knowledge of military science or the use of artillery resolved to take the town by bayonet assault which caused considerable slaughter of his own men. But the fighting was so effective that on the third day the Mexicans agreed to surrender if they be permitted to retreat and be granted an eight weeks' armistice, subject to the approval of the respective governments. Taylor accepted these terms, and "Old Rough and Ready," was acclaimed once more throughout the land Vexations followed The War department began to make sug-

gestions as to the movements of his subordinates and the administration disapproved the armistice. These matters incensed Taylor who was becoming convinced that Polk and Marcy were trying to discredit him because of their political differences. He vetoed the plans for his subordinates, wrote a letter to Gen. Gaines criticizing the administration which later found its way into the press and brought down Marcy's rebuke, and moved on to Saltillo which he occupied Nov 16, deciding to take possession of the territory between that point and the sea-coast where Tampico had fallen into the hands of the navy. While carrying out these plans he received a letter from Gen Scott informing him that Scott was to lead an expedition into Mexico and, without divulging the plan, indicated that he would need most of Taylor's troops, requesting a meeting to perfect the details Taylor upon receiving this note decided that instead of meeting Scott he would go as far away as he could and accordingly went to Victoria which Quitman had lately occupied When Scott learned of this move, he contented himself with ordering the greater part of Taylor's troops to the coast to embark for Vera Cruz while with the remainder Taylor was to defend the occupied territory in northern Mexico Taylor protested to the War department and informed Senator Crittenden that he was a receptive candidate for the presidency. Reluctantly he led the remnant of troops left him by Scott back to Monterey, but instead of remaining there moved southward where word came that Santa Anna with 20,000 troops was advancing upon Taylor who had only a quarter of that number. The armies met at Buena Vista (q.v.), Feb. 22, 1847, and in spite of his lack of skill, his army inspired by his presence snatched a victory from defeat and the north of Mexico was saved At home, the feeling was general that Taylor had been stripped of his troops by a jealous administration and left to perform the impossible. This ended his military activity but his political availability increased.

Shrewd politicians had become increasingly convinced of his potentialities as a candidate. The Whig party was especially in need of a strong candidate to retrieve the defeat of 1844. Very early in the war, Thurlow Weed of New York began pushing him and popular enthusiasm made his task easier. His correspondence was skillfully handled; he was reluctant, he maintained, and with had moved down to the mouth of the Rio Grande with a force of truth, to be a seeker for the office; he had never voted and though

a Whig in sympathy was not an avowed partition. As a slaveholder, also he was certain to gain votes in the south where there was a good deal of suspicion that northern uniteness dominated the Wing manages. These advantages were sufficient to ensure success and in the Wing convention on the fourth ballot, Taylor won the normanton from Clay, Webster and Scott. An opportune split in the Democratic party ensured his victory and on March 5, 1849, he was manuranted ensured.

Few presidents have had less knowledge of what was expected of them. The new executive expected to be a nonpartisan president, leaving to congress all legislative matters and confining himself to executing the laws "With Col Bliss, in so-in-rlaw, to phrase his thoughts, he, at first, was more or less influenced in his policies by Vice-Pers Fillmore, but it was not long before the superior astuteness of Sen. Seward, Fillmore's rival in New York state, accompladed results. The new president became convinced that it was his duty to build up the Whing party by means of elever natronace, and deservine Whise becam to come into their own

With these preliminary lessons learned, Taylor found his most perplexing problem to be the status of the newly acquired territory. As a soldier he was anxious to see stable government established. In order to hasten this he authorized Congressman King of Georgia to go to California and urge an application for statehood When congress met, Dec 1849, the president had the pleasure of reporting that California was ready to become a state and that New Mexico would be soon He recommended the admission of Cahfornia and hoped that the slave issue would not be injected into the situation. When southern representatives objected because California had prohibited slavery, he resented their protests He declared himself willing to accept any law providing for admission, passed by congress and warned southern leaders that he would take the field if necessary to carry out such a law and hang any who resisted His attitude was the natural reaction of a military executive to those opposed to the regular process of law and order. Consequently he was not in favour of conciliating those opposed and referred contemptuously to the Compromise measures of 1850 as the "Omnibus Bill." In other respects his administration was not proving a sinecure; charges were made against his secretary of war. Crawford, to the effect that he had used his official position to pursue a claim successfully before the secretary of the treasury by which he benefited financially This charge involving the secretaries of war and the treasury as well as the attorney general, deeply mortified Taylor who prided himself on scrupulous honesty and he determined to reorganize his cabinet. Then came the fatal July 4, 1850, when exposure to the heat and injudicious eating combined with worry, aggravated an attack of typhus fever, which caused his death five days later. A combination of honesty, simplicity, determination and common sense had brought him successfully through a variety of difficult situations and by a strange turn of the wheel carried him to the White House. Taylor had six children, three of whom survived him. One daughter, Sarah Knox Taylor, married a young subaltern, Jefferson Davis, in 1835, surviving the marriage but three months. His only son, Richard Taylor (1826-1879) graduated from Yale in 1845 and after a short service in his father's camp, became a sugar planter and politician in Louisiana. At the outbreak of the Civil War he entered the Confederate army and served in various capacities, finally commanding an army

and serven in various capacities, many commanding an army which surrendered in May 1366, "Scachary Taylor" in Great Communication of the Communication of the Communication of the Mexican War (1968); Justin H. Smith, War with Mexico (1976); Frederick Bancrott, Wilson H. Seeard (1899). (R. F. N.)

TAYLOR, an anthractic running borough of Luckawanna Co.,

TAYLOR, an anthracite-mining borough of Lackawanna Co., Pa , U.S., on the Lackawanna river. Pop. (1950) 7,167.

TAYLOR, a city of Williamson county, Texas, U.S., 35 ml. N.E. of Austin, on the Missouri-Kansas-Texas and the Missouri-Pacific railways. Pop. (1950) 9071; (1940) 7,875. Taylor is a great inland cotton market. A large bedding factory, pecanshelling plants and other industries using local raw materials were established there.

Taylor was founded in 1876 and incorporated in 1882. It established a council-manager form of government in 1914.

**TAYLOR'S THEOREM**, the statement of a formula discovered by Brook Taylor  $(q \ v)$  in 1/12 and published three years later in his Methodus incrementorum directa et inversa (1715) It may be written in the form of an infinite series.

(1) 
$$f(x+h) = f(x) + hf'(x) + \frac{h^2}{2}f''(x) +$$

$$a = 1$$
,  $log_o(x+h) = O + h - \frac{h^2}{2} + \frac{h^3}{3} - \frac{h^4}{4} + \dots$ 

Taylor's formula with remainder may be written as a finite sum:

(2) 
$$f(x+h) = f(x) + hf'(x) + \frac{h^{n-1}}{(n-1)!} \int_{0}^{\ln(n-1)} (x) + R_n,$$
  
where  $R_n = \frac{h^n}{n!} \int_{0}^{\ln(n)} (x + \Theta h)$ , and  $\Theta$  is

a fraction between o and r Several other formulas have been devised for R<sub>\*</sub> Sometimes one of these may be used to check on the accuracy obtained by using a given number of terms of (r). Moreover, formula (2) is valid m some cases when formula (1) is not

Infimita (1) is not

See W A Granville, P F Smith and W R. Longley, Elements of
the Differential and Integral Calculus.

(L M G)

the Digerential and Integral Calculus.

TAYLORVILLE, a city of central Illinois, U.S., near the south fork of the Sangamon river, 25 mi. S.E. of Springfield, the county seat of Christian county, it is on state highways 29, 48 and 104 and is served by the Baltimore and Ohio, the Chicago and Illinois Midland and the Wabsha rialways.

The population was 9,188 in 1950 and 8,313 in 1940 by the federal census

Bituminous coal is mined near the city Agricultural products include soybeans, grain and dairy products, and there are poultry and other livestock farms Paper and paper products, tools and feed are manufactured

The Taylorville Municipal airport is 1.2 mi SW of the city The Breeze-Courier, a daily newspaper, was founded in 1894 and St. Vincent's hospital was established in 1006

Incorporated as a city in 1882, Taylorville established the mayor-council form of government The city became the owner and operator of a city waterworks

TCHEREPNIN, NICOLAI (1872-1945), Russian composer, was horn at S. Petersharq (Leningrad) on May 15, 1873. In 1895 he entered the St. Petersharq conservatory, where he studied composition under Nicolas Runsley-Korsskov. In 1997 he became professor at the St. Petershurg conservatory, and from 1909-12 he conducted for Sergel Dasphiley the ballet producer, in Paris and other cities. In 1914 he returned to Russia and was director of the conservatory at Trills; 1038-21 Trills; 1038-21.

He settled in 1921 in Paris, where he was director of the Russian conservatory, 1923-27 and 1938-45. He became president of the Conseil du Curatelle of the M. P. Belaieff foundation in 1938. His works include the ballets Le pavullon d'Armude, Naccissus and The Romances of a Munmy (1925); the opens and Vanha; orchestral compositions; and more than 200 songs. He died on June 28, 1945, in Paris

His son ALEXANDER TCHEREPNIN, born in St. Petersburg of Jan. 21, 180,0 became a composer and pianat. His pruncipal works include The Prescoss of Afonta, a ballet produced by Anna Pavlova in 1933, the open of 10 (1928), a number of compositions for chamber orchestra and more than 100 piano pieces. He toured extensively in the orient, Europe and the US.

In 1949 he was named professor of composition and piano at DePaul university in Chicago, Ill.

TCHERNAIEV, MIKHAII. GREGORJOVICH (1828-1898), Russian general, a member of a noble family, was born on Oct. 24, 1828. Educated at the Nicholas Staff college, he en-

Me Lon

tered the army in 1847 and distinguished himself in the Crimean War and in the Caucasus

After serving as divisional chief of the staff in Poland, he went to Orenburg in ±85 as assistant to the commander of the line of the Syr-Darya, and the following year commanded an expedition to support the Kurghtz tribes on the borders of the Sea of that against the Khuvans. He did duty on the staff of the army of the Caucasis for a time, and returned to Orenburg as chief of the Staff the Shrunars.

In 1864, having teached the rank of major general, he made his famous march with 7,000 men across the steppe of Turkestan to Chunkent in Khokand, to meet another Russian column from Semipalatinsk, in Siberia, in conjunction with which he successfully stormed Chimkent, and then unsuccessfully attacked Tashkent, so mi farther south. Wintering at Chimkent, he captured Tashkent the following year. This was contrary to his instructions, and although he was received in St. Petersburg with enthusasm, and presented with a sword of honour by the emperor, he was not again employed in the military service, and retred from it in July 1874

Tchernaiev bought, and edited with great success, the Russkiy
Mir in Slavonic interests, devoting himself to the pan-Slavic idea.

In the summer of 1876 he was appointed commander in chief of the Serbian army, but on entering Turkey was driven back by Osman Pasha, who followed him into Serbia, defeating him at Zavechar and Yavor in July, and the campaign in Serbia proved disastrous He rashly proclaimed Milan king of Serbia in September, and in October Aleksmats and Deligrad were in the hands of the Turks and the road open to Belgrade An armistice was concluded, and Tchernaiev resigned his command. In 1877 he visited Austria in connection with his propaganda, but was expelled, and lived for a time in France. In 1879 he organized a Bulgarian rising, but was arrested at Admanople and sent back to Russia. He succeeded Kaufmann (q v.) as governor of Turkestan in 1882, but his aggressive policy led to his recall two years later, when he was appointed a member of the council of war at St. Petersburg. In 1886 his opposition to the central Asian military railway caused him to lose his seat in the council

Tchernaley died on Aug. 16, 1898, at his country seat in the province of Mogiley.

TCHIHATCHEFF, PIERRE DE (PETR ALEKSANDROVICH CHIKHACHEV) (1808-1890), Russan naturalist and geologist, was born at Gatchina near St. Petersburg, in 1808. He entered the diplomatic service and was (1842-44) attached to the embassy at Constantinople; whence he wisted Asa Minor, Syrua and Egypt In 1844 he was charged with a scientific mission to the Altai mountains.

He died at Florence on Oct. 13, 1890 (N.S.). His publications include. Voyage strentifique dans l'Altau oriental et les tions macude. Voyage strentifique dans l'Altau oriental et les Asse Minaure, soit de la frontière de Chine, with atta (1845); Asse Minaure, soit de la constitute de la constitute de cette contrée, 4 parts, Bouque, saint les cassasses de la constitution

TCZEW German Directary), a town of Gdansk province, Poland; pop. (1937) 24,728; (1946) 26,934; on the left bank of the Vistula, o m. S. from Gdansk (Danagy), at the junction of the Wistula, o m. S. from Gdansk (Danagy), at the junction of the wind railway to the wall railway with the main railway with one into nividges. The chief industries are railway with one with the main railway change and the manufacture of sugar, cement and agricultural mighements. It was at Tezew that some of the first battle of WW model.

of the first battles of World War II were fought.

The Poles blew up bridges across the Vistula in an effort to halt the Germans advancing from East Prussia and Danzig, but

the town was occupied in the early stage of the campaign.

TRA. The name given to the leaves or leaf huds of the ten tree
or tea shrub; the manufactured product prepared from the green
leaves by fermentation and firing, the drink prevend from the nair
ufactured product; the afternoon social function at which the
beverage is served.

The word "tea" comes from the Chinese local Amoy dialect word "te, pronounced "tay." In Cantonese it becomes ch'a, pronounced

"chah" The name travelled in this form to Japan, India, Pesia and Russia The Dutch brought the form 'fe to Europe via Para. The English word "tea," originally pronounced "tay" and later "ree" was derived through the Dutch. The word is not to be found in the Bible, the works of Shakespeare, or any other publication in English, previous to the latter half of the 7th century.

Early History .- There is a Chinese legend which places the introduction of tea drinking in the reign of the mythological Emperor Shên Nung, about 2737 BC, but the earliest credible mention is AD 350, when tea was described by Kuo P'o in the Erh Ya or ancient Chinese dictionary The original area of production was in that portion of southeast Asia which includes boidering provinces of southwest China, northeast India, Burma, Thailand (Siam) and Indochma Cultivation and the use of the beverage spread throughout China and Japan under the patronage of Buddhist priests, who sought a means of combating intemperance. Tea had its first handbook in the Ch'a Ching, written by the Chinese scholar, Lu Yu, about A D 780. In it the product appears as a kind of cake made from leaves that had been steamed, crushed and moulded. To prepare it the cake was fired or toasted and shredded, after which it was steeped in salted boiling water. Tea was taxed under the Tang dynasty in China AD 780

The earliest notice of tea in Japanese literature dates from A D. 593, and its cultivation from AD. 805. Japan also had its book of tea, but not until AD 1200

The favourite legend of the origin of tea concerns Bodhidharms or Daruma, a Buddhist saint, who, having fallen asleep over his devotions, cut off his eyelds on awakening and threw them on the ground, where they took root and grew up as a bush, the leaves of which, when drued and infused in hot water, produced a beverage that would bansh sleep.

From China the cultivation of tea spread to Japan from whence it was introduced into Java in 1684 by Andreas Cleyer, a German naturalist and doctor of medicine. Later, in 1837, J. I. L. L. J. Lacosson introduced the first tea plants from China into Java and became known as the founder of Indonesia's tea industry. Tea growing in Formosa dates from the early roll occurry.

Indigenous tea was discovered in northern India (upper Assam) by Major Robert Bruce in 1823, but the founding of the Indian industry dates from the appointment by Gov Gen. Lord William Charles Cavendish Bentinck, in 1834, of a committee to formulate a plan for the introduction of cultivation.

In Caylon, tea dramatically replaced coffee, destroyed by the coffee rust (Hemilien oscitatrs), in the late 1870s. Russia began growing tea in 1847; Uganda, Nyasaland and Kenya 1900. The U.S. experimented with its cultivation under the direction of Dr. Charlie U. Shepard at Summerville, S.C., from 1890 to 1975, when it was given up as impracticable from an economic standpoint. The climate was suitable, but labour was too high, and there was no tariff protection after the Spanish-American War tax of ten centis per pound was repealed (1903).

The first account of tea reached the Arabs A.D. 850; the Venetians in 1559; the English in 1598; the Portuguese in 1600. The Dutch brought the first tea to Europe about 1610; it reached Russia in 1618; Paris, 1648, and England and America about 1650.

Tea was first mentioned in European literature in 1559 as chaicata, "tea of Chma," in Voyages and Travels by Giambattista Ramusio, a noted Venetian author. The first printed reference to tea in English appeared as chas in a 1598 translation of the Travels of Jan Hago van Lin-Schoolen, a Dutch navigator.

R. L. Widdham, in charge of the English East India company/a seproy at Finando, Japan, achieved the distinction of supplying the first reference to tea by an Englishman. In a letter, dated June 27, 1615, to the company's agent at Macoo, Wickham said. "I pray you buy for me a pot of the best chaw." This is probably the earliest poign English for the Chinese che."

The earliest mention of the use of milk in tea appeared in a book of travel by the Dutch author, Jean Nieuhoff, who observed the practice in Canton, China, in 1655.

The first newspaper advertisement for tea appeared in Mercurius Politicus, London, in 1658. It announced: "That Excellent and by all Physitians approved China drink, called by the Chineans Tcha,

862 TEA

by other nations, Tay, alias Tee, is sold at the Sultaness Head Cophee House in Sweetings Rents, by The Royal Exchange, London." About this time metal or leather trade coms, used in lieu of small change, and known as tea and coffee tokens, were much in vague in London's 2,000 coffee houses

Samuel Pepys, in his famous diary for 1660, records that. "I did send for a cup of tee (a China dinik) of which I never had drank before" In 1662 Edmund Waller wrote the first eulogy of tea in English verse and at the same time eulogized England's first tea



FLOWERING SHOOT OF THE TEA PLANT (CAMELLIA SINENSIS), AND (A) SEED POD

drinking queen, Catherine of Braganza. The poem begins:

Venus her Myrtle, Phoebus has his bays, Tea both excels, which she vouchsafes to praise.

It is to Anna, duchess of Bedford, that we owe the custom of afternoon tea. She had tea and cakes served at 5 o'clock because, to quote her, she "had a sinking feeling."

After the coffee houses, tea was sold by chemists' shops, glass sellers, millhers, silk mercers and chmaware dealers. There is even a reference to a "short-hand author" selling tea—his only other trade. As late as 1805, grocers in the Strand were weighing tea in spothecartes' scales.

The world's greatest ten monopoly, the English East India company, on, as it was popularly known, John company, flourished from 1600 to 1858, when it was dissolved. Meanwhile, it figured in many adventures, including the introduction of China and India tess into England and America and the enactment of the Tea act of 1775, which caused the Boston Tea Party and helped precipitate the American Revolution. The Tea act attempted to perpetuate John company's monopoly of the tea trade, a thing distasteful like to British and American merchants. There followed, not one, but say American tea parties.

Here it is interesting to note that, just as England had started out to be a nation of coffee drinkers before John company began

sta propaganda for tea, America started as a nation of tea drinkers; it was the Boston Tea Party that cast the de for coffee. By mid20th century the tea and coffee habits of the two countries were reversed; on a per capita, pound basis. England drank about 5 times as much tea as coffee, the U S drank about 25 times as much coffee as tea.

One of the most picturesque eras in maritime history was the day of the clipper ships, which transported tea from China to England and America. Its most celebrated chapter was perhaps that of the Great Tea race of 1886, which started at Foochow and ended go days later at London after covering 16,000 mil Out of 11 clipper ships, "Taeping" was the winher at the London dock, "Anel," the winner at the Downs, ten muntes shaed of her rival

Three noted American pioneers made their fortunes in the China tea trade They were John Jacob Astor, Thomas Handasyd Per-

kins and Stephen Girard

The advent of the London pleasure gardens in the 18th century brought tea into the open for the first time in England, where it was drunk in public by both sexes Among the historic London tea gardens, Yauxhall, Ranelagh and Marylebone became famous

Tea in Literature and the Arts.—Tea and tea drinking have been celebrated in many ways in literature and the fine arts more than 12 centuries. A notable contribution to tea by the Japanese was its glorification in the art and practice of charno-yit, tea ceremony, literally, "hot water tea." The origin of the teaport is the Chinese wine jug Dr. Nicholas Brady, chaplain to the court of William and Mary, called tea "the sovereign drink of pleasure and of health," in his poem, "The Tea Table." William Cowper wrote of "the cups that cheer but not inchmate," borrowing the phiase trom Bishop Berkeley Paul Revers, the American particle, was farmed to the complex of

Production.—The world's production of tea in the 1900s totalled about 1,300,000,000 ibs annually from an area of approximately 2,000,000 at. These figures do not include production or acreage of China or the US SR, both of which have no bearing on the world supply as exports outside of the two areas are negligible. Authorative sources indicated 1951 production in China of 360,000,000 lb and in the US SR of 40,000,000 lb. For many years prior to World War II China was the largest tea producing country in the world, but India assumed that position in 1941, accounting for more than half of the known world total

While the total yield at best is an approximation, the amount actually placed on the world markets is obtainable from official sources, and according to official reports the quantity exported in 1952 was 918,200,000 lb. Table I shows tea exports of principal countries in 1048—52.

About 1930, increasing surplus supplies of tea on world markets led to unremunerative prices to producers. Regotations for the restrictions of exports from India, Ceylon and what was then the Netherlands East Indies led to the International Tea agreement which came into operation on April 1, 1933, and which established a quota system of exports on a percentage basis of fixed stander export figures. The agreement was renewed in practically the same form from time to time until March 20, 1950, when a new agreement was reached by India, Ceylon, Pakistan and Indionessa Which continued the main features of the previous agreement as regards

TABLE I.—Tea Exports of Principal Producing Countries
(In 1,000 lb.)

Country	1948	1949	1950	1951	1952
India Ceylon Indonesia British East Africa Pakistan Formosa Japan Others*	348,652 295,838 19,760 24,372 32,086 10,485 8,884 34,177 774,854	487,262 297,573 48,350 23,038 27,245 27,904 15,947 26,466 953,785	401,688 208,099 62,850 28,835 16,246 16,463 15,798 35,201 875,180	448,941 305,171 88,387 30,058 47,171 24,963 19,179 35,885 990,755	410,092 314,495 70,268 29,885 23,971 20,553 20,783 28,153 918,200

†Includes among others Indochina, Malaya, Mozambique, Brazil, Southern Rhodesia

TEA 803

regulation of exposts and control of the extension of tea cultivation. After 1940 the export quotas were placed as high as 130% of the standard figure in order to assure unrestricted production of tea while none was available from China. Japan and Indonesia, and in the years 1010wing World War II when demand was aftead of the supply. Administration of the International Tea agreement was entrusted to the international tea committee. London

The bulk of the world's tea is grown in Asiatic countries, Ceylon tion second to India in 1952, with 24% of the total world production exclusive of China and the USSR Next were Japan 9%, Indonesia 6%, Pakistan 4%, British East Africa 3%, Foimosa 2% and other sources 2%

On an exporting basis in 1952 India also led with 44½% of the world total, Ceylon followed with 34%, Indonesia 7½%. British East Africa 3%; Pakistan 2½%, Japan and Formosa 2% each, and all others about 4½% Tea is grown commercially in 19 countries.

Consumption.—About two-thirds of the world's known tea production is shipped each year to importing countries and is consumed there barring stocks held in the principal markets, notably London. The largest tea consuming countries are the United Kingdom, which consumes half of the world's annual exports, the United States, Australia and Canada. The Bittish Commonwealth accounts for the bulk of the world's tea trade—more than two-thirds of all imports and about 109% of recorded exports in 1952.

TABLE II -World's Consumption of Tea (Net imports in 1.000 lb., per capita in pounds)

Countr	1946	1948	1950	1952	
United Kingdom	Total Per Capita	347,840	404,394 8 16	357,808	472,90E
United States	Total Per Capita	91,667 53	89,259	113,563	92,749
Australia	Total Per Capita	50,623 6.85	47,985	60,303	52,956
Camada	Total Per Capita	27,010	34,738	54,876	45,308
Egypt	Total Per Capita	10,778	29,745	35,786 1.75	35,766 1 78
French Moracco	Total Per Capita	8,753 1 03	16,129	23,565	27,389
Union of South Africa ,	Total Per Capita	11,861	17,633	19,734	23,529
Iraq	Total Per Capita	3,860	13,532	15,135	19,0009
Ireland	Total Per Capita	16,173	25,804 8 o7	24,099	17,241
Netherlands .	Total Per Capita	11,913	13,115	18,849	16,186 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
West Germany	Total Per Capita	1 1	1,600	3,698	6,058
Others*†	Total	89,416	130,866	136,484	150,117
Total World*		669,900	824,800	863,300	959,200

\*Estimated †Incides tea imported into producing countries for domestic consumption,

The per capita consumption in the principal consuming countries (1952 estimated) was: United Kingdom, 9 lb.; Australia, 6,5 lb; Ireland, 5,3 lb, New Zealand, 5,1 lb, 1raq, 3 9 lb., Canada 3 4 lb; French Morocco, 3,2 lb.; South Africa, 1,9 lb.; Egypt, 1 78 lb; the Netherlands, 1,8 lb; United States, 66 lb. (W.H.U.)

Botany.-While the tea plant was originally designated by Linnaeus under the binomial system in 1753 as Thea smensis, it is now placed in Camella as C sinensis (family Theaceae). Later Linnaeus recognized two species as previously described by John Hill, viz., T viridis and T. bohea. It was erroneously assumed that the latter was a source of black tea, while T viridis was held to produce green tea. In 1843, however, Robert Fortune found that black and green tea were produced from the leaves of the same kind of plant by varying the process of manufacture There are many synonyms including Thea bohea, T viridis, T. cantonensis, T assamica, Camellia thea, C. theifera and others. At the same time various authors proposed numerous varieties, but many of these have been shown to be untenable, and there is no agreement among botanists or horticulturists as to varietal limits A part of the difficulties was due to the facts that early authors had wholly inadequate collections of reference material and that the tea plant in cultivation, like all cultivated plants, varies in characters, dependent on local conditions and on the special qualities for which various strains were selected and propagated

While the accepted binomial stems from Linnaeus in 1753, the species was well known to earlier European botanical authors, necluding Gaspard Baubin (1633), Dr Jacob Bontius (1658), Lornaeus gives no less than ten references to European pre-Linnaeus gives no less than ten references to European pre-Linnaeus protamial tentrature Linnaeus originally proposed two genera, Theo and Comellia, but it has been clearly shown that two groups cannot be recognized here, because of intergrading characters. The generic name Comellia was retained for this group by action of the International Botannical congress (See TERLECREE) (X)

The tea plant is an evergreen shrub, which in its natural state grows to a height of 5 to 5 of 1, but the tea planter keeps it pruned down to a height of 5 to 5 of 1. In its general appearance and the form of its leaf, it resembles the myrtle, its biossoms are white, with yellow anthers, and suggest the wild rose. These are succeeded by the tea fruit, containing three seeds. The plant grows best in the monsoon climate of the tropics, from sea level up to 6,000 ft; in most temperate zones, where there is danger of frost, it must be kept to low elevations. It does best in the higher altitudes of the tropies. The commercial tea belt of the world is largely confined to a ring of mountains around or near the equator, with as? Wand 33° S

Ten usually is grown from seed in nursery beds On large tea estates the young plants are transplanted to the prepared tea fields when they are 6 to 8 in high, usually in six months' time They are set out in rows, 3 to 6 if apart. In two years they reach a height of 4 to 6 if. Then they are cut down to something less than a foot By the end of the third year they are ready for plucking Chinese, Japanese and Formosan tea growers (mostly small family gardens) do not set out nurseries but propagate by planting the seed streetly where they are to be grown or by layering, i.e., transplanting Weeding, cultivation between the rows and prining go on regularly at different periods for 25 to 50 years, the average life of a tea bush. When in full berang—about the roth year a bush yields as much as a quarter of a pound of leaf in its several flushes during the season!

The quality of the tea is at its best at different seasons in the various tea countries. Teas are pinched all the year around in southern India, Ceylon and Indonesa. Seasonal teas are those countern from ordering finding, the China greens, congous, Japan teas when the countries of the countries

Kinds of Tea.—Generally speaking, teas may be divided into three classes. (1) fermented or black; (2) unfermented or green; and (3) the semifermented or oolong teas. Tea comes from practically the same plant in all countries, the differences in the various classes being due to methods of manufacture and local climatic, soil and cultivating conditions. There are about 1,500 different growths and about 2,000 possible blends.

The fermented, or black, tass include the China congou, or "Englash breakfast," teas, subdivided into north China congou (black leaf) from Hankow and the south China congou (red leaf) from Foochow, India, Ceylon, Java, African and, since 1929, Jana and Formosa blacks. The unfermented, or green teas, include two main varieties—Chinas and Japans; also, such green teas as may be manufactured in India, Ceylon and Indonesia. The semi-fermented (colong) teas are obtained from Formosa and Foochow in China

Manufacture.—Black and green teas result from different manufacturing processes applied to the same kind of leaf. After plucking, the leaf is withered by being spread on bamboo trays in the sun, or on withering tats within doors. The process takes 18 to 24

hours Next it is solled by hand or by machines. The object of rolling is to break the leaf cells and liberate the juices and enzymes sealed within. The roll may last as long as three hours Then it 15 taken to the roll breaker and green leaf sifting machine and after that fermented in baskets, on glass shelves or on cool cement floors under damp cloths for 1 to 41 hours The firing process (drying) follows, in pans or baskets or in firing machines It takes 30 to 40 min The difference between black tea and green tea is the result of manipulation Green tea is manufactured by steaming without fermentation in a perforated cylinder or boiler, thus retaining some of the green colour Black tea is allowed to ferment after being rolled and before firing. In the case of back tea the process of fermentation, or oxidation, reduces the astringency of the leaf and it is claimed, develops the colour and aroma of the liquor In making green tea, the fermentation process is arrested by steaming the leaf while it is green and by light rolling before drying

Semifermented or oolong teas have some of the characteristics of both black and green teas. They are allowed to wither in the process of manufacture and partially ferment

After hrang, teas are graded by being put through outting, sifting and sorting machines, before being packed in wood or mefal tea chests. The principal grades are broken orange pekoe, consisting of terminal buds with portions of the finest leaf that have broken off in the mauricature, orange pekoe, consisting of some terminal buds and the finest leaves; pekoe and pekoe Souchong, consisting of coarser leaves; pekoe dust, dust of the broken time.

Trade Characteristics—The teas that grow and are plucked all the year 'cound are those of southern India, Ceylon and Indonesia. The best qualities in southern India are the fermented teas produced in December and January. In Ceylon the finest quality fermented teas are produced in the months of February, March, April, July, August and September Cypion teas are known chiefly by their garden marks Fernented teas of Indonesia are best in July, August and September. These teas are also known as Javas or Sunatrias or by their garden marks

Northern India's fermented tess are best when made from the second flushes of July, August and September In Assam and the Duars, however, the finest tess are made in November and December Indian tess are named after certain distracts, the best known being Dargeeling. The first pickings from April to October of the north and south Clinia blacks are the best. The north China congous are the burgundres of China tess, the south Chinas are the Clarks. The best China prens are made in June and July although the China are the constant of the China prens are made in June and July although the China are the China prens are made in June and July although and second (July and June) are several crops, but the first and second (July and June) are best, Japans are the white wines of tess. In Formosa there are five recognized crops, viz., spring, summer (two), autumn and winer. The sesson octands from April to November First and second dismere crops (June and July) are the finest. They have been called the champagnes of tess.

Chemical Aspects and Tea Brewing.—The principal chemical constituents of tea are afferne, tannin and essential oil. The first supplies the stimulating quality, which, because of its purity, is without harmful reaction; the second, the strength of body, and the third, the flavour and aroma, chief factors in determining our value in a trade sense:

Arguments against the healthfulness of tea are frequently founded on the experience of individuals or on the assumption that tea is taken in excess; however, tea is the beverage of people in many parts of the world, living in every kind of climate, and generalizations are dangerous.

In 1935 Dr. C. R. Harder, a chemist of the Indian Tea association, said: "A cup of tea contains, on the average, a little under a grain of caffeine and about two grains of tamin. The medical dose of caffeine assignated in the British Pharmacentical codex is 10 5 grains and of tamin 5 to 10 grains. It will be realized, therefore, thick, the average cup of tea these two most important constituents of tea are present in very small amounts, especially, when it is remembered that the caffiene is injected gradually and the tamin is fixed by proteins during its journey through the alimentary tract. The infusion is faintly acid, almost neutral.

Gastric fuice is a thousand times as acid

"When milk is added to tea, the tannin is fixed by the casein in the milk. Sugar added to the tea merely sweetens it and adds to the value of the drink as a food. The addition of milk to tea robs it of practically all its astringency.

"When the infusion is drunk, it passes first into the stomach, where the sugars are absorbed as ordinary foods, and the ingestion of caffeine begins. The comforting effect of the warmth of the drink is at once felt, but the stimulus due to the caffeine comes about a quarter of an hour later."

Table III - Chemical Analysis of Leading Teas\*

	Cafferne per cent	Tannin per cent	Soluble solids per cent
Java (Indonesia) black teas	2 7-4 4	6-20	16-26
Japan green teas	2 0-3 3	4-12	16-26
China black teas	2 0-3 7	5-10	16-22
Formosa colong teas	3 1-3 7	12-23	23-25
India black teas	2 0-3 0	6-10	22-25

Trive-minute intusion
Source J J B Deuss, L'Agronomic Coloniale (Paris, 1924), No 80 and C R Harler,
the Callure and Marketing of Tea (New York, 1933)

In the British Isles, Australasia, North America and the Netherlands, where most of the black teas of India, Ceylon and Indonesia are consumed, the beverage is drunk primarily for its stimulating effect. The alkaloid caffeine, responsible for the stimula, has a slightly bitter taste when taken in medicinal quantities, but the small amount present in the usual cup of tea is practically tasteless. Usually, sugar, milk or cream is added

In Russia a pot of strong China tea is brewed and put in the samovar. A little of the extract is put in a glass, hot water added, also a slice of lemon, sugar or jam. Americans have made iced tea

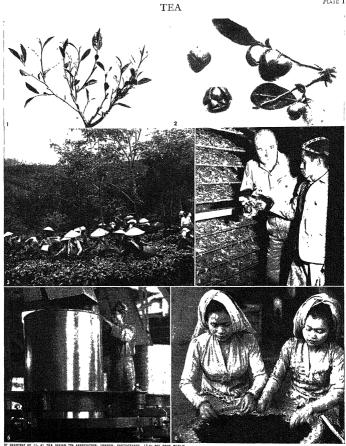
a favourite summer drink The ideal preparation of tea is one which extracts a maximum of caffeine and a not excessive amount of tannin. Such a preparation also conserves the aroma and flavour-evanescent qualities easily lost by careless preparation. From the chemist's point of view the two main essentials in tea brewing are fresh water, freshly boiled, and a three- to five-minute infusion. The tea used should be suitable to the water of the locality in which one lives. Tea infuses more readily in soft water than in hard. Small, thick, full teas are required for soft water, brisk, full, flavoury teas where the water is hard. Liverpool water, which comes from the Welsh mountains near by, is said to be the softest water in England and the best for making tea Water fresh from the tap is the first essential The second is to bring it to a bubbling boil and pour it at once upon the tea leaves To delay means that the water will go flat, and flat water will spoil the finest tea Hence the discouraging concoctions on steamships and railways

Generally speaking, a five-minute infusion is best for fully fermented teas like those of India, Ceylon or Indonesia, but George F. Mitchell, a U.S supervising tea examiner, reached a slightly different conclusion in a series of tests in 1904-05 at the U.S. department of agriculture.

These investigations demonstrated that a perfect cup of tea from a chemical standpoint was, unfortunately, not a perfect cup of tea from the consumer's standpoint. From a chemical standpoint the length of time in which the maximum amount of caffeine and total soluble matter was extracted, with the minimum amount of tamm, averaged three minutes after boiling water had been poured on the leaves. After that time more tannin was extracted, with only a small amount of caffeine. Usually, however, this makes a view "skinny" cup of tea, lacking body and a certain amount of punequely that is desired by all tea drinkers; and, of course, if cream or milk is added to this beverage, it takes away from the small amount of pungency that is dost of the standard papears even less desirable.

For this reason Mitchell concluded it best to brew tea, that is to be drunk without cream or milk, from three to four minutes, and that to be drunk with cream or milk from four to five and even six minutes, as in some teas the real flavour does not come out until after a sx-minute infusion.

Stated in general terms for all loose teas, this, then, is the best practice: (x) buy the highest grade of the kind of tea suited to your taste and the locality where you intend to use it; (2) use



PREPARATION OF TEA FOR MARKET

- 1. A tea shoot Only the bud spike and the first two leaves are plucked 2 Tea seed-vessels, showing the seeds
- 3. Harvesting tea in Java The pickers ordinarily pluck the tender new flushes from the tea shrubs every ten days
- Drying room, where het air dries out the sap and moisture in the leaf
   Machine in a Javanese factory which rolls the text leaf
   Javanese women sorting text to remove stray twigs

TEA PLA1E II



MARKETING TEA

Tea auction at Colombo, Ceylon
 Samples being prepared for buyers at a tea auction in Ceylon
 Ench
 A Packaging tea in a London factory sample is weighed and boiled for the occasion

3 Professional ten tasters at a factory in London

freshly drawn slightly soft or slightly hard cold water from the tap or laucet, (3) burng it to a bubbing boil, (4) allow one counsel, slandard teaspoonful of ten for each cop of a required; (3) pour freshly boiling water over the ten leve of a red electricative, porcelain, or glass pot and let them steep for therefore the depending upon the kind of tea used. Six while naturang; (6) pour off the fuquor into another heated china pot, never use the leaves a second time

Bullocouselly — C. P. Cohen-Stuart. "A Bais for The Schettlyng Bull Jard Bol Businesors, in 1. 139-120, Dl. 1-21, thiblograthyng 160-319 (1919), Kalano Ökakuna, The Book of Tea, 14th edl (New York, 128.), F. W. F. Staweser, Tea and Tea Deains (Toronto, 1918), and the Common of the

TEA-CADDY, a box, jat, canister or other receptacle for a. The word is believed to be derived from catty, the Chinese pound, equal to about a pound and a third avourdupors. The centrest examples that came to Europe were of Chinese porcelain, and in shape resembled the ginger-jar. They had lide or stopers likewase of china, and were most frequently blue and white. The English kilns at first imitated them, but speedily devised forms and ornament of their own, and there was hardly a ceramic factory in the country which did not compete for the supply of the own fashion. But tea-caddies were not for long confined to pormation and the control of the

TEA CEREMONY is a time-honoured institution in Japanan institution rooted in the principles of Zen (a sect of Buddhism) and founded upon the adoration of the beautiful in the daily nonline of life, such as preparing a meal and tea, cleaning the house and garden, etc. The Japanese word for tea ceremony, Cha-no-yu, literally hot water of tea, means an aesthetic way of entertaining guests, usually five at a time, with thick and weak tea of pulverized tea-leaf whipped in hot water, preceded by a meal, according to the established rules of etiquette. The entertainment takes place in the tea-room (chaseki), usually a small building constructed to suggest a refined poverty, though with great forethought and after endless trouble in the choice of the material and in the construction. The room in which the guests are entertained is generally about 9 ft. square, or smaller, containing an alcove for ornaments and a small fire-place for boiling the kettle, sunk into the floor. Into that room each guest in humility crawls through a small opening less than 3 ft. square. It is connected with the waiting room by stepping stones through a garden path (roji), which should contain a water basin (tsukubai) for the guests to rinse mouth and wash hands before entering the tea-room.

In this ancient institution—for it was founded under the Shogun Yoshimasa (1449-73) and perfected by Senon Rikyu in the 16th century—which still continues to influence the life of the Japanese people and all their art, the spirit of old Japan still lives.

BIBLIOGRAPHY.—E. S. Morse, Japanese Homes and Their Surroundings (1885); F. Brinkley, Japan—Its History, Arts and Literature (1901); Kukuzo Okakura, The Book of Tea (1906). (J. Has.)

TEACH [Tharcit or Thack!]. EDWARD (d. 1718), English pirate, popularly known as Blackbeard, is believed to have been born at Bristol. He is said to have gone out to the West Indies during the war of the Spanish Succession, to have enged in privateering, and after the declaration of peace (1713) to have turned pirate, but he is not actually heard of in this capacity till the end of 1716. The following year he captured a large French merchantman, rechiratened her "Queen Anne's Revenge," and converted her into a warship of forty guns. His outrages in the Spanish main, the West Indies, and on the coasts of Carolina and Virginia, quickly earned him an infamous notoiety. He made his winter quarters ha an inlet in North Carolina, the of his crimes, but the governor of Virginia at last despatched two sloops, manned from the British warships on the station, to cubim out On Nov. 22, 1718 Lieutenant Maynard boarded Teach's sloop, after a sharp fight, and himself shot the pirate dead

TEACHERS, TRAINING OF. The traumg of teachers dates, in England, from the beginning of the 19th century, when the National Society for Promoting the Education of the Poor in the Principles of the Church of England and its Nonconformist rival, the British and Foreign School society, first attacked the problem of elementary education on a national scale. Both these societies adopted the "monitorial system," the principle of which was that picked older scholars should learn their lessons from the adult teacher in charge of the school and hand them on to the younger children. Some training of the instruments of this system was found to be necessary and training schools were accordingly set up to give it. One of these developed into the Borough Road training college which is still in existence. About 1840 James Kay (afterward Sir James Kay-Shuttleworth), a far-seeing official to whom, more than to any other single man, the English educational system is due, began the movement which replaced the monitors by "pupil-teachers"; i.e., boys and girls who were regularly apprenticed for a period of five years from the age of 13, and both learned the art of teaching and continued their education under the head teacher of an elementary school. Kay's scheme also involved training colleges where the professional and academic education of at least the best pupil-teachers could be carried to a higher stage after their apprenticeship was completed. He himself founded the college which, as St. John's college, Battersea, London, was taken over by the National society and furnished a model widely imitated. Within a few years the church had training colleges in a large proportion of its dioceses and there was a smaller number of others founded by Nonconformist bodies. As the result of Kay-Shuttleworth's efforts these colleges came into a definite relationship with the government; they received financial assistance toward the cost both of building and of maintenance, a competitive examination was instituted upon the results of which "Queen's scholarships" were awarded to former pupil-teachers who came to them for a period of training, and contributions were made to the salaries of the teachers they turned out. As a condition of this financial aid to the colleges and their students, the government laid down the courses to be followed, conducted the examinations on the results of which it awarded to successful candidates its Elementary School Teacher's certificate and required the colleges to submit to inspection.

The voluntary colleges which developed on this basis are still an important factor in the training of teachers. At the beginning of the 20th century the length of their course became standardized at two years; they are, accordingly, often referred to as two-year colleges. Their monopoly of training was broken in 1893, when new regulations made it possible for the universities to open grant-ided departments for the training of teachers. All the universities and university colleges have taken advantage of these regulations. The Education act of 1902 made it possible also for local educational authorities to found and maintain training colleges. These differed from the voluntary colleges in having no religious affiliation and in being often day as distinguished from residential colleges.

The act of 1902 led also to drastic changes in the education of pupil-teachers. Under the act the local authorities were given

powers in connection with secondary as well as elementary educa- year students who had taken a degree in honours at the end of tion and could establish secondary schools. It thus became possible for the board of education to insist that entrants to training colleges should normally have taken a four-year course in a secondary school. The effect of this reform upon the culture and outlook of the elementary school teacher-who had hitherto spent his life, as a rule, within the confines of the elementary systemwas without doubt highly beneficial It also led to the gradual disappearance of the pupil-teacher system, for as the standards of secondary education rose it proved impossible for the young intending teacher to comply with them, and at the same time to receive the old thorough training in teaching. Pupil-teachers tended first to give place to "student-teachers," who after an uninterrupted general education until the age of 17 entered upon a year of preliminary training in an elementary school chequered by continued attendance at their secondary school But a departmental committee on the training of teachers for elementary schools reported in 1925 against the perpetuation even of this remnant of the old system, and although many local authorities long clung to a belief in its efficacy there was a growing tendency to follow the recommendations of the report and to allow intending teachers to complete the full secondary course terminating at the age of 18 and to enter college without passing through any considerable period of professional probation or initiation. The resultant advantages were a wider and deeper culture in the teachers and the preservation of a power of growth which the older system, it is alleged, often destroyed; it is, on the other hand, only fair to note that the strain upon the disciplinary powers of the young teacher-which only the drastic training of the old system could enable him to meet-has largely disappeared under modern condi-

The curriculum in the two-year colleges has always included academic and professional elements side by side With the improvement in the educational standard of the entrants and the attenuation of their preliminary training there was for long a growing tendency to emphasize the professional side of the work The academic studies were practically confined to subjects within the curriculum of elementary schools, the professional work comprised instruction in the theory of education, methods of teaching, hygiene, practical subjects and teaching practice under supervision in schools Until 1930 the curriculums were laid down by the board of education, which also conducted the final examination for the Elementary School Teacher's certificate In that year the training colleges were classified into groups around the universities and university colleges and joint examining boards. representative of the universities and the colleges concerned, took over the conduct of the final examination Boards of studies, similarly representative, framed the syllabuses. The board of education retained the right to judge the efficiency of the practical training given by the colleges.

Concurrently there were important developments in the university training departments. These were established to enable a select number of intending elementary school teachers to come under the broadening influences of university life and teaching; they developed into institutions by whose aid future teachers might obtain a university degree and professional training. For some time the maximum length of the course was three years and professional training was given along with the student's academic studies. It was, however, found that the full value of the scheme could not thus be obtained; the course was, accordingly, extended to four years, the first three being devoted entirely to preparation for a degree and the last wholly to a course of professional training. Students admitted to the four-year course received a free academic teaching and professional training and, like the two-year students, an annual grant for maintenance from the board of education.

The original theory of the four-year course was that it was to supply the elementary school system with teachers of superior ability, education and training; but a very large proportion of the graduates it turned out found their way into secondary schools. Eventually the board extended its grant system to include graduates in honours in the university departments, and permitted fourthe third year to be transferred to those departments So slight a change in official regulations has not often produced greater consequences Formerly training expressly intended to fit teachers for secondary school work was almost nonexistent; within a few years it became almost universal

After World War II radical changes transformed the organization, curriculums and methods of teacher training. In 1944 a departmental committee, under the chairmanship of Sir Arnold MacNair, recommended (though not unanimously) that the universities should assume responsibility for the training of all teachers, establishing schools of education for the purpose With three exceptions the universities and university colleges acted upon this recommendation In 17 geographical areas university (or college), local education authorities and training establishments (including university training departments) combined to form area training organizations (ATO), responsible for the training and examining of intending teachers, providing refresher courses and other services for serving teachers and promoting research. At the centre of each ATO was the school (generally called institute) of education In the three areas where the university had not accepted full responsibility the organization was similar, but financed by the ministry of education

The Education act, 1944, demanded a greatly increased teaching force Between 1945 and 1951 the ministry of education organized an emergency training scheme Men and women from the armed services and war industries were given an intensive 13-months' course in 55 colleges specially created, staffed (largely by serving teachers) and equipped for the purpose The scheme produced about 35,000 qualified teachers, and a large amount of experimental work, the fruits of which were incorporated into the prac-tice of the permanent colleges The two-year course comprises professional studies (including supervised teaching practice) and personal education The former, obligatory for all students, covers the principles and practice of education, health education, physical training and a course in English usage. The latter is a matter for personal choice The student selects, with guidance, two (occasionally more) subjects from the list the college has to offer, one to be studied intensively to the highest standard within his capacity, the other more extensively but to less depth.

Training facilities were more than doubled during these postwar years By 1952 there were 24 university training departments, III general and 25 specialist colleges and 16 approved art schools with an annual production of about 14,000 teachers

Europe.-In continental countries it is usual for elementary and secondary school teachers to be trained separately and differently, the former in training colleges and the latter by graduating at a university-to which professional training may or may not be added. In France all teachers in state elementary schools have to be trained, but only those teachers in secondary schools who are teaching pupils who have come from elementary schools. In Germany the secondary school teacher does his training by working in a school, the elementary school teacher in a Padagogische Akademie The Danish training colleges qualify graduates for both elementary and secondary schools, but most secondary school teachers have attended a university. (H. C. D.)

## UNITED STATES

In the United States, as in England, teacher training began in the monitorial schools. The Lancasterian system was introduced into New York in 1806 and spread quickly to other cities. The system could be used only in large schools; and to direct these the head teacher had to be skilled in organization and management Joseph Lancaster himself instituted a model school to train head teachers for his system in Philadelphia in 1818, and some who were prepared there organized monitorial schools in other cities. Lancaster's book entitled Improvements in Education was imitated by U.S. writers who prepared guides to the system The popularity of the monitorial schools soon declined and by 1830 they were dying out.

Academies flourished in the 19th century and became the second type of teacher-training institution. In an academy at Concord,

# TEACHERS REGISTRATION COUNCIL

Vt., Samuel Read Hall began in 1893 and continued for some years to conduct classes for teachers, and he prepared a textbook, Lectures on School-Keping (1820), which dealt with school discipline, the course of study and methods of teaching. His book was used in other academy training classes and was otherwise widely distributed. The legislature of New York had 10,000 comes initied for the teachers of that state

In 1844 the New York legislature authorized the regents to substidie training classes in selected academies. They were required to teach, in addition to other subjects, "the principles of teaching." This may be, as has been claimed, the first state was on the training of teachers. Except for a short interval, the substidies to the academies were continued even after the state

had begun to maintain normal schools

State Normal Schools.—The preparation of public-schools teachers gradually came to be considered a function of the states, and this was the beginning of the modern teacher-training system In 1839 Massachusetts created a state normal school at Lexington This paralleled similar foundations in Europe, Great Britand Latin America, and was everywhere due in part to the sprand of the teachings of Johann H Pestalozia (qr v) Against opposition, Horace Mann persuaded Massachusetts to establish three additional state normal schools The policy of so locating the schools that they would be accessable from different sections of a state was widely adopted Before 1800 eight states and by 1900 nearly all of the states had one or more such institutions.

The normal schools admitted pupils who came directly from the elementary schools and prepared them to teach in those schools. The length of the course of study was, at first, only a year or less, but was in time increased to two or even three years It comprised reviews of the common school branches, professional studies including school management, principles of teaching and observation and practice teaching in a model school

Advanced subjects were taught to provide some secondary education, but this tended to change the normal schools into collegepreparatory institutions, and the custom of using the vocation of teaching as a steppingstone to a more lucrative profession rein-

forced this trend

The typical normal school was neither organized nor staffed to prepare teachers for high school students—a group that expanded rapidly after about 1890. The failure of the normal school to meet the rising standards of the teaching profession and of its graduates to compete successfully with graduates of colleges and universities became increasingly apparent and, by 1915, the regardination of normal schools into degree-granting four-year teachers' colleges, a movement that had begun before the turn of the century, was well under way.

The progress of the whole movement may be traced in the sense of organizations formed to promote it. The American Normal School association (18,88) was followed by the department of normal schools (18,70) of the National Education association, and this in 1917, under a slightly different name, by the American Association of Colleges for Teacher Education.

Supplementary Training—At no time were the normal schools themselves able to supply the schools with enough qualified teachers and, therefore, other, often mere stopgap, means to provide some degree of training were organized. From about 1850 several of the young and struggling state universities maintained normal departments for a time. They discontinued this practice when their casdemic enrolments became larger, but in one or more cases it led to the formation of collegized departments of education (see below). Some cities maintained normal classes to prepare teachers for their own schools. County normal schools to prepare teachers for their own schools. County normal schools and normal institutes lasting four their anothers alsting a week and normal institutes lasting four their properties of the properties

Teacher Training in Universities.—In colleges, teacher training is administered in special departments, but in large institutions the departments were expanded and reorganized into schools or colleges of education. The larger self-administered

units are able to control their own programs; to aid teachers and schools with practical problems; and to develop specialized and technical courses and research in school administration, psychology, etc.

Lectures on teaching were given at Brown university, Providence, R I., as early as 1850 and at the University of Michigan. Ann Arbor, in 1860, but neither course was continued Permanent departments in which education was taught were instituted at the State University of Iowa, Iowa City, in 1873, at the University of Michigan in 1879, at the University of Wisconsin, Madison, in 1881 and at others soon after. Teachers college in New York city was an independent school for about a decade before it became affiliated with Columbia university in 1898 The University of Chicago organized its school of education in 1900. The department at the State University of Iowa became a school of education in 1907 An example in the south was the George Peabody College for Teachers in Nashville, Tenn, which began as a normal school in 1875, was later given most of what was left in the Peabody fund and became a teachers' college in 1000 By the 1050s departments or schools of education were to be found in nearly all academic colleges and universities

Bibliography —W D Agnew, Administration of Professional Schools for Teachers (1924), Thomas E Finegan, Teacher Trauming Agencies (1927), L. G. Hubbell, The Development of University Departments of Education (1924), Jesse M Pangburn, The Evolution of the American Teachers College (1932)

TEACHERS' PENSIONS: see Pensions Teachers' Pen-

TEACHERS REGISTRATION COUNCIL. Originally authorated by the English Education (Administrative Provisions) act of 1907, the Teachers Registration council was established by an order in council of Feb 29, 1912 It consisted 61 44 members, all of whom were teachers or persons recently engaged in teaching

These members were elected by the appointing bodies named in the first schedule of the order in such a manner that I I universities and 42 associations of teachers were represented on the council, II members being drawn from each of the 4 main groups of teachers

Under a new order, officially known as the "Teachers Registration Council Order, 1966," the number of the council may be increased to 50. There are 4, groups representing, respectively, university teachers, teachers in public elementary schools, teachers in secondary schools, specialist teachers with teachers in technical institutes, and each group is represented by 12 registered teachers engaged in the type of teaching work to which the group belongs These 48 elected members may, if they choose, co-opt two additional members to represent any type of teaching work which, in their opinion, is inadequately represented among their own number. The period of office for each council was extended from three to five years. The 12 university members are appointed by the 12 universities in England and Wales.

Representatives of teachers other than university teachers are elected directly by the registered teachers of the country, who vote according to the types of teaching work to which they belong and have a number of votes equal to the number of representatives assigned to that particular type in the order. For admission to the register, the council framed conditions

which must be fulfilled by all applicants. The great variety of examinatons in special subjects renders the task of standardization very difficult, but the council established standards of attainment and of professional training in connection with the teaching of such subjects as muse, at, handwork and domestic science. The man principle kept in view was that no one should be permitted to become a fully recognized teacher or to claim promitted to become a fully recognized teacher or to claim pro-

fessional status who has not undertaken a suitable course of study and a course of training in the art of teaching.

The council took steps to bring within its purview not only those eligible to become registered, but also those likely to become eligible, by the institution of a list of associate teachers, open to all passing an approved entrance examination. The council decided to remove from the list of associate teachers all who did not become fully registered within seven years of their admission to

In the United States there is no teachers' organization that corresponds to the Teachers Registration council. There the governmental agencies certificate teachers directly, and there is no legister kept except the list of persons who have been granted governmental certificates

TEAK (Tectoma grander) is one of the most valuable of timbers The Sankent name is sade, it is certain that in India tesh has been known and used largely for more than 2,000 years Teak is a large deciduous tree, of the family Verbenaceae, with a fall, straight but often buttressed stem, a spreading crown, and the branchlets four-sided with large quadrangular pith. It is a native of the Indian pennyula, Burma and Thalland, and is also found in the Thilippine Islands, in Java and elsewhere in the Malay archipelage, although there is no record of its being native in these places. In India proper its northern limit is 24° 40° on the west side of the Aravalli hills, and in the centre, near Jhansi, 25° vs N lat.

In Burna it extends to near Myitkyina, in lat. 25° 30′. In Bengal or Assam it is not indegenous, but plantations have been formed in Assam as far as the 27th parallel. In the Punjab it is grown in gardens to the 2nd Teak thrives best in districts with a mean annual rainfall of more than 50 in. The mean annual temperature which assist it best here between 75° F. and 85° F. Near the coast the tree is absent, and inland the most valuable forests are on low

hills up to 4,000 ft.

It grows on a great variety of soils, but there is one indispensable condition—perfect drainage or a dry subsoil. On level ground, with deep alluvial soil, teak does not always form regularly shaped stems, probably because the subsoil drainage is imperfeat.

During the dry season the tree is leafless; in hot localities the leaves fall in January, but in moist places the tree remains green till March

At the end of the dry season, when the first monsoon rains fall, the fresh foliage comes out The leaves, which stand opposite, or only whorled in very young specimens, are from 1 to 2 ft in length and from 6 to 12 in. in breadth. On coppuce shoots the leaves are much larger, and not rarely from 2 to 5 ft. long.

In shape they somewhat resemble those of the tobacco plant, but their substance is hard and the surface rough. The small white flowers are very numerous, on large erect cross-branched panicles, which terminate the branches.

The tree seeds freely every year, but its spread by selfsown seed is impeded by the forest fires of the dry season, which in India generally occur in March and April, after the seeds have ripened and have partly fallen. Germination is slow.

The bark of the stem is about half an inch thick, grey or brownish grey, the sapwood white; the heartwood of the green tree has a pleasant and strong aromatic fragrance and a beautiful golden-yellow colour, which on seasoning soon darkens into brown, mottled with darker streaks. The tumber retains its aromatic fragrance to a great age

Durability of Teak.—The principal value of teak timber for use in warm countries its text-nordinary durability. In India and in Burma heams of the wood in good preservation are often found in bulldings sweet conturies old, and instances are known of teak heams having lasted more than 1,000 years. In one of the oldest bulldings among the ruins of the old city of Vijayanagar, on the hanks of the Tungabhadra in southern India, the superstructure is supported by planks of teakwood y in thick. These planks were examined in 7881; they were in a good state of preservation and showd the peculiar structure of teak timber in a very marked mainer. They had been in the bullding for 500 years (Indian Prosters, vii, 260).

In the wall of a palace of the Persian kings near Baghdad, which was pillaged in the 7th century, two Americans found in 1811 pletes of Indian teak which were perfectly sound (Ouseley, Travels' in Perious Constries of the East, it, 250, no. 67). In the old cave temples of Saleste and elsewhere in western India pieces of teak have been found in good preservation which must have been more this acco versa old.

Teak is used for shipbuilding, for furniture, for door and window frames, for the construction of railway carriages and for many other purposes. White ants eat the sapwood, but rarely attack the heartwood of teak I tis not, however, proof against the bornings of the feredo, from whose attacks the teak piles of the wharves in the Rangoon rurer are protected by metal.

Growth.—In its youth the tree grows with extreme rapidity Two-year-old seedings on good soil are five to ten feet high, and instances of more rapid growth are not uncommon. In the plantations which have been made since 1856 in Burma, the teach kas on good soil attained an average height of 60 ft. in 15 years, with a girth, breast high, of 19 in This is between 16° and 18° N lat, with a mean annual temperature of 78° F, and a minfall of roc in In the Burma plantations it is estimated that the tree will, under favourable circumstances, attain a diameter of 24 in (girth 22 in), at the age of 80°.

Timber of that saze is maketable, but the timber of the natural forests which is at present brought to market in Burma has grown much more slowly, the chief reason being the annual forest fires, which harden and impoverish the soil. In the natural forests of Burma and India teak timber with a diameter of 24 in is never less than 100 and often more than 200 years old. The trees are not generally more than 100 to 150 ft. high, even under favourable circumstances.

#### THE TEAK TRADE

While it is true that by far the largest volume of the teakwood produced is used in India and Burma, Cevlon and the east, nearly all of the best quality is exported to other parts of the world, the demand from all countries having been on a continually increasing scale Nearly all the produce of the forests of Travancore, Cochin, Madras, Coorg, Mysore, Bombay, Berar and Madhya Pradesh is so consumed, although small supplies from Travancore and Madras and Bombay have continued almost annually to find their way to Europe. The actual output from Burma, shipped from Rangoon and Moulmein, far exceeds anything which is produced from any other source, with about 500,000 tons cut annually prior to World War II. In 1938-39, 204,000 cubic tons (a cubic ton equals 50 cu ft.) were exported from Burma by sea, 160,000 cubic tons of the total going to India Next in volume is ordinarily that produced in Thailand and shipped from Bangkok; certain quantities have been regularly shipped from Java and Saigon The timber brought to the Burma poits is derived from the forests in the coast provinces. Pegu and Tenasserim: from the forests in the former kingdom of Burma, floated to Rangoon down the Sittang and Irrawaddy rivers; and from the forests in the Shan states formerly tributary to Burma, from the Karenni country and from western Thailand, where it is floated to Moulmein by the Salwin river. In India and Burma a large portion of the teak-producing tracts were placed under conservancy management in 1856 to prevent overcutting and to maintain a permanent and gradually increasing supply Similar measures were taken in Thailand and in the teak-producing native states in the peninsula. The teak plantations in Java had come into bearing in 1908, but the expectation that teak might be produced in the Philippine Islands was not ful-(X.: A. L. H.)

TEAL, a small and beautiful duck, highly esteemed for the table. It inhabits the whole of Europe and Asia, visiting northern Africa in winter. In habits and nesting sites this species (Anas creeca) resembles the wild duck (q.v.) though it more often nests at a distance from water.

The teal is replaced in North America by the green-winged teal, A carolinense or Nettion carolinense, and in China by the mandarin duck, Aix galericulata. Hardly less showy than these are the two species of the subgenus Eumetta,—the falcated duck, E. falcate, and the Balkal teal, E. formosa.

TEANO (anc. Teanum Siducinum), a town of Campania, Italy, in the province of Caserta, 21 mi N.W. of Caserta on the old main line to Rome from Naples, forming conjointly with Calvi an episcopal see. Pop. (1951) 15,236 (commune). It is at the S.E. foot of Rocca Monfana, 643 ft. above sea level.

There is a feudal castle built by the dukes of Sessa in the 15th

century. Teanum Sidicinum (there is a Teanum Apulum in Apulia) was the capital of the Oscan tribe of the Sidicini which drove the Aurunci from Rocca Monfina Remains of the city walls, of a theatre and an amphitheatre still exist, and some extensive baths and Roman dwellings, both some way below the modern town

A tomb with a mosaic representing the visit of the three kings to Bethlehem was found in 1907

TEAPOY (Hindustani tēpāi), a small table, supported upon a tupod, for holding a tea service

TEA ROOM: see RESTAURANT.

TEASEL. Wild teasel is a common plant of the English copses and hedges, with a tall, stout, rigid, prickly stem, bearing large spreading opposite leaves, the midub of which is prickly, and conspicuous oblong heads, the purplish flowers in which are subtended by very long, narrow, stiff, upright bracts The plant is known botanically as Dipsacus sylvestris

Fuller's teasel. D fullonum, in which the bracts are hooked, is probably a cultivated form of the wild species, the dry heads are used to comb up the nap on cloth The wild teasel is extensively, and the fuller's teasel sparingly, naturalized in the eastern parts of the United States

TEATE MARRUCINORUM: see CHYETI

TEBESSA (the Roman Theveste), a town of Algeria in the department of Constantine, 146 mi S.E of Bona by rail and 12 mi W of the Tunisian frontier, on a plateau 2,950 ft. above the sea Pop (1948) 18,573 The modern town, which is within the walls of the Byzantine citadel, boasts nothing of interest save a church built from the ancient ruins.

The Byzantine walls, pierced by three gates, are in tolerable preservation. They are strengthened by numerous square towers. One of the gates is formed by the quadrifrontal arch of Caracalla, a rate form of construction. The arch, elected AD 214, 18 in good preservation. A pair of monolithic columns, disengaged,

flank each facade

The most important ruins are those of the great basilica This building, one of the finest Roman monuments in Algeria, bears evidence of having been built at various epochs; the earlier portions probably date from not later than the beginning of the and century A.D

The basilica was partially destroyed by the Berbers in the 5th century, and was rebuilt in A D. 535 by the Byzantine general Solo-mon, who surrounded it with a wall about 25 ft. high, still standing The tessellated pavement which covers the basilica proper is in almost perfect condition. Next to the basilica are the ruins of the forum

Theyeste was founded toward the close of the 1st century A.D. In the next century it was connected with Carthage by a great highway. In the 5th century, under Vandal dominion, it declined

in importance

Refounded by the Byzantines in the 6th century, the city disappeared from history at the time of the Arab conquest of the country in the 7th century. In the 16th century the Turks placed a small garrison of janussaries in the place, but Tebessa continued to be but a small village until establishment of French rule. Near by are the important phosphate quarries of Jebel Kouif, with annual output of 450,000 tons

BIBLIOGANHY.—Sir R Lambert Playlair, Handbook for Travellers in Algeria and Tunis, pp. 233-240 (1895), Guides-Joanne, Algérie et Tunise (1928); Abbé Kopp, Tébessa, guide historique (Tebessa, 1923), Pleire Castel, Tébessa, 2008

TEBU ("men of Tu"; i.e, "of the rocks"), a nomad Negro-Beiber race of the eastern Sahara. Their westernmost settlements are the oases of Agram, Kawar and Jebado, their northernmost the district of Gatron (Qatrun) within the Fezzan frontier, while south and southeast they merge in the negroid populations of Kanem, Bornu (Chad basin), Wadai and northwest Darfur. But the bulk of the nation is concentrated in Tibesti or Tu. hence

There are two main divisions—the northern Teda, or less negroid Tebu, and the southern Daza; or more negroid Tebu. Less closely connected are the Baele of the eastern and southeastern

oases and the Zoghawa (Zaghwa) of Darfur.

The Tebu are usually identified with the Garamantes of Herodotus (1v, 183), whose capital was Garama (Idrisi's Germa) in Phazania (Fezzan), and of whom Ptolemy spoke doubtfully as Ethiopians (Negroes?) But Leo Africanus transfers them to the Berber connection, whose fifth great division he deals with under the names of Gumeri (Garamantes?) and Bardaei oi Bardoa, that is, the Teda of the Bardai oasis, Tibesti

TECHNETIUM (from the Greek, τεχνητός, artificial), element 43, is the homologue of manganese (25) and ihenium (75) m the periodic system. Formerly known as masuium, it follows molybdenum (42) and precedes ruthenium (44). The chemical

symbol is Tc.

This element has been extensively sought in natural ores by several authors, notably I. and W. Noddack, who in 1925 claimed to have detected its X-ray spectrum in the same series of experiments that led to the discovery of rhenium However, the findings of the Noddacks were not confirmed by other experimenters, and since their initial paper nothing had by 1948 been published on a natural element 43 We now know that its natural existence is most improbable because it would contradict well-established rules of nuclear stability

In 1937 C. Perner and E. Segrè found several radioactive isotopes of element 43 in molybdenum targets that had been bombarded with deuterons in the cyclotron. Using the methods of adjochemistry they gave positive proof that some of the radioactivities were caused by element 43. At the same time they established several chemical properties of the new element This was the first example of the creation of a hitherto unknown ele-

ment by artificial means.

Element 43 can be produced by several types of nuclear bornbardments, such as neutrons on molybdenum or deuterons on molybdenum, and is also a product of the fission of uranium (O. Hahn and F Strassmann, E Segrè and C. S Wu). The latter nuclear reaction promises to supply the largest amounts of element 43 If it existed in nature, its geochemistry would probably be similar to that of rhenium

The element is undoubtedly metallic in its properties as is thenum. In the course of a chemical analysis it would senarate in the second group (sulphides insoluble in acid solution) and would usually appear with rhemum, although it can be separated from this element by a distillation at 180° C. in a current of hydrogen chloride. Its separation from molybdenum, which is often of practical importance, can be obtained by precipitating the molybdenum from an acetic acid solution with 8-hydroxyquinoline Element 43 stays in solution.

Not less than 12 isotopes of 43 are known. They are all radioactive, some emitting electrons, some decaying by orbital electron capture while at least one undergoes an isomeric transition. Following this isomeric transition the characteristic X-ray radiation of element 43 is emitted and this has provided an opportunity for the spectroscopic observation of the K X-ray lines of this element.

Beginning in 1944, substantial progress in the study of technetium was made in the laboratories of the U.S. Atomic Energy commission. Taking advantage of the fact that the technetium isotope of mass on has a beta decay period of about 1,000,000 years, it was possible to isolate several milligrams of it. This isotope is obtained either as a fission product, or by neutron capture of molybdenum followed by a beta decay.

The availability of relatively large amounts of technetium permitted study of it through the ordinary methods of chemistry and physics, without taking advantage of its radioactive properties. Its X-ray spectrum by external excitation, the crystal structures of the element and some of its compounds, and the main optical spectral lines were investigated. Also several chemical compounds were prepared in pure form and studied, confirming the general analogy with rhemum.

See C. Perrier and E. Segrè, "Some Chemical Properties of Element (3)" Journ. Chem Phys., 5, 775 (1937). TECHNICAL EDUCATION. Technical education (Greek τέχνη, art or craft) may be defined as instruction in the sciences and skills required for the practice of trades or professions, especially those nuvolving the use of machinery or scientific equipment. In Great Britain a distinction is increasingly being drawn between technological education, a term used to describe the higher levels at which advanced knowledge of theory is important, and technical education, directed primarily at the equipment of skill in techinques. The term vocational education embraces all studies tolated to any form of employment.

### THE UNITED STATES

The first technical instruction in the United States appears to have been given in connection with the US Mintary academy, organized in 1802 at West Point, NY Naturally the instruction was concerned with military prolibems in 1824 Rensselaer Polytechnic institute was founded at Troy, NY, and started the work of training "crill", so-called in distinction to "military," engineers. Rensselaer conferred its first engineering degrees in 1835. Harvard opiened the Lawrence scientific school and Vale established the Sheffield scientific school in 1847. The University of Michigan began instruction in engineering in 1853. The Polytechnic Institute of Brooklyn was founded in 1844, Cooper Union in 1859 and the Massachustets Institute of Technology in 1861.

In 1862 congress passed the Morrill Land Grant act and thus laid the foundation of the land-grant colleges from which have grown many of the state universities. The act in setting aside public lands for the support of these colleges specifically prescribed that they shall teach "such branches of learning as are related to agructiive and the mechanic arts" Under the impetus of this act and the economic pressure resulting from the needs of a new country engineering grew apace.

Thus, Cornell university was founded in 1865, the University of

Illinois in 1867, etc.

Technical education of university grade grew therefore under two auspices, namely, private ownership and state ownership. In the first group were to be found technical schools of high grade. independent of general educational functions as illustrated by the Massachusetts Institute of Technology, Rensselaer Polytechnic institute and California Institute of Technology Again many large privately endowed universities such as Harvard. Yale. Cornell, etc, have engineering colleges which are integral parts of a group of colleges that comprise the university. Others such as Stanford and Princeton have engineering courses integrated with general education In some of the state universities the colleges of engineering and agriculture are separated from the general courses not only educationally but geographically as well. Thus, the University of Michigan proper is at Ann Aibor while the Michigan State College of Agriculture and Applied Science is at East Lansing some distance away. The increase in the number of technical schools of collegiate rank is noteworthy. In 1866 there were but six engineering colleges of established reputation and only 300 men had been graduated in the previous 31 years. In 1951 there were more than 150 degree-granting colleges with a total enrolment of about 150,000.

While there is considerable variation in the entrance requirements of this large group, in general a high school education is required.

In general, the entrance requirements of the privately endowed colleges are somewhat higher than those of the state institutions, the latter from the nature of state educational systems being closely articulated with the high schools of the state.

There is also a considerable degree of uniformity in the curricula of the better type of technical college. This is necessarily so in a measure since engineering is an application of the basis sciences of mathematics, physica and chemistry and their deray-tives. Analytic mechanics, which is a key course, is usually completed by the middle of the third year, leaving at least one and one-balf years of the four-year course for engineering fundamentals and applications. There is considerable variance, however, in the matter of instruction for specific technical callings. Pentically all colleges recognize four principal fields of engineering, namely, civil, mechanical, electrical and chemical. For the most part also the higher technical schools recognize the necess-

sity of offering a limited amount of instruction in specialized fields such as heat-power, radio, industrial, hydraulic engineering. etc. in the senior year, usually as optional studies. There is always, however, a strong pressure from the industrial field in the direction of highly specialized courses with their beginnings much earlier and not a few colleges have yielded to this pressure. Thus, there are many colleges offering engineering courses of good quality and accredited courses in aeronautical, agricultural, architectural, ceramic, chemical, civil, electrical, electrochemical, fuel technology, general, industrial, mechanical, metallurgical, mining, naval architecture and marine, petroleum, and samtary engineering For the most part, however, educators have become convinced that the student's time is best spent dining the first three years, at least, in acquiring fundamentals Specialization should be deferred as long as possible and any extended special study should be carried to a fifth-year study. All technical colleges of repute offer graduate study

Until comparatively recent years the technical colleges were the principal centre of research work in engineering and the chief sources of engineering data. The growth of commercial research laboratories has changed this situation but there is still an immense amount of research conducted in college laboratories. There is a growing tendency for industrial enterprises to co-perate with college laboratories in the prosecution of special problems. If properly conducted such joint efforts are most fruitful since the commercial concern can supply the practical data for the problem and the funds for its prosecution while the college can supply the necessary apparatus and knowledge

The growing tendency of the engineer to take a leading place in industrial administration gave ruse to a need for a broadening of the curriculum by the introduction of economics, accounting and subjects of a more liberalising character such as history. While a certain amount of such topics were introduced into the standard four-year courses any great addition necessitated a lengthening of the curriculum and five-year courses came into

No outline of US technical education would be complete without mention of the co-operative methods in many colleges whereby
the student spends part of his time in practical work and part in
study, thus obtaming his practical training and theoretical work
at the same time. Students in such courses may "earn as they
learn" and contact with industry stimulates interest in theory.
There is also an important group of polytechnical institutes offering instruction in technology somewhat below the level of the
higher schools but of great importance. Pratt institute in Brooklyin, N.Y., may be cited as an excellent illustration. The high
schools during this period also tended more and more to prepare
boys and girls specifically for life and to lay less accent on college
preparation. Many state educational departments continued to
offer technical training in the high school grades. (D. S.K.)

## UNITED KINGDOM

England and Wales.—Technical education in the modern sense did not develop in England on any substantial scale until the last decade of the 19th century. The mechanics' institutes, founded in great numbers from 1833 to about 1860, were intended to mistruct workingmen 'in the scientific principles of arts and manufactures,' but for the most part they quickly became diverted to social and literary rather than industrial education. The Great exhibition of 1851, which confirmed fears that Britain's industrial primacy was being threatened, led the government to establish a science and art department, but the grants that it distributed did little beyond developing an and exammation system

The 1807 international exhibition at Paris shook British complenency. It led to a royal commission which, reporting in 1875, moved the livery companies of the City of London to found in 1880 the City and Guilds of London institute to promote the teaching of applied science. In 1838, the institute opened the Fins-bury Technical college for the training of artisans and in 1834 the Central Training college at South Kessington to train technical teachers and the higher ranks of industry. Meanwhile, quite independently, Jouint's Mego geneed in 1838 the Polytechnic in

Regent street, London (See Polytechnics)

By that time another 10yal commission on technical instruction (1881-84) was sitting Its recommendations brought about the Technical Instruction act, 1889, which empowered the newly created county councils and the county borough councils to give limited aid to technical education out of public funds. In 1891 the Local Taxation (Customs and Excise) act unexpectedly made further large sums of money (popularly called "whiskey money") available for this purpose Consequently, the decade 1889-99 saw great activity in the provision of buildings for the teaching of applied science and technology In addition to public effort, funds provided by the City of London Parochial Charities act, 1883, aided the building in London of more polytechnics

In 1899 the Board of Education act created a single national department charged with the supervision of public education throughout England and Wales The Education act, 1902, similarly made the county and county borough councils general purpose education authorities, responsible for supplying or aiding the supply of secondary and technical as well as elementary edu-Unfortunately, the preoccupation of the board of education and the local education authorities with the development of the newly established secondary system considerably slowed down provision for technical education for more than a decade

Nevertheless, three important developments took place during that period. About 1905 trade schools for boys and girls leaving elementary schools began to be established in London, Middlesex and elsewhere In 1913 these schools were made eligible for grant as "junior technical schools" In 1907 the Imperial College of Science and Technology was founded by royal charter which merged the Royal College of Science, the Royal School of Mines and the City and Guilds of London Institute Engineering college into a single institution (though functioning largely as three bodies) devoted to the highest levels of education and research in science and technology, especially in their application to industry. In 1908 the college became a school of the University of London. The third development was the most important of all. This was the foundation, between 1900 and 1909, of six universities. Birmingham, Liverpool, Manchester, Leeds, Sheffield and Bristol The importance to technical education lay in the fact that three of these universities-Birmingham, Leeds and Sheffield-had grown out of colleges mainly devoted to applied science and were already strongly biased thereto, while the others were much more disposed to grant it a prominent place in their program than the older universities This remained the case

The period between World Wars I and II was one of slow and fitful but continuous expansion and improvement of facilities for technical education, made almost exclusively by the local education authorities The years of greatest progress were 1925-29, when Lord Eustace Percy was president of the board of education He not only encouraged building but set on foot a number of investigations, which resulted, among other things, in the board of education Report on Education for Industry and Commerce (1928), the Clerk Report on Education for the Engineering Group of Industries (1929) and the Goodenough Report on Education for Salesmanship (1931). A scheme for a big expansion of facilities was prepared during the late 1930s, but World War II pre-

vented its being implemented.

A previous development calls for special note. Shortly after World War I the board of education, in co-operation with professional institutions related to industry, established an entirely new system of examination and certification for technicians, leading to the award of national certificates and diplomas. The certificates, available to part-time students only, were awarded on the cumulative results of concurrent industrial experience and technical education. They were of two grades: ordinary, to be obtained normally after a three-year course, and higher, following a further two-year course. The first scheme begun was for mechanical engineering, in 1921. By 1951 a dozen technologies had similar schemes, and the national certificate was firmly established as the nongraduate technician's recognized qualification.

World War II brought to England full recognition of the im-

portance of technical education in an industrial society outbreak the country found itself dangerously short of technologists, technicians and skilled craftsmen and of means to train them By ingenuity and improvisation-the latter including the introduction of two- or three-shift training programs into many technical colleges-the shortages were temporarily overcome. Technical colleges alone gave special courses of training to nearly 300,000 men and women

Meanwhile the nation looked to the future. In 1943 the ministry of labour asked industry to consider the recruitment and training of juvenile employees after the war, as a result, by the early 1950s about 80 sections of industry had drawn up national apprenticeship schemes including systematic education and training, and the number of young employees receiving such training in working hours had increased sevenfold. In 1944 the minister of education appointed a committee on higher technological education, under the chairmanship of Lord Eustace Percy. It reported in 1945, recommending the upgrading of technical college courses to train technologists and the development of joint consultation between education and industry for national and regional planning of vocational education The latter recommendation was carried into effect in 1947-48 by the creation of the National Advisory Council on Education for Industry and Commerce and ten regional advisory councils for further education

The Education act of 1944 made it the statutory duty of the local education authorities to secure sufficient facilities for all types of education (except university education) in their areas. But until 1947 hardly any new building was possible, so that with a greatly increased demand for vocational education many technical institutions became grossly overcrowded. The demand was partly a result of the government's Further Education and Training scheme, under which men and women who had served in the armed services or work of national importance during World War II could receive grants for higher education and training It was also a result of a progressively increasing demand from industry for vocational training, especially during working hours, of all kinds for employees of all ranks.

In 1946 the ministry of education urged technical colleges to undertake more research and invited their co-operation in establishing national schools devoted to advanced work in particular branches of technology By 1951 seven such national colleges had been established for aeronautics, foundry work, rubber, leather and food technology, horology and instrument technology and heating, ventilating, refrigeration and fan engineering. In Jan. 1953 the government announced its intention, during the years 1957-62, to double the number of students at the Imperial College of Science and Technology so as to establish a technological institution of university rank (in accordance with an announcement of June 1952). It further offered technical colleges increased grants for approved high-level courses.

In 1951 there were 530 major establishments with 672,000 students, 203 art schools with 98,500 students and 10,705 evening institutes with 1,228,000 students.

Scotland.-Modern technical education in Scotland began with the founding by George Birkbeck in 1800 of a class for instructing Glasgow operatives in "mechanical and chemical philosophy." In 1823 this class broke away from the Andersonian institute to which it was attached to form the first Mechanics institution, Two years previously there was opened in Edinburgh the School of Arts, claimed to be the first institution in Great Britain founded

expressly to give scientific instruction to workingmen,

Until 1897 the English science and art department covered Scotland as well, and consequently statutory development of technical education was broadly parallel with England, except that under the Educational Endowments (Scotland) act, 1882, schemes were made and money was provided for establishing and maintaining technical schools. Among other changes, the Andersonian institute and the Glasgow Mechanics institution were merged in what became the Royal Technical college, Glasgow, and the School of Arts in the Heriot-Watt college.

Codes of regulations made in 1899 and 1901 organized elementary technical instruction in "continuation classes." To encourage advanced work the 1901 code provided that outstandingly good and well-equipped technical colleges could be exempted from its regulations and grant-aided on special terms. The Education (Scotland) act, 1908, recognized 11 of these "central institutions, as they became known. In 1951 there were 17, including 3 agricultural and 2 veterinary colleges Among them the Royal Technical college, Glasgow, and the Henot-Watt college, Edinburgh, were affiliated to the universities in these cities. Other technical education was given in "continuation class centres." There were 31,669 students in central institutions and 227,878 in continuation class centies

In the early 1950s the pattern of technical education in Scotland was (nomenclature apart) closely similar to that in England, except that the latter had no designated central institutions. Five

regional advisory councils had been established

Northern Ireland .- Before 1922 education throughout Ireland was regulated from England In the 19th century, despite the nonindustrial character of the country, technical education de veloped remarkably It received an added stimulus in 1849 when a department of agriculture and technical instruction was created In 1922, 30 technical schools managed by local authorities were handed over to the Northern Ireland government They included the Belfast College of Technology, one of the largest and best in the British Isles

The Education (Northern Ireland) act, 1923, further stimulated technical education by abolishing the restriction on expenditure to a 2d rate and merging it in the general expenditure of the local authorities Junior technical and commercial schools expanded, especially in the provision of day classes. The Belfast College of Technology prepares students for degrees in engineering and related subjects offered by the Queen's university. Among its students are also trades scholars, who are apprentices granted scholarships by the ministry of education for extended courses.

## REPUBLIC OF IRELAND

The department of education set up in 1924 took over the functions of the technical instruction branch of the department of agriculture and technical instruction established by the Agricultural Technical Instruction (Ireland) act, 1899. Following the report of the Commission on Technical Education, issued in 1927, which noted especially the lack of technical instruction in rural areas, a system of rural continuation schools was developed offering full- and part-time classes to meet the needs of their localities. Technical colleges and schools maintained by local authorities were established in all cities and large towns.

The National University of Ireland established faculties of engineering at two of its three constituent colleges, Cork and Dublin, and the University of Dublin (Trinity college) also established an engineering faculty. Both universities offer degrees in agriculture.

## BRITISH COMMONWEALTH NATIONS

Australia .- With increasing industrialization, much attention was paid to technical education, especially after 1940. In all states there are technical secondary schools or courses. In South Australia all apprentices in "proclaimed" trades and areas are required to attend trade schools for one half-day a week and one evening. Most apprentices in New South Wales attend technical colleges on a similar basis.

Many new technical colleges and schools have been built in Australia. In 1947 the New South Wales University of Technology was founded; it provides degree courses in civil, electrical, chemical and mechanical engineering, mining, applied mathe-matics, physics and chemistry. The Gordon Institute of Technology at Geelong in Victoria includes a textile college which meets the requirements of the whole commonwealth for highly trained executives for the wool industry. The School of Mines of Western Australia at Kalgoorlie similarly covers the mining industry. The University of Queensland runs correspondence courses in technical education up to degree standard.

New Zealand,-At the secondary level there are technical high schools in the large towns; in the smaller ones consolidated ture.

schools offer technical courses. The Auckland and Canterbury colleges of the university have engineering schools and Otago has a school of mines that grants its own diplomas The Lincoln and Massey agricultural colleges are affiliated to the university, of which they form the school of agriculture

Canada.-Recent years have seen great educational developments, especially in the piairie provinces In both English and French educational systems there are technical high schools and trade schools at the secondary level Technical institutes covering the senior high school years and beyond were increasing in the early 1950s The Nova Scotia Technical college, and the agricultural, pharmacy and veterinary colleges in Ontario are of university status, as is Macdonald college, the agricultural faculty of McGill university, Montreal, Que The western universities and New Brunswick have schools of engineering and agriculture

Union of South Africa .- Though each province had its own department of education, all forms of university and vocational education were financed by the union education department, which also conducted the examinations, during the early 1950s Technical education was provided in universities, technical colleges and schools and agricultural schools. The universities of Cape Town, Natal and Stellenbosch had schools of engineering and agriculture, those of South Africa and the Witwatersrand engineering schools

India.-Despite recent progress, facilities for technical education were far below the country's needs during the early 1950s In many elementary and some secondary schools instruction in handcrafts was made compulsory Beyond that, technical education was provided in universities and technical institutions at four levels institutions which could be entered from the seventh standard of a high school and offering courses leading to a certificate, institutions requiring matriculation for entry and offering diplomas; institutions offering degrees or equivalent courses, and institutions doing mainly postgraduate and research work

The responsibility for education was assumed by the states, but the central government, through the All-India Council for Technical Education, co-ordinated and improved facilities It maintained the Delhi polytechnic and was establishing similar national establishments such as the Institute of Technology at

Kharagpur in West Bengal (1950)

Pakistan .-- At the time of partition in 1947 Pakistan had three engineering colleges and some industrial institutes. The Council of Technical Education prepared a national development plan In 1951 the first of six technical secondary schools was opened at Karachi and the establishment of the Karachi polytechnic (assisted by the Ford foundation) begun. By 1953 the establishment of new engineering colleges in the Punjab and the North-West Frontier Province was in hand and Dacca engineering college was re-equipped. Technicians were being sent overseas for practical training. The universities had faculties of engineering and agriculture and there were agricultural colleges at Lyallpur and Sakrand.

## EUROPEAN COUNTRIES

France.-Technical education was brought under state control in 1892 and codified by the Loi Astier of 1919. Provisions were made for three main levels; apprenticeship, intermediate and higher. The first and second were usually entered from the elementary school; the third was open only to students possessing the baccalauréat awarded at the end of a secondary course.

At mid-20th century elementary school children could get the rudiments of technical education in the collèges modernes (formerly écoles primaires supérieures) and the cours complémentaires, both available from the age of 12. For elementary school leavers there was, after 1945, a great development of centres d'apprentissage, which offered to young people between the ages of 14 and 18 a three-year course of full-time trade training along with general education, leading to the certificat d'aptitude professionelle, awarded for a wide variety of crafts. At a higher level there was the development of colleges techniques and of regional schools of agriculture, the latter run by the ministry of agricul-

At the highest level are the national schools such as the École Polytechnique, which trains engineers for state service, both military and civilian, the École Centrale des Arts et Manufactures, whose aim is to produce future industrial leaders, and the Écoles Nationales d'Agriculture at Grignon, Montpellier and Rennes There are similar national schools for horticulture, veterinary

science, aviation and mining German Federal Republic,—During the 19th and early 20th centuries Germany built up a comprehensive national system of vocational training for workers of all grades. The Hitler regime perverted this, and the collapse of Germany in 1945 temporarily laid it in ruins. It was later built up again on similar lines, at

varying rates in the different Lander

In the early 1950s there were four main levels. Berufschule, Fachschule, Hohere Fuchschule and Technische Hochschule All boys and girls leaving elementary schools at 14 were due to enter Berufschulen, and by 1951 compulsion was said to be generally operative throughout the republic. They had to attend for three years, eight hours of instruction a week being required Alternatively, in some Lander they could attend a full-time Berufsfachschule for one year or more Fachschulen served students who completed their basic vocational education and wished to be more highly qualified in their trades, these schools were usually full time for one year Höhere Fachschulen are equivalent to English technical colleges, though usually possessing fewer departments, and recruit mainly from the gymnasien (grammai schools).

Technische Hochschulen, of which there were 13 in the Federal Republic in the early 1950s, had university status The famous Charlottenburg institution in Berlin was made a full university in 1946 to compensate for the fact that the Friedrich Wilhelm

university was in the Russian sector of the city

Netherlands .-- A system of continued education with a vocational bias for children leaving the elementary school is followed by junior technical schools (ambachts scholen) giving general and vocational education, trade schools (vakscholen) giving more intensive training in one trade (or group of allied trades), and technical schools, training for supervisory posts At university level are the Technical High school at Delft, offering degrees up to the doctorate in engineering, and the Agricultural institute at Wageningen, offering doctorates in agricultural science to students qualified as agricultural engineers

Belgium,-Technical education is largely in the hands of private bodies though it was placed under the supervision of the ministry of education in 1945. At Verviers a municipal École Supéneure de Textiles training textile engineers was established; by study there and at Liège university a degree can be obtained. The Faculté Polytechnique de Mons, devoted principally to en-

gineering, has university status.

Denmark.-There are many technical schools and three institutions for advanced instruction, of which two, the Royal Veterinary and Agricultural college and the Technical University of Denmark (both in Copenhagen) grant degrees. Some of the newer folk high schools have vocational biases, notably those

preparing women for nursing.

Norway.—Some continuation schools provide vocational courses for young people leaving the elementary schools. Youth schools cater for rather older students (aged 17-20) who wish to prepare for entry to more advanced vocational training. Trade schools for crafts, industrial occupations, seamanship and domestic science are numerous. At university level there are the Norwegian Institute of Technology at Trondheim and the Agricul-tural College of Norway at Vollebekk,

Sweden .- Practical lower secondary schools and upper secondary schools emphasize vocational work; the former offer a certificate for it. Full-time technical instruction is given in trade schools. There are two national technical colleges, the Royal Institute of Technology at Stockholm and the Chalmers Institute of Technology at Göteborg, both under the same governing board; they grant degrees up to the doctorate. Many of the folk high schools include vocational and quasi-vocational work in their programs, especially in gardening, farming, forestry, domestic science and gymnastics.

Finland.—There are numerous trade, technical and agricultural schools The National Institute of Technology, at Helsinki, grants bachelors' and doctors' degrees. The people's high schools teach handicrafts, agriculture for men and domestic subjects for women.

Italy.-After the elementary school, which gives a five-year course from the age of 6 to 11, pupils wishing to learn a trade can (on passing an entrance examination) enter the scuola di avmamento al lavoro, which offers three-year vocational courses and a diploma ranking in status with the secondary school certificate

Alternatively, elementary school children may (again on passing the necessary entrance examination) go to the scuola media (lower secondary school) between 11 and 14, which also offers prevocational courses. After the scuola media students can (by examination) enter an istituto tecnico for a four-year course leading to the abilitazione (professional diploma).

General postschool technical education is administered by provincial associations under the control of the ministry of public education Courses granting vocational qualifications are conducted by professional bodies, such as the National Institute for Training and Improvement of Industrial Workers (I.N A.P.I ), which work under the control of the ministry of labour highest level the government maintains polytechnics in Milan and Turin, and schools of engineering in Rome, Naples, Bologna, Padua, Palermo and Pisa

Switzerland .- There are many excellent technical schools administered by the cantons, to which the federal government delegates responsibility for education The École Polytechnique at Lausanne constitutes a faculty of the cantonal university famous Swiss Federal Institute of Technology (Eidgenössische Technische Hochschule) at Zurich 15 maintained and administered by the federal government, ranks as a university and has an international reputation. It was organized in it schools of architecture, civil, electrical and mechanical engineering, agriculture, agricultural engineering and surveying, forestry, chemistry, mathematics, physics, natural science, military science and pharmacy It also established a department of optional studies teaching the humanities, politics and economics

Turkey.-Steady progress toward a comprehensive system was made after the act of 1942, which outlined a ten-year plan. Mobile courses teach smithing and carpentry in villages Primary school leavers can enter three- or five-year trade schools and go on from there to two- or four-year technical schools or a school for master builders. There are also evening trade schools for men and women. The Technical University of Istanbul, created in 1944 from the former Imperial Engineering school, admits graduates of lycées and technical schools to a five-year course. In the early 1950s a similar university was projected for Ankara. There are training colleges for technical teachers (men and women) at Ankara.

BIBLIOGRAPHY .-- Annual reports of the Ministry of Education, Eng-HIBMIOGRAPHY—Annual reports of the salmistry of Leucenton, solg-land and Wals, the Scottub Education Department and the Ministry and and Wals, the Scottub Education People of the Advisory Council on don, 1947). Technical Education, report of the Advisory Council on Education in Socialia (H M.S.O., London, 1946). London University Institute of Education, Year Book on Education (London, annual); publications of the Association of Technical Institutions of the United

publications of the ASSUMENCE.

Kingdom (London).

Australian federal and state government publications; Australian Council for Educational Research publications; Indian government, Facilities for Technical Education in India (1948), Review of Education in India (1948), Review of Education in India, 1950–51, Canadian dominuon and provincial government.

The Adabasents (London, 1968).

tion in India, 150--51, Lanadana common and provincial government, publications.

10 philacitons.

10 philac

TECHNOCRACY. The movement known as technocracy originated in the United States in 1932 It sought to give expression to a group of principles which for many years had found place in the writings of a few engineers, economists and students of science. Its basic principles were (1) Social phenomena are measurable and the laws of social control may be derived from these measurable and the laws of social control may be derived from these measurable and the laws of social control may be derived from these measurable and the laws of social control may be derived from these measurable and the laws of social control may be derived from these measurable and the laws of social control may be derived from these measurables. ments (1) In application of the fractune to the production to good and services has made it impossible to measure the value of the goods produced in terms of any single commodity (gold, for example) and thus the enginee bad destroyed the price system (3) The expansion of credit, sometimes termed the creation of debt, under the capitalistic system has disturbed the relative claims of capital and labour to the goods produced to such an extent that the capitalistic system has already collapsed (4) The economics of the social order are too compli-cated to be understood and controlled by politicians Control should in the hands of engineers and scientists.

TECK, a ducal castle stuated in Wuttemberg, immediately to the north of the Swabian Jura and south of the town of Kirchheim, crowning a ridge (2,544 ft ) of the same name. It

was destroyed in the Peasants' War (1525)

The duchy of Teck was acquired early in the 11th century by Berthold, count of Zahringen, whose great-grandson Albert, or Adalbert, styled himself duke of Teck In 1381 it passed both by conquest and purchase to Wurttemberg The title, which had lapsed with quel and purchase to wurttenners. The title, which are mpeer write the extinction of the Zahringen line ritgs, was revived in ragig by the temberg. The dignity was renounced by Duke Frederick William Chales upon his elevation to the rank of king in 1866. In 1863 the title "pnoze of Teck" was conferred by King William I of Wuttenstein the Challes upon helder of Duke Alexander of Wurttenberg (1862). perg upon the children of Diluce Alexander of Wurtchinderg (1804-85) by his morganistic marriage with Claudine, countess Rhédey, emobled as countess of Hobanstein; in 1871 Prince Francis, the eldest son of Duke Alexander, was created duke of Teck. His eldest son Adolphus (b. 1863) was in 1910 the holder of the title TECUCI, the capital of the Tecuci department of Rumanus TECUCI, the capital of the Tecuci department of Rumanus.

picturesquely situated among wooded hills on the right bank of the river Bêrlad, and at the junction of railways from Bacau, Bêrlad and Galatz Pop. 17,259 Tecuci has a large transit trade in grain, timber, cattle and horses, between northern and eastern

Moldavia and the Danubian ports.

TECUMSEH. TECUMTHE OF TECUMTHA (¢ 1768-1813). American Shawnee chief, was born probably in the old Shawnee village of Piqua, near the site of Springfield, O , between 1768 and 1780 While still a youth he took part in attacks on settlers passing down the Ohio river and in widely extended hunting expeditions or predatory forays to the west and south; and he served in the Indian wars preceding the treaty of Greenville in 1705 His eloquence and his self-control made him a leader in conferences between the Indians and whites as early as 1800, and when in 1804 and 1805 the Indians of the northwest became aroused by a series of treaties calling for new cessions of their territory and by the prospect of war between Great Britain and the United States, the opportunity was presented to Tecumseh and his brother Tenskwatawa (1e., the Open Door), popularly called "the Prophet," to put into operation a scheme which followed the ambitious dream of Pontiac. With some scattered Shawnee clans as a nucleus, the routine. With some scattered Snawmer claim as a nucleus, the borders proceeded to organize, first near Generville, O, and borders proceeded to organize, first near Generville, O, and els town," which was based on a sort of communism and was apparently devoted to industry and sobneys, but their actual plan was to combine all the Indians from Canada to Florida in a great democratic confederacy to resist the encreachment of the whites Tholarmatic confederacy to resist the encreachment of the whites Tholarmatic confederacy to resist the metaconduct of the whites Tholarmatic confederacy to resist the metaconduct of the whites Tholarmatic confederacy to resist the metaconduct of the whites Tholarmatic Confederacy to resist the metaconduct of the whites Tholarmatic Confederacy to resist the metaconduct of the whites Tholarmatic Confederacy to resist the metaconduct of the whites Tholarmatic Confederacy to resist the metaconduct of the whites Tholarmatic Confederacy to the metaconduct of the metaconduct of the whites Tholarmatic Confederacy to the metaconduct of the whites Tholarmatic Confederacy to the confederacy to the metaconduct of the whites Tholarmatic Confederacy to the confederacy to the metaconduct of the metaconduct of the whites Tholarmatic Confederacy the metaconduct of the metac organizations were to be disregarded, but all warrors were to be represented at pronderal assemblages where matters on interest to all Indian sensitive and assemblages where matters on treets to all Indian mate this league was the adocument and political lageauity of To commit and the superstitutions reverence aroused by the Prophet. This program alarmed the whites along the northwestern border. In the course of the parent three years of two William Harry Harriston of Indian held interest the properties of the organizations were to be disregarded, but all warriors were to be repreing that of 1869 which deprived the Indians of their best hunting ground, were given up and it no purchases were made thereafter with a ground, were given up and it no purchases were made thereafter with a ment and, during Tecunsesh's absence in the south, made a hostile ment and, during Tecunsesh's absence in the south, made a hostile ment against the Peripher's town.\[The Technology of the property of the purchase of the purchase of the purchase of the purchase of the purchase of the purchase of the purchase of the purchase of the purchase states of the purchase state of the purchase of the purcha

but a series of border outrages indicated that the fatal moment could not long be postponed. With the breaking out of the Ward of \$12\$ is ward of \$12\$ is ward of \$12\$ is the third of \$12\$ is ward of \$12\$ is the third of \$12\$ is the property of \$1 in 1834 Like Pontiac, whom he doubtless imitated consciously,

m 1834 Like Pontiac, whom he doubless imitated consciously, he had a wonderful eloquence and a power of organization rare among the Indians. He is depicted in many historical plays and novels to the product of the pr

He studied in England and in France and deducated himself chiefly to bibliography and library administration In 1873 he became librarian to Lord Acton and several years later librarian of the Athenaeum club. In 1889 he was also appointed secretary of the club and held both offices until his resignation in 1922. He was one of the active promoters of the first international conference of librarians held in London in 1877, out of which grew the Library Association of the United Kingdom of which Tedder was first honorary secretary and, from 1880 until his death, treasurer. He was active in all the society's meetings and undertakings and contributed about 20 papers to its different publications He was treasurer of the Royal Historical society from 1904 until his death, secretary to the Herbert Spencer trustees and editor of a continuation of Spencer's Descriptive Sociology, and a member of the Royal Commission on Public Records from 1910 to 1919 He wrote for the Encyclopædia Britannica, 11th edition, and for the Dictionary of National Biography and Dictionary of Political Economy. He died Aug. 1, 1924.

TEDDER: see HARVESTING MACHINERY

TEDDINGTON, a parish in the borough of Twickenham Middlesex, Eng., close to the Thames, 12 mi. WSW of Hyde Park corner, London. The district is residential Teddington is well known for its lock, largest on the Thames, being 650 ft. long, 25 ft wide and 10½ ft. deep The intake of all London water companies must be above it. Teddington is the headquarters of the National Physical laboratory.

TE DEUM, opening words of the ancient Latin hymn Te Deum laudamus (We praise Thee O God), at one time believed to have been written by St. Ambrose of Milan and now generally ascribed to Nicetas, bishop of Remesiana in Dacia. Its noble character speedily procured its incorporation in the liturgy of the Latin church while it has been set separately by countless composers as a hymn of thanksgiving for special occasions.

TEE, in golf a small conical mound made of damp earth on which the ball is placed before making the first drive for a hole Sometimes an artificial tee, usually made of rubber or wood, is used. In some games, such as quoits, horseshoes and hobs, the

tee is the mark toward which the player throws.

TEELE, RAY PALMER (1868-1927), U.S economist, was born in Fillmore county, Minn, on Oct 22, 1868 He was educated at the University of Nebraska (MA, 1899), and from 1899 until his death was economist of the US department of agriculture. In 1910-12 and 1919-21 he served as special agent of the bureau of the census in charge of irrigation. He made investigations and wrote a number of government reports on water rights and irrigation and also contributed numerous articles to periodicals on these subjects He was the author of a large number of government bulletins, including "Land Reclamation Policies in the United States" (department of agriculture, Bull, No. 1257 [1924]) and "The Western Farmer's Water Right" (department of agriculture, Bull. No 913 [1920]). He also wrote Irrigation in the United States (1915) and The Economics of Land Reclamation in the United States (1927). He died at Myton, Utah, on Sept. 1, 1927.

educated in law at St. Petersburg university and began to practise in Reval (Tallinn) In 1905, however, he associated himself with the revolutionary movement for which he was condemned to death by the Russian government He escaped to Switzerland but after a number of years he returned to Russia and served a sentence of impusonment. After the 1917 revolution he took an active part in paying the way for an Estonian government, was a member of the constituent assembly, 1919-20, and after 1920 of the Estonian diet He rose to power as a leader of the Agrarian party and was prime minister from Dec 1925 to 1927 and again in 1932 but failed to be re-elected to parliament in 1938. He was arrested and deported in 1940 by the Soviet occupation forces, after which his fate was unknown

TEES, a river of England, rising on the east side of Cross Fell (see Pennine Chain), 8 mi. N of Appleby in Westmorland and flowing 70 mi SE and E to the North sea Part of its earlier course forms the boundary between the counties of Westmorland and Durham. From its source to Middleton-in-Teesdale it flows through bleak moorland with hills using 2,500 ft and more above the sea Two famous falls above Middleton-in-Teesdale where the brown, peaty niver traverses the hard, black dolerite of the Whin Sill, are known as Caldron Snout and High Force At Caldron Snout the water dashes over huge steps of rock and at High Force it falls from a vertical rock 70 ft high into a swiling pool below From a point immediately below Caldron Snout to its mouth the river forms the boundary between Durham and Yorkshire almost without a break. Below Caldron Snout trees appear, contrasting with the broken rocks, and as the river flows through the wide vale past Middleton-in-Teesdale the scenery becomes gentler The town of Barnard Castle, Eggleston abbey and Rokeby hall-well-known through Sir Walter Scott's poems-are passed, and then the valley begins to open out, and the river crosses the rich plain south and east of Darlington. The Tees now becomes an important commercial highway, having on its banks such ports as Stockton-on-Tees and Middlesbrough and forming an outlet for the chemical plant at Billingham and the iron-working district of Cleveland in the North Riding of Yorkshire The drainage area is 708 sq mi.

TEETH, the modified papillae or elevations of the mucous membrane of the mouth, impregnated with lime salts Each tooth has a biting part or crown covered by enamel, a neck where the gum surrounds it, and one or more roots or fangs fitting into sockets (alveoli) in the jaw bone. For surgery of the teeth see DENTISTRY.

There are 32 permanent teeth in man, 16 in the upper and 16 in the lower jaw; they are also arranged in symmetrical sets of 8 teeth on each side. The upper and lower symmetrical sets of 8 will be described The two teeth from the mid-line in front are "incisors" and have chisel-shaped crowns The central mcisor of the upper jaw is broader than any of the others, and bites against the central and lateral incisors of the lower jaw, the same want of exact adaptation continues throughout the series, so that every tooth in the upper jaw except the last molar bites against its corresponding tooth of the lower jaw and also against the tooth hehind that

Next to the incisors comes the "canine (or eve) tooth," the crown of which is somewhat peg-shaped, while behind this are the two "premolars" or "bicuspids," whose crowns are flattened from before backward and bear two cusps, the larger of which is external As a rule there is a single root, though sometimes in the first upper premolar it is double

The three "molars" are placed behind the premolars, and the upper and lower sets can be easily distinguished because the upper have three roots while the lower have only two The grinding surface of the crowns of the upper molars shows three or four cusps, while on the grinding surface of the lower molars four or five cusps are found.

Of the three molars the first is the largest, and the third, or wisdom tooth, the smallest, while the upper wisdom tooth is smaller than the lower.

are only 20 teeth, to in each jaw and 5 in each segment. They

TEEMANT, JAAN (1872-? ), Estonian statesman, was are two incisors, one canine and two so-called molars These molars occupy the position which the permanent premolars later on take. The temporary teeth differ from the permanent in their smaller size, their whiter colour, the greater constriction of their necks, and in the fact that the roots of the molars are widely splayed

The dates at which the milk teeth are cut are very variable The lower central incisors come first between the sixth and ninth

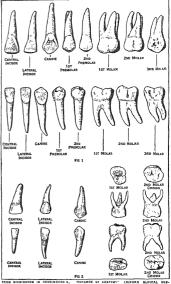


FIG 1-PERMANENT TEETH OF THE RIGHT SIDE. SHOWING INNER OR

LINGUAL ASPECT. FIG 2 -MILK TEETH OF THE LEFT SIDE

month, or even later, then come the central and lateral upper mcisors, then the lower lateral incisors, followed closely by the first molars. After a rest of four or five months come the canines, while by about the end of the second year the second molars have appeared, and the milk dentition is complete. The milk teeth are cut in batches with resting intervals between.

The first permanent tooth to be cut is the first molar, and this happens during or soon after the sixth year. It does not displace any of the milk teeth, but comes down behind the second milk molar. During the seventh year the central milk incisors fall out and their place is taken by the permanent ones; the shed teeth are mere shells of the crown, all the root having been absorbed.

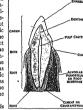
The lateral incisors succeed their milk predecessors at about In the "milk teeth" or temporary dentition of the child there eight years old, the first premolar takes the place of the first temporary molar about nine, the second premolar that of the 876

the second molar comes down behind the first about twelve The third molar, or wisdom tooth, usually appears between eighteen and twenty, but may be much later, indeed it is sometimes never cut at all, and when it is, it often does not come down to a level with the other teeth It is believed that man is gradually undergoing a suppression of his last molar teeth.

Histology .- In a vertical section the exposed part or crown is seen to be covered with enamel, which, microscopically, is composed of fine hexagonal prisms arranged at right angles to

the surface of the tooth, and formed chiefly of calcium phosphate with small amounts of calcium carbonate, magnesium phosphate and calcium fluoride, but containing practically no organic matter The enamel rests on the "dentine," of which hard vet elastic substance by far the greater part of the tooth is composed. It is made of the same salts as the enamel, but contains in addition a good deal of organic matter and forms a structureless mass through which the fine "dentinal tubes" run from the pulp cavity to the periphery.





PRON SIRKINGHAM IN CUNNINGHAM'S, "TEXT BOOK OF ANATOMY" (OXFORD MEDICAL FOR-LICATIONS) FIG 3 --- VERTICAL SECTION OF CANINE TOOTH ILLUSTRATING ITS

epithelial cells, the "odontoblasts," lying close against the wall of the cavity and forming new dentine. Slender processes ("Tomes's fibrils") project from these cells into the dentinal tubes and are probably sensory. A nerve and artery enter the apex of the root of the tooth, but it is not understood how the nerve ends

Surrounding the dentine where it is not covered by enamel is the "cement" or "crusta petrosa," a thin layer of bone which is only separated from the bony socket by the alveolar periosteum

Embryology.-The lip is marked off in the mouth by a "lip groove," which, in the case of the lower jaw, grows obliquely downward and backward, and the mass of ectodermal cells bounding it penetrates for some distance into the surrounding mesoderm below the bottom of the groove. This is known as the "tooth band"

On the under surface of this oblique tooth band (still taking the lower jaw), and close to its edge, appear ten thickenings, below each of which the mesoderm rises up into a "dental papilla," and so moulds the thickening into a cap for itself-the "enamel organ" The superficial cells of the dental papilla become the "odontoblasts" and manufacture the dentine, while those cells of the cap (enamel organ) which are on its concave surface and therefore nearest the dental papilla are called "ameloblasts," and form the enamel. The cutting or grinding part of the tooth is first formed, and the crown gradually closes round the dental papilla, so that at last, when the root is formed, the central part of the papilla remains as the pulp cavity surrounded by dentine except at the apex of the root. The roots, however, are formed slowly, and as a rule are not complete until some time after the tooth is cut. The mesoblastic connective tissue surrounding the developing tooth becomes condensed into a fibrous bag called the tooth-sac, and round this the lower jaw grows to form the alveolus. The crusta petrosa covering the root is developed from the tooth-sac, Hence of the various structures which make up a tooth, the enamel is derived from the ectoderm, while the dentine, pulp and crusta petrosa or cement are mesodermal.

Comparative Anatomy.-The details of the teeth vary so greatly in different animals, and, on account of their being the most durable tissues of the body, are so important for classifica-tory purposes, that they are dealt with freely in the various

second temporary molar about ten, the canine about eleven, while zoological articles All that can be done here is to give a broad general survey, taking the details of man's dentition as a point of denarture

In some fishes the teeth are continuous over the edges of the jaws with the scales on the surface of the body, and there is no doubt that teeth should be regarded as modified scales which have migrated into the mouth

In the Cyclostomata (lampreys and hags) the teeth are horny cones, but beneath them there are papillae of the mesoderm covered with ectoderm which resemble the dental papillae and enamel organs although no calcification occurs except in Bdellostoma In the Elasmobranchii (cartilaginous fishes) the teeth are arranged in several rows, and as those of the front row fall out the hinder row take their place, sometimes they are triangular and very sharp as in the sharks, sometimes flattened and arranged like a pavement for crushing as in rays. These teeth only represent the crowns of man's teeth, and they are not embedded in sockets except the teeth in the saw of the saw-fish (Pristis), moreover the dentine of which they are largely composed resembles bone and fills up the whole pulp cavity. From its structure it is known as osteodentine.

In the Teleostomi (teleostean and ganoid fishes) there is great variability; sometimes, as in the sturgeon, there are no teeth at all, while in others every bone bounding the mouth, including the branchial arches, bears teeth. As an example of a very full tooth armature the pike's mouth and pharynx may be instanced Both in the pike and the hake hinged teeth occur; these bend backward during the passage of prey down the throat, but are re-erected by elastic ligaments As a rule, the dentine of the Teleostomi is osteodentine, but sometimes, as in the bake, it is vascular and is known as vasodentine

In the Amphibia teeth are not so numerous as in the fishes, though like them they are not confined to the jaws, since vomerine teeth are very constant. The toad is edentulous, while the frog has no teeth in the lower jaw. An extinct order of tailed amphibians, the Stegocephali, are often called labyrinthodonts on account of the complex way in which the enamel is involuted into the interior of the teeth.

In the Reptilia various arrangements of the teeth are found. In the Chelonia (turtles) there are no teeth, although the ectodermal ingrowth (dental band) from which they are developed in other animals is present in the embryo. The place of the teeth in these reptiles is taken by horny jaw-cases.

In the Ophidia the non-poisonous snakes have two rows of teeth in the upper jaw, one on the maxillae and another on the palatine and pterygoid bones, while in the lower jaw there is only one row These teeth are sharp pegs anchylosed to the bones and so strongly recurved that one of these snakes would be unable, even if it wished to do so, to let any prey which had once entered its mouth escape. The poisonous snakes have a special poison fang in the maxilla of each side; these have a deep groove or canal running down them which transmits the poison from the poison gland. In the colubrine snakes, such as the cobra, the poison fang is always erect, but in the viperine, such as the adder and rattlesnake, there is a mechanism by which the tooth is only erected when the jaws are opened for striking. At other times the teeth lie flat in the roof of the mouth.

In the lizards or Lacertilia the teeth usually consist of a series of pegs in the upper and lower jaw, each resembling the one in front of it; sometimes, as in the chameleon, they are anchylosed by their bases to the bone, but at others, as in the iguana, they are fused by their sides to a ridge of bone which forms a low wall on their lateral surface. In the former case the dentition is spoken of as "acrodont," in the latter as "pleurodont,"

In the Crocoditia the teeth are fitted into definite sockets as in mammals and are not anchylosed with the jaws. This arrangement is spoken of as "thecodont." Existing birds are coothless, but palaeontology shows that they

originally had teeth of a reptilian character.

In all these lower vertebrates then, the teeth are similar or nearly similar in character; at least they are not divided into definite incisor, canine, premolar and molar regions. Their denti-

877 TEFTH

tion is therefore known as "homodont." Another characteristic is that in almost all of them there is an arrangement for a continuous succession of teeth, so that when one is lost another from behind takes its place, and to this arrangement the term "polyphyodont" is applied

Mammalia.- In the Mammalia the different groups of teeth (incisor, canine, etc.) already noticed in man are found, and these animals are characterized, with some exceptions, by having a "heterodont" as opposed to a homodont dentition. In the mammals too the polyphyodont or continuous succession of teeth is reduced to a "diphyodont" dentition, which means that there is only one relay of teeth to replace the first set In the marsupials the reduction of the succession is carried still further, for only one premolar in each segment of the law is replaced, while in the toothed whales there is no succession at all When one set has to

do duty throughout life the dentition is called "monophyodont" It is uncertain how the complex back teeth of mammals with their numerous cusps were derived from the simple conical teeth which are generally assumed to have been the primitive arrangement The "tritubercular" theory, which is most favoured, is largely based on the researches of E D. Cope and H F. Osborn, two American palaeontologists. According to this theory a simple peg-like ("haplodont") tooth develops two additional smaller pegs or cones, one in front and one behind the original main cone. This is known as the triconodont stage, and it is found in some of the oldest extinct mammals. As a later adaptation the two small cones become external to the original cone in the upper jaw and internal in the lower. The surface of the tooth has now a triangular shape with a cone at each angle, and this is the "tritubercular tooth" which is very common among the ancestral mammals Other cusps may be developed later, and so the quadricuspid and quinquecuspid molar teeth of man and other mammals are accounted for.

Incisor teeth are those which in the upper jaw have their sockets in the premaxillary bone; they are generally chisel-shaped, and with their opponents of the lower jaw act like scissors The canine tooth is the first tooth behind the premaxillo-maxillary suture, provided it be not far behind it, it is almost always the first of the maxillary series, speaking accurately, which is elongated and sharply pointed. The premolar teeth are those in the maxillary bone which are preceded by milk teeth. The molar teeth are those, behind the premolars, which are not preceded by temporary teeth

In front of the premolar teeth, and between them and the canine, if it be present, or the incisors, if it be absent, there is often a space called the "diastema." It is best marked in the Rodentia and Ungulata, and in the horse is familiar as the place where the bit lies. The elephant's tusks are modified incisors, those of the walrus and wild boar are modified canines.

Dental Formulae .- In recording the teeth of any particular mammal it saves time and space if a dental formula be used This simply means setting down the number of each kind of tooth in one side of the upper and lower jaw in their order from before backward. Thus man's formula would be, incisors  $\stackrel{2}{\rightarrow}$ 

canines  $\frac{1}{1}$ , premolars  $\frac{2}{2}$ , molars  $\frac{3}{3}$ . This is condensed into  $\frac{2 \cdot 1}{2 \cdot 1 \cdot 2} \cdot \frac{3}{3}$ Some other typical formulae are-

Catarrhine (old world) monke	ys		2.1.2.3
Platyrhine (new world) monke	eys		2.1.3.3
Marmosets			2.I.3 2 2.I.3.2
Most lemurs			2.1.2.3
or			2.1.3.3
Insectivorous bats (full series)			2.1.3.3

-		
	Frugivorous bats	· · · 2.1 2 3 2 1 3 3
	Insectivora (teeth variable)	
	Hedgehog	3 I 3 3
	rieugenog	2 Y 2.3
	Mole	$\begin{array}{cccccccccccccccccccccccccccccccccccc$
	Carnivora—	
	Cat family (Felidae)	· 3 1 3.1
	Dog family (Canidae) } Bear family (Ursidae) }	3 1 4.2
	Civet family (Viverridae) Racoon family (Procyonidae)	} . 3 1 4 2 3 1.4 2
	Hyaena family (Hyaenidae)	. 3 1.4 1 3 1.3 1
	Weasel family (Mustelidae)	3 1.4 1
	Eared seal family (Otariidae)	3 1 4 1
	Seal family (Phocidae) .	3 1 4 1
	Walrus family (Odobenidae),	
	In a young animal (probabl	2 7 2 2
	Ungulata	3 1.3.1
	Hippopotamus	$\frac{2.1 + 3}{2.1 + 3}$
	Pig family (Suidae)	$\frac{3 \text{ I } 4 \text{ 3}}{3 \text{ I.4 3}}$
	Camel	<u>1 1.3 3</u> 3.1 2 3
	Chevrotain (Tragulidae) .	o.r 3.3
	Deer family (Cervidae) .	o (oor1).3 3
	Hollow-horned ruminants (Bo	vidae) . 0.0 3 3
	Tapir	3.1 4.3 3.1.3.3
	Horse (Equidae)	· · 3.1.3.3
	Rhinoceros	· (0-2).0.4.3 (0-1).(0-1) 4.3
	Procavia (Hyracoidea) .	(1-2).0.4.3
		x.i.x.c.o.d.m.(3~4)m.3 0 0 0 (3~4) i 3
pl at	this animal the milk molars (d.m.) a lace one another from before backy t there are never more than two backy	nd true molars gradually ward throughout life, so

In y that there are never more than two back teeth in each segment of the jaw at any one time.

Rodentia-

Typical rodents (Simplicidentata)		1.0. (0-2) 3		
- 72	•	1.0.(0-1).3		
Hares and rabbits (Duplicidentata)		1.0.2.3		

878 TEETH

Cetacea -In the living toothed whales (Odontoceti) the dentition is homodont and may be as great as

There is every reason to believe, however, that they are derived from heterodont ancestors

The homodont dentition of the whales is a retrograde process, and is therefore not comparable to the homodont dentition of the

vertebrates below mammals. Sitenia -The dentition is monophyodont. The manatee has

1.  $\frac{2}{2}$ , c $\frac{o}{o}$ , back teeth  $\frac{\text{II}}{\text{II}}$ , these are replaced, like packages in a

vending machine, from behind

Edentata -The anteaters (Myrmecophagidae) are toothless, while the armadillos (Dasypodidae) and sloths (Bradypodidae) have a homodont dentition, which, like that of the whales, is retrogressive In the giant armadillo (Priodon gigas) the formula is

25 This animal therefore has a hundred teeth. In none of the 25

Edentata are the teeth covered with enamel.

Pholidota .- The pangolins or scaly anteaters are toothless, but show tooth germs in the foetus

Tubulidentata.—The aardvark (Orycteropus) has 5 to 6 enamelless cheek teeth These are simple for the most part, but several are bilobed. They lack a pulp cavity, but are provided with numerous prisms, each with a nutriant canal.

In the Marsupiaha the typical formula is 5 1.3 4. They are

divided into diprotodont, in which there are not more than 3

incisors, often 3 as in kangaroos, and polyprotodont, in which

the incisors are more than 3, as in the Tasmanian wolf (Thyla-

cinus) and Tasmanian devil (Sarcophilus).

In the Monotremata the echidna or spiny anteater is quite edentulous, while the duck-mole (Ornsthorhynchus) has functional molar teeth in youth, though in the adult these are lost, and their place is taken by horny plates.

Reviewing the various tooth formulae of mammals the following is usually regarded as primitive.

3.1.4.3

This, it will be noticed, is the formula of the pig, and it is also that of almost all the Eccene Ungulata

Brief Dental Glossary.—As the teeth are of such importance in the classification of animals, some of the chief terms by which they are described are recapitulated and briefly defined here

Acrodont, a tooth which is anchylosed by its base to the summit

1 ACCOGOM, a toout when is analytically a solution of a paraget on the jaw.
2. Biophodom, a molar tooth having two transverse ridges on its grunding snikee, as in the tapir.
3 Brackyodom, a low-crowned molar tooth—the opposite of hypso-

oht.

# Baucodout, a tooth bearing conical cusps

5. Diphyodout, having two series of teeth (milk and permanent)

6. Diphyodout, a marsupal with not more than § incisors, often
nly one on each side of the mandable

Haplodont, a tooth having a simple conical crown with a single

8. Heterodont, a dentition in which the teeth are not all alike, chiefly characteristic of the Manufielia
9. Homodont, a dentition in which the teeth are all alike, as in many of the lower vertebrates and some mammals

in the control vertex and some manners.

16. Hysiochem, a high-crowned molar tooth, such as that of the horse—the opposite to brachyodont.

11. Lophogodont, a transversely ridged molar tooth.

12. Monophyodont, having only one dentition (cf. diphyand molar tooth.)

polyphy-odont) 13. Multituberculate, a tooth, the crown of which bears numerous coulcal cusps; held by some to be the primitive condition of the mam-

14. Pleuradont, a tooth anchylosed to the inner side of a parapet on the law.

15 Polybunodout, a synonym foi multituberculate.
16 Polybhyodout, having an endless succession of teeth, as in most vertebrates below the mammals.
17 Polyprotodout, a marsup J having an incisor formula of more than \$\hat{a}\$.

18 Protodont, a stage met with in fossil mammals which is an advance on the haplodont tooth in that two small cusps are added

to the main cone 19. Secodont, a back tooth adapted to cutting, as in many of the Carnivora.

20 Selenodont, a molar tooth with crescentic ridges on its grinding

surface, as in most rummants
21 Thecodont, a tooth embedded in a socket or alveolus, as m mammals

Triconodont, a fossil stage in advance of the protodont. There

are three well-marked cones in an antero-posterior line
23 Tritubercular, a fossil stage succeeding the triconodont The
main cone is external in the lower teeth and internal in the upper A

man cone is external in the lower teeth and internal in the upper A very common form of back tooth in tosis forms and one which gives its name to the "tritubercular theory."

Bullionary.—Sir C. T. Times and the proper of the property of t

TEETH, ARTIFICIAL. Artificial teeth are those inserted in dentures to take the place of missing natural teeth. They are to be distinguished from artificial crowns, which replace only the crowns of teeth when the roots are retained, and from facings, which replace a visible surface of a metal tooth on a bridge (see DENTISTRY)

In early times the materials used were bone, ivory and hippopotamus tooth, and the restoration was often made in one piece, the teeth being carved from the same material as the base which rested on the gum tissue Individual human teeth or the teeth of various animals, especially the sheep, were sometimes mounted on gold or ivory bases, and were the best before the introduction of porcelain.

In the last quarter of the 18th century, one-piece restorations of porcelain began to be used, and at the beginning of the 19th century Giuseppangelo Fonzi, an Italian dentist practising in Paris, introduced individual porcelain teeth which were mounted on gold or platinum bases.

Porcelain teeth were introduced into the United States about 1817, reputedly by Anthony A Plantou (1774-1837). The form and quality of these teeth were much improved in America during the early decades of the 19th century,

The materials used in making teeth are essentially the same as those employed for other fine porcelain. Silica of exceptionally high fusing point is used to hold the form of the tooth. Kaolin forms the body material of the tooth Feldspar is the flux. A porcelain fine in texture, translucency and strength results Colour is supplied by metallic oxides which are incorporated in the basic ingredients

When vulcanized rubber (vulcante) began to be used about 1860 for bases on which the potoclam teeth were mounted, the teeth were designed with recesses in their bases (diatoric teeth) by means of which the vulcante retained them in position on the denture. In the fourth decade of the zoth century, when synthetic resus were introduced for denture bases, denture teeth were retained in the same manner. At middenture bases, definite tech were retained in the same manner. At mic-century the rapid development of many nontrillating plastics was bidding fair to revolutionize the production of all types of dentures. Early in the roth century, through the efforts of J Leon Williams, the appearance of artificial teeth was much improved by designing the

teeth to harmonize with the shape of the face. Teeth were made in three typical facial forms, square, tapering and ovoid. At the same time the effectiveness of the chewing surfaces of the back teeth was improved by the anatomical designs of Alfred Gysi of Switzerland During the fourth quarter of the 19th century several new designs of the posterior teeth were introduced which varied from the natural form and were intended by their inventors to increase the effectiveness of the teeth in mastication

The Cetter in massicasion in Britanoise and the Complete Denture Prosthesis, and ed., ch. vij. "Tooth Selection" (Philadelphia, 1946); E. W. Skinner, The Science of Dental Materials, 3rd ed rev., ch. xia and xii (Philadelphia, 1946); Walter H. Wight, 'Selection and Arrangement of Artificial Teeth for Complete Prosthetic Dentures," J. Am., Dent. (G. B. D.) Assn., vol. 22, pp. 2291-2307 (Dec. 1936).

TEGEA, an ancient Greek city of Arcadia, on a plateau enclosed by Mts Pathenum and Maenalus on east and west, and by transverse tanges which separate it from the plateau of Orchomenus and from the Eurotas valley Tegean territory occuped the southern part of this plani; the northern half belonged to Mantineas ( $q \circ$ ). Its geographical position accounts for the conficts which arose with Mantinea and with Sparta

Terea was one of the most ancient cities of Peloponnesus; tradition ascribed its concentration (synoecism) out of eight or nine primitive cantons to a mythical king Aleus As several Cretan townships passed for colonies of Tegea, oversea connections may be inferred in prehistoric days. The prominence which legend assigns to its king Echemus in opposing the Heraclid invasion shows that it was one of the chief Peloponnesian communities in pre-Dorian days For several centuries Tegea screened Arcadia against expanding Sparta; ultimately subdued about 550 BC it was allowed to retain independence and Arcadian nationality During the Persian invasion the Tegeans displayed a readiness unusual among Peloponnesian cities, in the battle of Plataea they were the first to enter the enemy's camp A few years later they headed an Arcadian and Argive league against Sparta, but after losing two pitched battles at Tegea and Dipaca they resumed their former loyalty about 468-467 In 423 there was open war with the Mantinesans, and when the latter rebelled against Sparta and allied themselves with Argos and Athens, the Tegeans stood firmly by Sparta's side in the decisive battle of Mantineia (418) their troops had large share in the overthrow of the coalition, and during the early 4th century Tegea continued to support Sparta against the Mantineians and other malcontents. But after the battle of Leuctra the philo-Laconian party was expelled with Mantmeian help

Tegea henceforth took an active part in the revival of the Ar-cadian League and in alliance with Thebes against Sparta (371-362), and the defection of Mantineia confirmed its federalist tendencies The foundation of the new federal capital Megalopolis threw Tegea somewhat into the shade Hostile to the Macedomans, in 266 it joined the Chremonidean League against Antigonus Gonatas To the incorporation of Mantineia into the Achaean League (233) Tegea replied by allying itself with the Actolians, who in turn made it over to Cleomenes III of Sparta (228). From the latter it was transferred by Antigonus Doson to the Achaean League (222); in 218 it was again occupied by the Spartans but reconquered in 207 by the Achaean general Philopoemen In Augustus' time Tegea was the only important town of Arcadia, but its history throughout the Roman and Byzantine periods is obscure, it ceased to exist as a Greek city after the Gothic invasion of 395. The site is now occupied by the small village of Piah

Archaeology.-The temple of Athena Alca at Tegea is described by Pausanias as excelling all others in Peloponnese The original temple built by Aleus, the founder of the city, was superseded by a larger one which was destroyed by fire in 395 B C. Rebuilding was entrusted to Scopas, the great sculptor; and probably he also provided the pediment sculptures, representing at the front, the hunt of the Calydonian boar, and, at the back. the battle of Achilles and Telephus. Both subjects were intimately associated with the temple, for Atalanta had dedicated in it the face and tusks of the boar, and Telephus was the son of Heracles and the priestess Auge. Two heads of heroes and that of the boar were found before 1880; later excavation, in 1883, showed the plan of the temple, which had six columns at front and back, and thirteen at the sides. Like the temple at Phigalia (q.v.) it combined all three orders-Doric, Ionic and Corinthian. In 1900 the French School at Athens recovered more fragments, including a head of Heracles and the torso and possibly the head of Atalanta, these last two of Parian marble. See GREEK ART.

Statish Carlotte 1, 65 ff. it. 35, 70; Thuryddes v. 38-73; Xeophon, Heleider, v. viv.; Folyhini 31, 64, 54, 77 v. viv. Xrophon, Heleider, v. viv.; Folyhini 31, 64, 65, 64, 77 v. viv. Xrophon, Heleider, v. viv.; Folyhini 31, 64, 65, 64, 77 v. viv. Xrophon, Heleider, V. V. viv. V

Rebus Tegratics (Lepng, 1886); Teropla rijs Tryins; Eső, iva rod Ewskeyov Teyearow (Athens, 1896), for come: B. V. Head, Historia Numorium (Oxford, 1881), pp. 350–331; G. Trusthied d. deutsch Inst Athen, vi. 1881; W Dunpled, iod ; vur 1883; G Mendel, Bulleim de correspondance helhangue, xxv. 1901. (See also NUMIS-

TEGERNSEE, a lake in Upper Bavaria, situated in a beautiful mountan country, 2,38 ft. above the sea, 34 m south from Munch by rail to Gmund, a village on the north shore. The lake is 4 m long, 12 broad, and about 235 ft deep. Its waters discharge through the Mangfall into the Inn It is one of the most frequented summer resorts in the vicinity of Munich

The village of Tegernsee, on the east bank, has a 15th century parish church and a ducal castle (formerly a Benedictine monastery)

TÉGETTHOFF, WILHELM VON, Bason (1827–1871). Austrian admiral, son of Leutenant-Colonal Karl von Tegethan was born at Maribor (Marburg) on Dec 23, 1837, After passing through the navla college at Ventice, he cease ensign in 1848 and heutenant in 1853. He served in the North Sea against the Danes (1848 and heutenant in 1856). He served in 1866 heutenant of the effective force of the Austrian 1867 and the North Sea against the Danes (1865). In 1866 he was placed his channel of the effective force of the Austrian 1867 and the Sea an

at Vienna on April 7, 1871.

TEGNER, ESAIAS (1782-1846), Swedish writer, was born on Nov. 13, 1782, at Kyıkerud in Wermland. His father, a pastor, whose name had been Esaias Lucasson, took the surname of Tegnerus-altered by his fifth son, the poet, to Tegnér-from the hamlet of Tegnaby in Småland In 1792 Tegnerus died. In 1799 Esaias Tegnér, educated in the country, entered the University of Lund, where he graduated in philosophy in 1802, and continued as tutor until 1810, when he was elected Greek lecturer. In 1806 he married Anna Maria Gustava Myhrman In 1812 he was named professor, and continued as a lecturer in Lund until 1824, when he was made bishop of Vexió. At Vexió he remained until his death, twenty-two years later. Tegnér's early poems have little merit. He was comparatively slow in development His first great success was a dithyrambic war-song for the army of 1808, which stirred every Swedish heart. In 1811 his patriotic poem Svea won the great prize of the Swedish Academy, and made him famous.

In the same year was founded in Stockholm the Gothic League (Gotisha forbundet), of young and patriotic men of letters, of whom Tegaér quickly became the chief. The club published an excellent magazine, Idana, in which it urged the study of old Icelandic literature and history. Tegnér, Geiper, Afzelius, and Nicander became the most famous members of the Gothic League. Tegnér's fame rests principally on three longer poems Nativerdibarnes ("The First Communion," 1820), well known in Long-follow's version; Pribhiofs, 30g (1820-25), a romantic paraphrase of an old saga, which was translated into nearly every European language; and the romance, Agaér (1820). In later years Tegnér began, but left unfinished, two important epic poems, Gerda and Kronbrades.

The period of the publication of Pritipiofs sage (1825) was the critical epoch of his career. It made him one of the most famous poets in Europe; it transferred him from his study in Lund to the bishop's palace in Vexiô; it marked the first breakdown of his health, which had hitherto been excellent; and it witnessed his unhappy passion for Euphrosyne Palm. On Nov. 2, 184,6 led diel Nexiô Torm 1879 he had been a member of the Swedish Academy, where he was succeeded by his biographer and best imitates Böttiger.

See Böttiger, Techning af Tegnérs Lefnad; Georg Brandes, Esalas Tegnér; Thommander, Tankar och Löjen; E. Böök, Esalas Tegnér (vol. i, 1917).

TEGUCIGALPA (tā-goo-thē-gahl'pa), the capital of Honduras and of the department of Francisco Morazán; 3,200 ft, above

sea level, on the Choluteca, at the head of a highway to the port, development of Tehran is remarkable. There is a beet sugar of San Lorenzo on Fonseca bay. Tegucigalpa is the only capital city of the American republics without railway connections. Pop (1950) 72,385, including the twin city of Comayaguela. Tegucigalpa became capital of Honduras, a status it had previously shared with Comayagua, in 1880. During the 18th century the neighbourhood was famous for its gold, silver and marble, but in modern times the mines and quarries have greatly declined in value and farming is the chief local industry.

TEHRAN (te-rahn'), capital of Iran and of a province of that name, is situated in 35° 41' N., 51° 25' E., at an elevation of 3,810 ft., on an extensive gravel deposit which slopes down from the foot of the Elburz mountains (some 10 mi, distant) and extends for 52 miles beyond the city, on the south. It occupies a radical position in Iran commanding routes in all directions, Isfahan being 224 mi. distant on the south, Bushire 677 mi, Baghdad 500 mi. west, Tabriz 374 mi. northwest, Meshed 471 mi. northeast, Herat 672 mi., and the Caspian sea 70 mi. distant.

Streets and Buildings. Formerly Tehran consisted of a fortified polygon of 4-5 mi. circuit surrounded by a battlemented mud wall 20 ft, high flanked with circular towers and having a dry ditch and six gates. In 1860 under the reign of Nasr-ed-Din Shah the old walls and towers were demolished and replaced by a moat and earthen ramparts 12 mi. in circumference, constructed on the plan of the fortifications of Paris, as they were before the Franco-German war. Riza Shah decided to pull down these constructions including the 12 gates consisting of lofty archways and turrets all adorned with coloured tiles. The city now extends everywhere beyond the old circumferences, particularly to the north where the modern residential section is rapidly developing The centre of the city is the Meidan Sepah (formerly Topkhaneh) a large square surrounded by modern government buildings, the ministry of post and telegraph, the municipality, the police buildings and the Imperial Bank of Iran. To the south is the old royal palace within the precincts of which are the Talar, or throne room, with the marble throne of Karim Khan Zand brought from Shiraz; the Takht-i-taus or Peacock throne, made for Fath Ali Shah, largely made from lewels looted from India by Nadir Shah. In this part of the town are several other ministries and the bazaars. The new palace is in the western part of the city somewhat south of the Shah avenue which runs east-west and leads to the house of parliament, the Majlis, and the Mosque Sepah-salar, grand vizier and minister of war of Nasr-ed-Din Shah. North of the Meidan Sepah are most of the embassies and legations. Large avenues and thoroughfares, paved or asphalted and planted with trees, cut through the old parts, and new buildings combining modern architecture with Iranian motives are springing up everywhere. Tehran is the junction of the Trans-Iranian railway leading from the Caspian sea to the Persian gulf and the East-West line connecting Khurasan (Meshed) with Azerbaijan (Tabriz).

Pop. (1940 census) 540,087; but it is said to have increased considerably after that year, because of the influx from the country. The government's estimate (1944) made for rationing purposes was approximately 800,000. The overwhelming majority are Persians and Shiites. Baha'is are numerous and there are some 4,000 Jews and about the same number of Armenians.

Riza Shah made Tehran a modern city with all improvements, such as electricity, telephone, motorbus service, clubs, cinemas, etc.; the essential desideratum is still canalization and a sewage system. The water supply is almost wholly from kanats bringing the water from the Shemran slopes of the Elburz. There are some 40 of them, 5-8 mi, in length, the majority fed from underground sources, and entirely dependent upon the snow and rainfall. Tehran has a modern university with all faculties represented; it is co-educational. There are a large number of hospitals, a nursing school, etc. The foreign schools and colleges were taken over by the government in 1940. Much has been done in the way of sanitation in recent years and there is a distinct improvement in the health of the city. Tehran has a royal museum in the old palace (Gullstan, or Rose Garden) where the crown jewels are kept, a modern Museum of Iranian Art and Archaeology and a Museum of Iranian Ethnology. The industrial

refinery, a cotton spinning factory, a tobacco plant, an ammunition factory, a plant for the manufacturing of soap, a cement plant, a brewery, distillenes, a plant for the manufacturing of glass, etc. North of Tehran is the village district of Shemran with the summer seats of the legations, hotels, and many private residences for the hot season. Two broad asphalted avenues have been constructed to connect Shemran with Tehran. South of Tehran are the rums of Rayy, one of the oldest cities of Iran and



THE DAUGHTER OF A RUG-

intimately connected with her history until it was destroyed by the Mongols in 1221. It was famous for its beautiful nottery of the 12th and 13th centuries (commonly called Rhages). A few miles farther south is the Shahzadeh Abd ul Azim a place of pilgrimage whose shrine with its golden dome is much visited. The place is connected with Tehran by a narrow-gauge railway constructed in 1888.

TEHRAN PROVINCE is bounded N by Mazanderan, W by Kazvin and Hamadan, S by Qum, and E. by Semnan-Damghan provinces, and it embraces a large part of the southern slopes of the Elburz range, while again to the south is found the Dana-i-Namak, a salt lake or morass, which extends 150 mi. E. and W and has a breadth of 35 mi. in some places.

History.-Though a modern capital MAKER OF TEHRAN Tehran is old historically, but was for long small and insignificant. It is thought that the name means "the plains" in contradiction to shamran, ie, "mountains" Almost the earliest mention of the place is by Yaqut (12th century) who speaks of its houses, constructed underground. It is described by Hamdullah Mustawfi, in the 14th century, as of some importance,

Under the later Safavis (end of the 17th and beginning of the 18th centuries) Tehran was sometimes the residence of the count. Sir Thomas Herbert who visited the city in 1627 states that it then contained 3,000 houses built of sun-dried bricks and supplied with water from a little river. The town was taken and pillaged by the Afghans in 1723, and receives mention by Jonas Hanway, 1744. With the rise of the Qajar dynasty at the close of the 18th century, the first epoch of the city's ascendancy began, Agha Mohammed Khan selecting it, about 1788, to supersede Isfahan or Shiraz as his capital. Riza Shah Pahlavi made of Tehran (q v.) a modern city Under the rule of Fath Ali Shah the city so increased in size

and population that when visited by Ouseley and Morier about 1810, it had 12,000 houses and 40,000-60,000 people. It remained at about this size for the first 70 years of the 19th century until it underwent an entire renovation at the hands of Nasr-ed-Din Shah. Tehran province is the seat of many industries as beet sugar refineries, cotton spinning factories, mining industries (coal,

sugar refineries, cotton spinuing factories, mining industries (coal, manganese, copper), a high furnace, cement plant, etc.
Billiography.—G. N. Cutzon, Persie and the Persing Question (1863); R. G. Krowne, A year amongst the Persing (1863) and 1950), Dr. Perviner, Prost and d la court de Perse (1900). A. V. Williams in the Constant of the Constant

Fluckiger (1926).

TEHRI GARHWAL, a mountain state in northern India, in the Punjab Hill agency: area, 4,516 sq.mi.; population (1941) 397,369. It lies entirely amid the Himalayas, containing ranges from 20,000 to 23,000 ft. above sea level, and also the sources of both the Ganges and the Jumna, with the places of pilgrimage associated with them. The forests, which have been leased to the British government, are very valuable, yielding several kinds of pine, oak and cedar. The chief, whose title is raja, is descended from a Rajput family which formerly ruled over all Garhwal. and enjoys a salute of 11 guns. The existing state was created by the British after the war with Nepal in 1815.

TEHUANTEPEC, town, Oaxnes state, Mexico The name Tehuantepee. (from teeuant-tepee—")-gauer hill") is also given to the sithmus, guif and tailway. The town is on the Tehuantepee river about 1.5 mi from its mouth and 13 mi by real from Salma Cius Pop (1950) 10.687 It is a typical Indian town, occupying the slope of a hill on the Pacific side of the divide, with a view of the river valley and the distant serras to the north. Most of the streets are little more than crooked paths up the hillside, and the habitations are for the most part thatched, mud-walled huts The population of the town and of the surrounding district is composed aimset whelloy of Zanotec Indians (or v)

TEHUANTEPEC, an isthmus of Mexico lying between the gulfs of Campeche (Campeachy) and Tehuantepec, with the Mexican states of Tabasco and Chiapas on the east and Veracruz and Oaxaca on the west. It includes that part of Mexico lying between the 04th and 06th meridians of longitude W, or the southeastern parts of Veraciuz and Oaxaca, with perhaps small districts of Chiapas and Tabasco. It is 125 mi. across at its narrowest part from gulf to gulf, or 120 mi to the head of Laguna Superior on The Sierra Madre breaks down at this point into the Pacific coast a broad, plateaulike ridge, whose elevation, at the highest point reached by the Tehuantepec railway (Chivela pass) is 735 ft The northern side of the isthmus is swampy and densely covered with jungle. The whole region is hot and malarial, except the open elevations where the winds from the Pacific render it comparatively cool and healthful The annual rainfall on the Atlantic or northern slope is 48 in (10-year average) and the maximum temperature about oso in the shade. The Pacific slope has a light rainfall and drier climate.

Since the days of Cortés, the Tehanstepe isthmus has been consident of avourable route, first for an interconance canal, and then for an interconance ruliway. His proximity to the axis of international trade paper it some advantage over the Fhannit toute, which was continpred in the continuous control of a constant of a canal across the sthmus compelled engineers and capitalists to give it up as impracticable, numerous projects for the construction of a ruliway were undertaken and abandoned. Constituction of the ruling the control of the control of the control of the control of the rule of the control of the

in 1907 and way it spr ms long and extends from Costra-solice on the golf of Compeche to Saline Cruz on the guld of Rhunstepes and connections northwestward to Verscruz and Mexico city are made at connections northwestward to Verscruz and Mexico city are made at Santa Lucrean and those eastward along the guld of Telunantepee to the Gustemalan border are made at Lixtepe, pear Salina Cruz.

See Miguel Covarrubas, Mexico South, the Isthmus of Telunantepee to the Gustemalan border are made at Lixtepe, pear Salina Cruz.

See Miguel Covarrubnas, Mexico South, the Isthmus of Tehuantepec (New York, 1946, London, 1947).

TEHUELCHE, an almost extinct Indian tribe once occupy-

TERUELCHE, an almost extinct Indian tribe once occupying the plans of Patagona from the Rio Negro to the Strate of Magellan. Their great stature and physical vigour have created a gaint-tradition in European literature. As the and, wind-swept nature of Patagona unifits if for agriculture, the Tehuelche necessarily were nomadic hunters. Before the 16th century they lived much as did their kinsmen, the Ona, in Tierra del Fuego, but the advant of the horse resulted in greatly enlarging their sphere of action and in various cultural changes.

See G. C. Muster, A. home with the Patagonium (London, 1871);
F. F. Outer, La dad de pitadra en Patagonia (Bunnoa Aires, 1872);
TEIGNMOUTH, JOHN SHORE, 187 Banon (1751—1834), governor-general of India, was horn on Oct 8, 1751, the son of Thomas Shore, a supercargo in the service of the East India company. He was educated at Harrow and went out to India as writer in the Bengal civil service in 176). He became a member of the supreme council (1787—89) and assisted Lord Cornauliis in introducing many reforms, but dd not approve his permanent settlement of Bengal. On the retirement of Cornwallis, he was appointed governor-general (1792—98) and adopted a policy of noninterference; but he deposed Wasir Ali, for whom he substituted Saadat Ali as nawab of Oudh. He met a mutiny of In-

dian army officers with concessions. He died Feb. 14, 1834.

Bellocarrix Charles Shore, 2nd Baron Teignmouth, Memoir of Bet Life and Correspondence of John, Lord Teignmouth, 2 vol. (London, 1831); also Pooma Residency Correspondence, vol iv, ed. by V. G. Dighe (Sombay, 1937).

Gun 1825/1827
Dithe (Rombo, 1917), a seaside resort and residential town in the TEGINMOUTH, a seaside resort and residential town in the Twetton parliamentary division of Devon, Eng., 16 mi. S.S.E. of Exeter by road. It lies on the north side of the Teign, and the urban disturt includes the parish of Shaldon on the south side of

the river, there crossed by a bridge At Shaldon the Ness head-land and estate are a public park Pop of urban district (1951) 10.580 Area 32 sq m The town spreads along the valley and over the wooded uplands to Little Haldon (800 ft ) where 43 ac of heathland belong to the national trust

Tegnmouth possessed a church of St. Michael as early as 1044, when what is now East Teignmouth was granted by Edward the Coatessor to Leofric, bishop of Exeter In the middle ages Teignmouth was a flourishing port, able to supply 7 ships and 120 mariners to the Calais expedition of 1347, and depending chiefly on the fishing and sall industries. Teignmouth was midded by the French in 1340 and again in 1690. In the 179th century it was a fashionable watering place The harbour is still used, and there is sea and river fishing

TEIRESIAS, in Greek legend, a famous Theban seer, son of Eueres and Chariclo, a descendant of the Spartos (see CADMUS) He was blinded early in life either because he saw Athena (or Artemis) bathing naked, or because he told Zeus and Hera that women had far more pleasure of love than men, thus bitterly offending the latter At all events, he was comforted by the gift of seer-craft and granted a very long life, finally being allowed, even in Hades, to retain his wits and not be a mere phantom As a result of killing coupling snakes he turned into a woman, years later he repeated the action, and became a man again He died just after the capture of Thebes by the Epigoni. His grave was at the Tilphusian spring; but there was a cenotaph of him at Thebes, and also in later times his "observatory," or place for watching for omens from birds, was pointed out (Pausanias ix 16, Sophocles, Antigone, 999). He had an oracle at Orchomenus, but during a plague it became silent and remained so in Plutarch's time (De Defectu Oraculorum, 44)

TEISSERENC DE BORT, LEON PHILIPPE (1855-1913), Fiench meteorologist, was born in Paris on Nov. 5, 1855, the son of an engineer He began his scientific career in 1880, when he entered the meteorological department of the Bureau Central Météorologique in Paris under E E W Mascart In 1883, 1885 and 1887 he made journeys to north Africa to study geology and terrestrial magnetism, and during this period published some important charts of the distribution of pressure at a height of 4,000 metres. In 1892 he became chief meteorologist to the bureau but resigned in 1896 and founded a private meteorological observatory at Trappes, near Versailles, where he carried out investigations on clouds and the problems of the upper air In 1898 he published an important paper in Comptes upper all in 1999 to purpose an improvant paper in Compress Results detailing his researches by means of balloons into the con-stitution of the atmosphere. His discovery of the so-allief nothermal layer, or structosphere, as it is now generally called, will always stand out as one of the most important events in the study of the upper throughner. He also carried out investigations in Sweden and over the Zuider Zee, the Mediterranean and the tropical region of the Atlantic, and fitted out a special vessel in order to study the currents above the trade winds. He collaborated with Hugo Hildebrandsson in Les Basses e la météorologie dynamique (1900-05). He died at Cannes on Jan. 2, 1913.

TERIRDAG, a city of European Turkey, on the Sea of Marmara, 76 m. W. of Istanbul. A Greek settlement founded probably in the 7th century ne., it was originally called Rhaedestus or Blasnthe, later Rodosto. Since 1923 it has been officially known under the Turketh name of Technica (princes hill). Rodosto was under the Auditanople (Edirne) area, but its trade suffered when Dédérade (he namardroupoil), on the Aegean sea, became the terminus of the Canandroupoil), on the Aegean sea, became the terminus of the Turketh of the Auditanople (Edirne) area, but its trade suffered when Dédérade hill the Turketh of the Auditanople (Edirne) area, but its trade suffered when Dédérade hill the Turketh of the 1st it was occupied by the Russians in 1877-78, by the Bulgars of the North of Panage Remove the State of Panage Remove the Panag

TEKTITE, the name given by F. E. Suess to the glass bodies occurring isolated on the surface or in gravels, in Moravia

and Bohemia, where they are called moldavites, the East Indies, where they are known as billitonites, and Australia, there known under the name of australites and obsidianites (from Gr τηκτός, "melted"). In Tasmania, an exceptional type is met with in the Mt Darwin region on the west coast, these glass bodies are known as Darwin glass (or queenstownite) Isolated types of tektites have also been seen in Sweden and Colombia (South

In the Moldau district of Bohemia the moldavites occur as flat, rounded or ellipsoidal bodies of a bottle-green colour, and usually with a pitted or corrugated surface. The homes of these tektites are river gravels or deposits of late Tertiary or recent age. The colour of this material led to its being commonly called Bouteillenstein Australites are found distributed over wide areas remote from volcanic regions in Australia, principally in Victoria and the central goldfields of Western Australia They exhibit a great variety of curious forms suggestive of flight and rotation while in a molten or plastic state These shapes are ellipsoidal, pear-shaped or buttonlike with a projecting rim like a saucer. They are darker and less transparent than moldavites Billitonites resemble australites more than moldavites, being dark like the former. They occur in river gravels in the island of Billiton, and are for the most part roughly spherical or ellipsoidal and possess glossy, deeply sculptured surfaces Billitonites reach in size up to 3 in in diameter and in weight to 16 oz.

Composition .- While possessing the silica content of natural obsidians (70%-90% SiO2) the tektites contain a higher percentage of iron and magnesium, and excess of calcium and potassium over sodium. Nor do they contain, with one doubtful exception, signs of incipient crystallization as is common in obsidians The distinctive chemical composition of these bodies is reflected in their specific gravity and light refraction, which enables them to be separated from rhyolite and trachyte obsidians It has been claimed that they originated by the fusion of dust in the air by lightning and that they are really fulgurites, but little can be said for this view. Though they are of widely different composition from the iron or ultrabasic meteorites, a meteoritic origin remains as the least objectionable of all theories.

Analyses of some typical tektites are given below:

	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>2</sub>	FeO	MgO	CaO	$Na_2O$	K <sub>2</sub> O
1	77 75	12 90		260	0 22	3 05	0 26	2 58
2.	70 92	12 20	1 07	5 42	261	3 78	2 46	2 49
3.	68 gr	15 02	0.40	465	2 47	3 20	1.29	2.56
4	89 81	6 21	0 26	0.89	0 73		10.0	1 05

- Moldavite—Radomilitz, near Budweis, Bohemia
   Billatonite—Tebrug, Dendang, Indonesia
   Australite—Uralla, New South Wales
   Darwin glass—Ten-Mile hill, Mt. Darwin, Tasmania

BRILIOGRAPHY — F. E Stees, Mitt. Geo. Geetl., vol. vii, pp 51-121 (Wien, 1014), L J. Spencer, Mrn Mag, vol. xxv, pp. 425-440 (1939); F. A. Panelh, The Origin of Meteorites (Halley lecture), pp. 22-25 (Oxford, 1940).

TELAMON (mod. TALAMONE), an ancient city on the coast of Etrura, 11 mi. N. of Orbetello, where the Romans defeated the invading Gauls in 225 BC. Marius disembarked there on his return from Africa in 87 BC., but in 82 the town was destroyed by Sulla's troops and thereafter declined. The harbour was of some importance in the middle ages. The ancient site lay on the hill of Talamonaccio, (H. H. SD.)

TELANG, KASHINATH TRIMBAK (1850-1893), Indian orientalist, was born at Bombay on Aug. 30, 1850. In 1889 he became a judge of the high court, where his judgments are recognized as authoritative. He was a great Sanskrit scholar, his translation of the Bhagavadgita into English is a standard work, and he criticized Weber's theory of Homeric influence on the Ramayana.

Telang died at Bombay on Sept. 1, 1893.

See R. West, Telang's Legislative Council Speeches (Bombay, 1895). TELAY (Georgian TELAYI), a small town in the Georgian S.S.R., on the Alazan river, alt. 2,420 ft, in 41° 55' N., 45° 24'

in 803, it was the capital of Kakhetia until 1762, when King Herachus II of Kakhetia succeeded his father Teimuraz II as king of Georgia and united the two kingdoms, and the ruins of its forts still exist. In its environs are religious foundations of great antiquity, the 6th-century Iqalto monastery, the Alaverdi cathedral founded in the 10th century and the 16th-century Shuantı monastery

About 5 mi E of Telav is situated Tsinandali, once the domain of the princes Chavchavadze, where the best Kakhetian wine is produced (See Georgia )

TEL AVIV, a city in Israel, founded by Zionist settlers in 1909 on the sand dunes north of Jaffa. At the beginning of World War I it counted 182 houses with a population of 1,313 With the growth of Jewish immigration after the establishment of the British mandate in 1922 the population rose rapidly. By 1943 the city counted about 220,000 inhabitants and had surpassed in size and importance the neighbouring Jaffa, thus making Tel Aviv the largest city in Palestine.

Tel Aviv is a thoroughly modern city with up-to-date houses affording the most modern comfort, with broad shaded avenues and a bustling atmosphere of business in the American way. It is entirely inhabited by Jews, and thus forms the first all-Jewish city anywhere. After 1936 a new harbour was built to supplement or replace the old-established harbour of Jaffa The first Hebrew high school (gymnasium) in Tel Aviv was opened before World War I, and the city is today a centre of Jewish cultural life in Israel, the home of the Hebrew theatre and the place of publication of most Hebrew books and newspapers. Part of the long shore line of the city has been converted into a fashionable bathing resort.

Athletic competitions in which Jews from all countries participate are held every second year in Tel Aviv and are called Maccabiah In the first period of Israel's independence, Tel Aviv was the seat of government
In 1950 Jaffa was incorporated into Tel Aviv giving the city

a combined population estimated at 310,000. (H Ko , X )

TELECHRON, an electric timekeeper invented by Henry E. Warren which is operated and regulated by alternating current. The motive power is a small self-starting motor running in exact synchronization with a central station generator.

TELEGRAPH. Before the Christian era the attracting properties of rubbed amber and the magnetic attraction of the lodestone had been observed, but they were regarded purely as interesting phenomena until Giovanni della Porta, in 1558, suggested a "sympathetic telegraph." This he described as two needle-shaped pieces of steel, each mounted at the centre of a dial with letters equally spaced around the periphery, and "both needles magnetized by the same lodestone" A movement of the needle of one instrument was supposed to cause a synchronous movement of the other instrument, and it was thought communication could thus be set up between two distant points. Actually no practical results were obtained until after the discovery of the Leyden jar about 1745. Pieter van Musschenbroek demonstrated that the charge from a Leyden jar could be conveyed a distance over a wire conductor, and about the same time Benjamin Franklin disclosed the results of his investigations of electricity.

## EARLY TELEGRAPHS

Spark and Pith Ball.-Sir William Watson in England demonstrated in 1747 that an electric current could be transmitted through a considerable length of wire using the earth for the com-pletion of the circuit Eleven years after Watson's discovery, the first suggestion for an electrical telegraph was made in Scotland by an anonymous writer to Scots Magazine, signing himself C. M., who advised using an insulated wire for each letter of the alphabet. At the receiving end of each wire a pith ball was to be suspended above a piece of paper marked with an alphabetical letter. As a charge was sent along a given wire, the ball would attract the paper beneath it, and, by observation, words could be spelled out. He further suggested that bells might be substituted for the E., on a branch railway from Tilis. Its population (8,766) is papers, which could be struck in turn by a ball as a charge was sent mainly occupied in silk weaving and wine, production. Founded along any desired wire. The idea was carried out by Georg Louis Le Sage in Geneva in 1744, and similar telegraph systems were suggested by Bétancourt and Lomond in 1785. Then followed ones suggestions using a separate wire for each letter, by Reuzen in 1794, and by Don Francisco Salva in 1798, who each proposed a system of visual telegraphy by causing a spark to appear at a gan at the receiving end of each wire as desuited.

Sir Francis Ronalds worked a telegraph in England in 1816 with tanamitting and ieceving apparitus consisting of circular plates, on which were inscribed letters and figures. In fiont of each plate was a disk with an aperture which allowed one letter and its corresponding figure to be visible. The plates were rotated by clockwork regulated so that the same letter was displayed simultanously at both ends. A crude electric machine charged the line when the sender desired, and the divergence of a pair of pith balls at the roceving end indicated to the operator that the letter or figure appearing at that moment was to be recorded

Toward the end of the 18th century, Lung Galvam and Alessandro Volta conducted experiments which revolutionized presondre Volta conducted experiments when revolutionized presoncewed ideas of electricity and its effects. In 1786, Galvam accidentally discovered that it was possible to cause a direct conduction by bringing two dissimilar metals into contact with a most substance in 1800, Volta introduced an electric battery which became known as the voltaic pile, the principles of which became embodied in the modern battery, and in that year Salva demonstrated that voltaic currents could be used for transmitting simals

Electrolytic Telegraphs.—An immediate result of the introduction of the voltaic pile was the discovery by William Nicholson and Sir Anthony Carlisle in 1800, that the passage of an electric current caused decomposition of liquids into their constituent elements Based on this principle, Salva in 1805 and Samuel Thomas von Soemmerring in 1809 introduced apparatus in which a voltaic pile was used for sending signals whose presence were indicated at the receiving end by the liberation of hydrogen In Sommerring's instrument, 35 wires, each allotted to letters of the German alphabet and the ten numerals, terminated in a receptacle containing water (fig 1) At the sending station a voltaic battery was connected as desired to any of the line wires, and the message was read by observing at which of the terminals the bubbles of gas appeared Later researches by Sir Humphry Davy on the decomposition of chemical compounds by electric current were applied in the United States to another type of telegraph by John Redman Coxe in 1816, and Harrison Gray Dyar in 1828, who each operated a telegraph using the electric current to produce electrical decomposition at the end of the conductors. Dyar operated his telegraph line over 8 mi. on Long Island, using a single wire with ground return circuit to mark coded signals on a moving strip of litmus paper by discoloration from the received electric current.

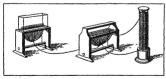


FIG. 1.-SOEMMERRING'S ELECTROLYTIC TELEGRAPH

Electromagnetic Needle—At the beginning of the 19th century, a new set of ideas followed the introduction of the electromagnet. In 1819, Hans Christian Oersted discovered that a magnetic needle could be deflected from its normal position by passing a current through an adjacent wire, and that the deflection was to the right or left, according to the direction of current. A year later Johann Salomo Christion Schweiger found that the deflection of the needle could be increased by surrounding it with a number of turns of wire, and in 1825 William Sturgeon in England

produced and named the electromagnet (fig 2).

The action of the electric current on a magnet was first applied to telegraphy by Andre Mares Ampier in 1820, at the suggestion of Perre Simon Laplace has the deflections of small magnets placed at the recurring the state of the surface of the surface of the state 


FIG 2 .- ELECTROMAGNET

In 1831, Joseph Henry constructed and successfully operated an electromagnetic signalhag apparatus which consisted of a magnetized steel bar supported on a pivot in a horizontal position, which could be attracted by a magnet When the magnet was energized by current the extremity of the bar was caused to strike a suttably adjusted bell

and intelligence was conveyed by coded sound combinations Gauss and Weber conducted important experiments in 1833 on line conductors in which they demonstrated that the line conductor need not be insulated over its entire length. In their experiments they used a single-needle telegraph to communicate with each other, and proved that by proper combination, five signs are sufficient for communication. In the early experiments of Cooke and Wheatstone, five wires and five needles were employed but later were reduced to one of each. In the single-needle instruments a magnetic needle was provided in the centre of a wire coil, and by deflecting it to the right or left, in accordance with a prearranged code, intelligence was transmitted.

### MORSE ELECTROMAGNETIC TELEGRAPH

In Oct 1832, Samuel F B Morse, a US artist, was returning from Europe on the packet ship "Gully." Following discussion with other passengers of a recent publication by Michael Faraday on electromagnetism, he made plans for a telegraph recording instrument and laid the principles for his dot-dash-space code, based on the duration or absence of the electrical impulses Three years later. Morse constructed an experimental model on a picture frame (fig. 3) The mechanical action of an electromagnet A, operated a lever B, carrying a pencil C Passage of electrical impulses through the electromagnet caused the pencil to move in contact with a paper tape D, moving over a cylinder E, under the pencil, thus drawing an undulated line embodying his code. The sending device, called a "portrule," sent electrical impulses over the line by causing contacts at the end of the lever I to close the line circuit The projections K were pieces of metal on the "rule" L to actuate the lever, and were so spaced as to form his code A crude model was privately exhibited at New York university in

As experiments progressed, it was found that the electric current, after passang over a line or mic or so in length, became too feeble to operate the receiving apparatus. With the assistance of Leonard Dunnell Gale and Henry, Morse devised a relay (fig. 4) which would automatically repeat signals into another section of line and join circuits in this manner for any desired distance.

In improved apparatus a number of modifications were made. The "portrule" was abandoned in favour of a simple cituit-closer, or key, by which the signals could be formed by hand. For the original penal-marking method three recording methods were substituted—the fountain pen, an inked wheel or a stylus which indented the paper. Later (r&4) Alfred Vail made the valuel educated when the substituted with the substituted with the substituted with the substituted with the substituted with the substitute of the substi

In Feb. 1838, Morse demonstrated his telegraph before Pres. Martin Van Buren and his cabinet. On March 3, 1843, a bill was

mental line was constructed between Washington, D.C., and dash and the space between words is twice one dash Baltimore, Md At first a portion of the line was an insulated, lead-covered pair of conductors buried in the ground by means of a specially constructed plow, but later the line was built above ground, on poles Morse sent the first public telegram, "What hath God wrought," over this 40-mi line on May 24, 1844 After

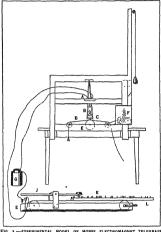


FIG. 3.-EXPERIMENTAL MODEL OF MORSE ELECTROMAGNET TELEGRAPH

a period of exhibition, the postmaster general decided the telegraph was a toy that never would support itself, and the government withdrew its support Morse then enlisted private capital, and in 1845 a company was organized to extend the telegraph line to Philadelphia, Pa., and New York city. By 1851, 50 companies using Morse telegraph patents were in operation in the United States, and by 1861 Morse systems were in use in Europe.

Although Morse methods were used to handle less than 5% of the telegrams in the United States after automatic printing tele-

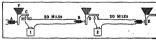


FIG. 4 .- DIAGRAM OF THE MORSE RELAY

graph systems came into general use in the 1920s, telegraph circuits in various parts of the world still employ the fundamental principles of the original Morse system. On circuits of this class, signals, in accordance with the Morse code (fig. 5), are transmitted as short and long pulses of current, separated by intervals of no current. The short and long pulses are termed, respectively, dots and dashes. The dot is a very short signal; when made by hand on a telegraph key it is about 1/24 of a second. The dashes are about three times as long. The space between components of a

passed appropriating funds to test its practicability An experi- letter is equal to one dot, the space between letters is equal to one

AMERICAN USED OR LAND LINES IN THE	INTERNA	
UNITED STATES AND CANADA.	USED ON LAND LINES IN RUNOPE AND FOREIGN COUNTRIES AND IN WIRELESS	USED ON OCEAN CABLES
A e ange	A o nema	A
B mangers	В шинее	B _eee_
C	C stores o stores or	C _e_e_
D seem o o	D some o	D -00-
E . (-! Unit)	в.	E
F o sous o	F e e gant e	F ee_e_
G шин ишин ө	G annua puntur e	6
H	Н	H 0000
I **	1 00	1 .22
Ј шин о мин о	J • mas men men	
K carrie o mana	K mma a mma	К "е
L managem (=5 Units)	L omaso	L eee
H mos gayes	M com som	H
N restar	N auto	N -
O e e	O sees sees may	P
Q company	Q seems peem o pages	
R • ••	R commo	R
Y men (-3 Units)	T mm	
U eemm	U semme	0
V econom	V eeems	V
W o response	W semperati	W
X ammed	X smarr o a treate	х
Y	Y sums a gentle summer	Y
2 *** *	Z man agent o o	Z -0.0
1 amm mms	I a consumer many many many	0000
2 0000000	2 0 0 0000 0000 0000	Z 98
3	3 *** (100 100)	3 ****
4	4 mu	4 2222
2 com state sound	5	5
6	б минее	6
7 1001 1005 9 6	7 1000 2000 0 0 0	7
9	8 1000 1000 1000 00	
	9 1000 1000 0000 0000 0	9 2000
O manageme (=7 Units)	0 0000 0000 0000 0000	****
PERIOD	PERIOD	PERIOD
CONNA	Сония	COMMA
INTERROGATION	INTERROGATION	INTERROGATION DO
COLON Man . Man	COLON MAN AND AND CO.	COLON
SENI COLON QUOTATION MARKS	QUOTATION MARKS QUOTATION MARKS	SHINI-COLON

FIG 5 .-- ADAPTATIONS OF THE HORSE CODE

The single-current Morse system most used in Europe employs an open-circuit arrangement (fig. 6), so called because no current passes over the circuit while it is idle. Sending and receiving instruments are connected to the line at each station, and whenever

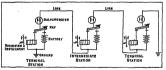


FIG. 6 .- DIAGRAM OF OPEN CIRCUIT

the transmitting key at any station is depressed the circuit is closed, causing the receiving instruments at all other stations to respond. American single-current Morse circuits are generally operated upon the closed-circuit plan (fig. 7). The only periods during which no current flows are those corresponding to the spaces between dots and dashes, this condition being affected by the opening of the transmitting key at one of the stations.

Double-current Morse systems (fig 8) have the great advantage of operating more rehably and with less need of readjustments of apparatus upon circuits of inferior transmission qualities, such sthose caused by excessive length of line, poor insulation or the

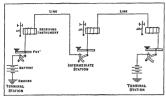


FIG. 7 -- DIAGRAM OF CLOSED CIRCUIT

inclusion of long sections of cable. They require a polarized receiving instrument and means for sending two polarities of battery from each terminal Battery of one polarity or the other is always applied to the line, one pole used for "marking" and the other for "spacing"

Duplex and Quadruplex Systems.—In the telegraph systems so far described, only one message can be transmitted over the line at a time. The economic advantages of being able to send two telegrams simultaneously over one wire led to the develop-

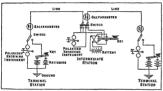


FIG 8 -DIAGRAM OF DOUBLE-CURRENT MORSE CIRCUIT

ment of duplex systems in which the two sendings can be in opposite directions. The first duplex arrangement was devised by Wilhelm Gintl of Vienna in 1853. An essential feature of any duplex system is the provision at each station of a relay or other receiving instrument, so arranged as to be unaffected by any signals sent out from that station, but fully responsive to all signals received from the distant station. All duplex schemes

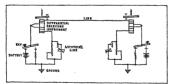


FIG 9 .- DIAGRAM OF DIFFERENTIAL DUPLEX CIRCUIT

employ the principle of having the sending impulses of current divided into equal parts, half going over the line to the distant station, and the other half going to an "artificial line" adjusted to be the equivalent of the real line in electrical characteristics

Differential Duplex.—In the method shown in fig 9, the electromagnet of the relay is wound with two equal coils of wire Curient through the sending key passes through the two coils of the lelay at the sending station in opposite directions, and the magnetic effects neutralize each other, resulting in no response of the instrument at the sending end. At the receiving end, however, the line current passes through the two coils in such a way that their magnetic effect is additive, and the distant instrument thus esponds to signals received. With apparatus arranged in this way, at each end of the line, both stations may send to each other at the same time without interference

Bridge Duplex.—Another method of duplex working employs the pumelps of the Wheatstone bridge, as shown in fig to The outgoing impulses pass to the line and artificial line through equal bridge arms and have no effect upon the receiving instrument forming the cross-connection at the extremities of those arms. The receiving matriment is, however, responsive to the unbalancing effect of any application of current at the distant station. It is possible to operate both differential and bridge duplexes by either single-current of double-current methods, but the double-current scheme is generally preferred.

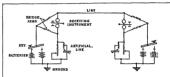


FIG 10 -DIAGRAM OF BRIDGE DUPLEX CIRCUIT

Quadruplex.—By combining a modified single-current system with the double-current dupler in 1874, Thomas Alva Edison produced the quadruplex. With this scheme four messages, two in each direction, may be simultaneously transmitted over one line wire. The two relays at each terminal of the line are arranged to be unresponsive to outgoing signal by either the differential or bridge methods. In receiving signals one of the relays responds only to reversals of current effected by the distant double-current key. The other relay responds only to microsist and decreasers in current strength, regardless of the direction in which the current is flowing. These variations in applied current are controlled by a single-current key at the distant station (fig. 11).

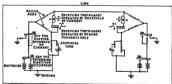


FIG. 11.-QUADRUPLEX CIRCUIT

#### AUTOMATIC TELEGRAPHS

The classification of automatic telegraphs may broadly include all systems in which signals are transmitted by machine methods and automatically recorded. Automatic means of transmitting and recording were proposed prior to Morse's invention, and Morse employed them in his first models, but it was only after the beginning of the 20th century that printing telegraph systems came into general use. Automatic systems fall generally into three classifications (1) signals recorded in code form, which must be transcribed; (2) messages received in printed form; and (3) reproduction of a facsimile of the original

Recording Systems .- The recording systems, which by 1930 had almost completely been displaced by other methods, comprised means much like the original Morse apparatus in which coded signals were recorded in various ways on a moving paper tape. In the Wheatstone system, which at one time was quite ex-

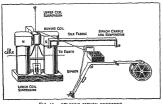


FIG 12 --- KELVIN'S SIPHON RECORDER

tensively used, the dots and dashes were printed as long and short marks, caused by the receiving electromagnet attracting an inked wheel against the moving paper.

Various chemical recorders, proposed by Dyar, Alexander Bain and Edison, used a metallic wire resting upon a moving chemically treated tape, the wire and tape forming part of the circuit. When current passed through them, an electrolytic decomposition occurred which caused discoloration of the tape.

The recording systems used on some older types of ocean cables were developments of ideas proposed by Werner Stemens and Johann Georg Halske, and Lord Kelvin In these systems the dots and dashes are received as impulses of equal duration but opposite in polarity, while spaces are intervals of no current. The recorder (fig 12) is a galvanometer with an ink siphon attached to the moving coil. The siphon rests against a moving paper tape, drawing a continuous line undulated above or below the centre by deflections of the galvanometer when impulses of dot or dash polarity are received.

Transmitters used with these recording systems were motordriven mechanical devices arranged so that perforations in a paper tape were caused to control the sending of proper impulses

to the line. The simpler types merely permitted a brush to make contact through the perforations with a metallic bed Perforated tape used for transmission in these systems was prepared in various types of perforating machines, the more modern of which were provided with keyboards like a typewriter, so arranged that the depression of a single key perforated the proper combination of dots and dashes for that character The first suggestion for a

reperforator was made by Bain in 1846.

Printing Telegraphs.—The early printing telegraphs incorporated the so-called step-by-step principle. Printers using this principle are provided with a rotatable type wheel upon which characters are evenly spaced around the periphery. The type wheel is provided with a stepping device operated by an electromagnet so arranged that each impulse received from the line will advance the type wheel one character. Assuming that the initial position and arrangement of the type wheel are known, the sending operator may transmit a sufficient number of impulses to move any desired character into printing position. When this has been done, an impulse of a different nature is transmitted which energizes a printing magnet to make the impression. These systems were commonly provided with an automatic keyboard transmitter containing a motor-driven commutator which, in the interval between the depression of any two keys, would send the required number of impulses to move the type wheel from its

previous position to the character corresponding to the key next depressed Names prominently associated with step-by-step printer developments were Royal E House, David Edward Hughes, George May Phelps, John E. Wright, John Burry and George B Scott The Hughes system, which was an improvement of House's idea, was the only one to be used to any extent for telegraph handling Several of the other step-by-step systems were extensively used for reporting gold prices and stock quota-

Modern printing telegraph systems make use of five-unit permutation code, early suggested by Gauss and Weber, but first applied by Jean Maurice Émile Baudot and commonly known as the Baudot code In these systems, five impulses are transmitted for every character, any one of which may be either selecting or nonselecting. With such a code it is possible to obtain 32 different combinations, 26 of which are assigned to letters of the alphabet, leaving 1 for the idle condition and 5 for functions such as space, figure shift, letter shift, etc (fig 13) The five impulses making up the code are sent to the line successively by means of a rotating distributor or commutator, and are distributed at the receiving end by a similar means to five receiving devices. These devices, through any of several selecting mechanisms, determine which one of the characters of a typewriting machine is to be printed. In order that the first impulse may properly operate the first receiving device, etc, each must be associated with the line while the corresponding impulse is being transmitted, ie, the sending and receiving distributors must operate in synchronism. This is accomplished in several different ways with different systems. In some, extra pulses are transmitted, while in others, the signals themselves are used. The printers used in these systems are arranged to record a telegram on a page, or on a paper tape which is then pasted on a blank by the receiving operator

Various transmitting mechanisms are used with these systems The earliest and simplest used five separate keys which had to be set up simultaneously in their various combinations by the operator, later methods employed a direct keyboard like a typewriter, each key acting upon five transmitting keys to set up the combinations. Another common method uses a keyboard perforator which prepares a paper tape which then passes through an automatic transmitter. The perforations in the tape actuate five key levers in the transmitter



FIG. 13 -TRANSMITTING TAPE PERFORATED WITH FIVE UNIT CODE

Among the printing systems employing the five-unit code may be mentioned the Murray, Morkrum, Kleinschmidt, Siemens-Halske and Creed. Other printing systems, developed by Charles L. Buckingham, Frederick G. Creed and John C Barclay, used the dot-dash code Multiplex Methods.-The multiplex system of printing teleg-

raphy, placed in general use on trunk telegraph lines in the U S in 1914, employs synchronous distributors to provide additional transmissions or channels of communication on a single-line circuit. This is accomplished by dividing the use of the line between the several channels, the distributors being used for this purpose The multiplex principle, illustrated by fig 14, shows a sending and receiving distributor, the brushes of which are rotated in constant synchronism and phase The sending distributor is provided with five segments, to which are connected five keys which may be operated manually or by automatic means to set up the five-unit combinations of the Baudot code. Five corresponding segments on the receiving distributor are connected to five selecting magnets of a printer. Assuming that a combination corresponding to the desired character has been set up on the transmitting keys, signals forming this combination will be transmitted to the line as the sending brushes pass over the sending segments. At the instant when the sending brush is in contact with the first sending segment, the receiving brush will be in contact with the first receiving segment, and if no 1 key is in an operated position the circuit will be completed and the first selecting magnet will be energized

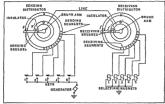


FIG 14 -DIAGRAM SHOWING THE MULTIPLEX THEORY

As the sending brushes pass to the succeeding segments, the remaning selecting magnetis will be operated or remain inoperative, depending upon the position of the corresponding key at the sending station, thus in each revolution an entire character is transmitted by the transmitter and received by the printer. While fig ar illustrates only one channel of communication, it is obvious that the section of the rings A and A' between segments 3 and 1 may be provided with additional groups of five segments which can be connected to other sets of keys and selecting magnets to provide additional channels of communication. The transmission is such that duplex methods may be applied to permit simultaneous operation in both directions

Multiplex methods were first proposed by Moses G Farmer in Amenca, who suggested duyson of ine tume between two or more operators. Myer and Patrick Bernard Delaney endeavoured to improve the system, but it was Baudot who developed the first practical multiplex printing system using five-unit code. This system became the basis of other multiplex systems such as the Murray, American and Morkrum multiplex systems of their multiplex systems employed codes of more than five-unit length in order to meet certain special requirements

Teleprinters.—In the early 1900s, it became apparent that a simple printing telegraph apparatus was needed which could be operated in locations without constant expert attention. To fill this need, telegraph printers, later classified as teleprinters, were developed by Edward E. Kleinschmidt and the Morkrum company in America, Creed and company in England and Stemens-Halske in Germany.

The teleprinter has a keyboard and printing unt and resembles a typewriter, but in the teleprinter these two units are not mechanically interconnected, except that they use a common electric motor drive. When a key of the keyboard is depressed, it sets up a code combination for the corresponding character which is transmitted to the line circuit by a distributor. The intelligence code employed was established, by international agreement, as the five-unit Baudot code, to which is added a start impulse and a rest impulse used for the purpose of maintaining an approximate synchronous relationship between the sending and receiving devices.

On the teleprinter at the other end of the line, the responses of the armature of a single electromagnet are distributed by mechanical means to position selector devices which cause the corresponding character to be prunted. The home-office printer may be connected in series with the ine circuit to give a home record from the transmission, or it may be connected in a duplex arrangement so that it will receive only incoming signals from the distant station.

The use of stop and start pulses added to the five-umt intelligence code gives the equivalent of a seven-unit code and such systems are frequently referred to as seven-unit start-stop printing telegraphs. These systems have been used extensively, not only for point-to-point telegraph trunk circuits, but they have been installed in great numbers in customers' premises and connected by direct wire with the commercial telegraph hetwork. They are also extensively used in telegraph exchange systems and in private leased-wire networks

The growth of punting telegraphy was particularly rand following World War I, with at least 95% of US. landline trafficbeing handled in this way. Prior to World War II telepiniters gave more than 20,000 US. telegraph customers direct wire connection with the telegraph system and extensive telepiniterexchange networks were started in the United States, England and Europe During the war, great impeties was given to increasing printing telegraph facilities, and extensive teleprinter networks, some encompassing the entire globe, were set up war ardio, landline and submarine cables, for use of the US armed services and other government agencies

Fassimile Telegraphy—Among the facsimile systems may be included writing telegraphs, such as the early telautograph invented by Elisha Gray (fig. 15). The transmitter for these writing telegraph systems consists of two rheostats which are varied through suitable linkages by the motion of a stylus. Each rheorizatis compected to a separate line wire which terminates in a sole-noid at the receiving end. The armatures of these solenoids are connected by smullar linkages to a recording pen. As the sending stylus is moved to form a letter, the vertical components of the motion are caused to vary one of the rheostats, while horizontal components vary the other, changing the currents in the two line write. In this way the attractive forces of the two receiving solenoids are changed in proportion and the receiving pen is caused to diplicate troughly the motion of the sending stylas World Was II developments improved the principle of the telautograph, using more modern techniques to gue faster and more faithfull reproduc-

Other types of facsimle systems are properly regarded as systems of telephotography. They are developments of early systems such as Bakewell's and D'Alneourt's copying telegraphs. In these systems be picture or text is specially prepared for transmission and then exposed, a minute area at a time, to a transmitting device, by means of which the line current is varied proportionately with the degree of shading in the exposed area. At the receiving end, equivalent mutuet areas of a sensitized paper are synchronously exposed to discoloration, the degree being controlled by the variations in line current, thus duplicating the contrasts of the original picture. "Scaming" of the sent and received copy is customarily done by either closely spaced binomontal lines across a flat page, or by a helix around the message when placed on a cylindical dium.

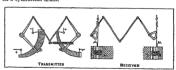


FIG 15 -GRAY'S FACSIMILE SYSTEM

Because early facsimale methods employed time-consuming processes in preparing the transmitted copy and developing the received telegram, these methods were not particularly suitable to the handling of fast telegraph tradific. The development by Western Union in 1924 of a high-speed, dry, permanent recording paper made it possible to scan optically any handwritten or typewritten telegram text and instantly receive a copy ready for delivery. As a result of this development, small low-cost facsimile machines were extensively installed in the United States to connect customers and branch offices to central telegraph offices, and the convenient application of this method of telegraphy resulted in the

uses Transmitters and recorders for heavily-loaded circuits were designed in which the telegram to be sent of a receiving blank may be placed upon cylinders which are loaded into a magazine from which the machines are automatically fed. In another type of transmitter, the telegram to be transmitted is merely dropped into a slot and the machine automatically wraps it around a drum and transmits it The Desk-Fax, a miniature facsimile machine, was installed in customers' offices to bring telegraph tacilities within aim's reach of the businessman These small sending and receiving machines enable the user to send telegrams by merely placing the message around the cylinder and pressing a button Electrical impulses, transmitted by an electric eye or a stylus scanning the message, flash over the wire and cause a receiving machine at the main telegraph office to create an exact pictorial reproduction on a special telegraph blank. The same machine also receives messages which arrive on the recipient's desk ready for immediate

Telephoto systems, designed prumatily for handling piess photographs, were developed by the American Telephone and Telegraph company, Radio Corporation of America, the Associated Press and the New York Times A telephoto system especially designed for use on submartice achile was developed by Western Union Other systems by Western Union, W. G. H. Finch and J. V. L. Hogan, using dry recording paper, were natended primanly for reproducing black-and-white copy in the form of messages or diagrams, although they reproduce haltfores with moderate success.

Telegraph Repeaters.—As Morse learned early in his experiments, wire telegraph creuts are subject to transmission dificulties which limit the length of line over which direct working is is practicable. Because of these difficulties, it is the practice to break up long telegraph circuits into sections, each of which is relatively easy to operate These sections are then connected together by relays or repeaters which receive the signals from one section and automatically retransmit them into the next section.

A very simple repeater, consisting of only two relays, may be used in single-current open-circuit working. When a pulse of current, representing a signal, is received over one section of line, the magnet of a relay is energized and its amature lever, in responding, applies a source of current to the other line, thus repeating the signal. For closed-ricuit working, a more complex preparating the signal. For closed-ricuit working, a more complex ramagement is necessary to avoid the tendency of each relay to repeat signals back into the line from which they were needwid. This tendency is overcome by interlocking electromagnetic de-

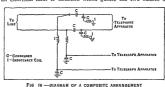
The repating elements of duplex repeaters are similar to those of open-circuit Morse repeaters, comprising a receiving relay for each of the line sections. This relay retransmits into the other line section the signal by which it is operated. An artificial line must be provided for each of the sections of line, and each relay must be arranged differentially or in accordance with the bridge method to respond only to incoming signals.

In printing telegraph operation it is often desirable that the signals not only be repeated with renewed power, but also be corrected and reformed so that they leave the repeater with all the characteristics of the original signal. The general principle upon which regenerative repeaters are based is to select from each received signal a small portice which is most likely to be free from imperfections. By using this fraction of the signal to operate a relay, and other mechanisms which control the length of pulses to be applied to 'the next section, the retransmitted signal can be made practically perfect.

Simultaneous Telegraphy and Telephony.—There are two methods for superposing telegraph circuits upon wires used as telephone circuits—composite and simplex.

Composite Mathod.—In the composite arrangement (fig. 16), two ground-return (elegraph circuits are obtained from the two wires forming a metallic-return telephone circuit. This is accomplished by (sking advantage of the fact that a condenser offers little impedance to the relatively high-frequency alternating currents which operate the telephone, but is an effective barrier to the much slower changes of current used in telegraphy, and that

development of a number of types of mechanisms for different an inductance coil can be so constructed that it will guestly opuses. Transmitters and recronders for heavily-blanded circuits were pose telephone currents but will readily pass the telegraph curdesigned in which the telegram to be sent on a receiving blank may rent: By forming an network of such condensers and inductances, be placed upon cylinders which are leaded into a magazime from an electrical filter is obtained which guides the two classes of



PIG 16 -- PIAGRAM OF A COMPOSITE ARRANGEMENT

currents into the proper channels for operation of the telegraph and telephone apparatus

Simplex Method —The simplex method of superposing permits one ground-return telegraph circuit to be operated over the two wires forming a metallic-return telephone circuit. In a common form (fig. 17), a repeating coil or transformer is intercosed at

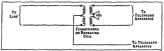
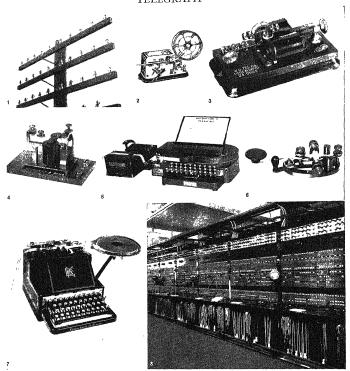


FIG 17 -DIAGRAM OF THE SIMPLEX CIRCUIT

each terminal between the telephone apparatus and the line The transformer wounding which is connected to the line wires has a centre tap connected to the telegraph apparatus. By this arrangement the telegraph currents are divided, half passing over each wire; no effect is produced upon the telephone apparatus because, in dividing equally, he two halves neutralize each other's magnetic effect. The alternating currents of the speech transmission so transverse the line wondings of the transformer as to cust the maximum magnetic effect and are thus repeated to the telephone amounts of the contract of t

Carrier Systems.—During the latter half of the 10th century, proposals were made for obtaining multiple transmissions over a single-line circuit by sending various tones and providing receiving instruments, each responsive to a particular tone. This principle was embodied in the Elisha Gray harmonic system, wherein vibrating reeds of different profis were arranged to transmit different frequencies to the line, each being controlled by a separate key. The receiving relays were also vibrating reeds, each airranged to respond to only one of the several frequencies impressed upon the line. These relays were caused to actuate sounders which received the messages in dots and dashes. Such systems were unstable and never achieved any great success

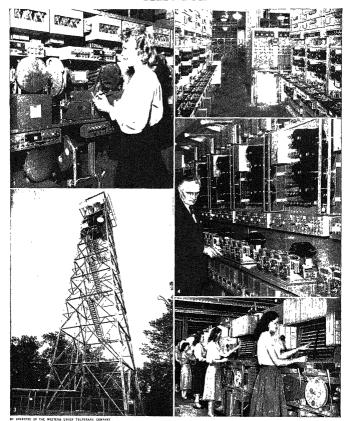
Following World War I, the above principles, using techniques developed in connection with radio, were applied to landline telegraphy to provide what later became known as carrier circuits. In such systems each telegraph instrument, by mid-soth century universally an automatic printing mechanism, controls a separate tone or carrier frequency. The pascing between these frequencies is determined by speed of operation of the particular printing system used. Usually spacings range from 100 cycles to 300 cycles. Control of these telegraph carriers is effected in either of two ways, the older method whiching the carrier off and on in ferred control method the carrier frequency. If continuously transmitted but its frequency is altered by a small increment to convey the code impulses. By either method the channels are separated at the receiving terminal by electrical filters, each of which rejects



COURTESY OF THE WESTERN UNION TELEGRAPH COMPANY

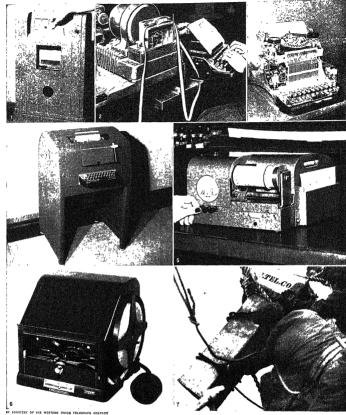
## OLDER TYPES OF TELEGRAPHIC EQUIPMENT

- L. Crossarms showing glass insulators used on open-wire pole lines
- Morse register or recorder, a machine in a telegraph office which records signals on tape when a customer turns the handle on a call box in his office to summon a messenger
- American Morse relay An electromagnet receives current from the line and its armature lever is thereby actuated to open and close a circuit in which local battery furnishes to the receiver a current of requisite strength
- 4. American Meres sounder or recolving instrument employed in connection with the triby of read-billing operators to read by sound only and the property of the control of the control of the control of the Tamerican Morres seeding lay, single-terre, showing portaonist knife which for making and breaking the circult Morre telegraphy was almost entity; replaced at mid-20th century by modern printing and fastimite methods of telegraphy
- 8. Telegraph switchboard



MODERN TRANSMISSION OF TELEGRAPH MESSAGES

- Automatie switching ains in high-speed message collected to see of collected to s
- 4. "Electrical brain" in an automatic switching centre. Messages are typed at point of origin, beginning with a call letter. At the switching centre the "brain" automatically selects the wire corresponding to the call letter, thus speeding the message to its destination without manual extransmission.
- Telegraph centre where incoming messages from all parts of the world are routed to their destination in the centre's area by merely pressing a button



MODERN TELEPRINTER, FACSIMILE TELEGRAPH AND CABLE EQUIPMENT

- 1 The Western Union facesmile telegraph by which selegrams dropped into a slot are automatically transmitted to a central office or to distant
- a slot are automatically transmitted to a central omee or to distant points of the poi
- 4 Teleprinter with cover An electric meter operates the printing and transmitting mechanisms.
  5. The Delefface, a ministers featinite machine used by businessmen for the printing and machine and the printing and machine printer.
  6 Teleprint printing and machine printer of Newfoundiand The use of amplifiers increased international message states by the prince than 6000,0000 weeks.



unwanted channel frequencies and delivers to the receiving equipment only the frequency carrying the desired intelligence for that particular channel. If the on-off switching method (amplitude modulation) is used, the receiver is a ranaged to desert the presence or absence of a carrier. If the frequency change method (frequency modulation) is employed, the electionic receiver responds to frequency change alone and not to amplitude change. A marked improvement in dependiability accrues to the FM method since the transmission circuit is prone to introduce unwanted amplitude changes.

Cairer telegraph channel frequencies are usually confined to a group covering about the range required ior the speech current of telephony (2,000 to 3,000 cycles) Groups of such channels, usually ro to 2 on number, are then stacked above one another in frequency, by a process of frequency translation—the same process by which multiple-channel carrier telephone is achieved on open-wire or cable pains it is common to operate roo-200 telegraph channels, with an operator transmitting a telegram on each channel, smultaneously over a single-line pair. Microwave radio relay systems are also available as a transmission medium of extremely high capacity carrier telegraph systems operated by the same multiple-tange principle.

Telegraph Statistics .-- At mid-20th century the United States had about one-third of the world's telegraph wine, with Western Union, world's largest telegraph company, using nearly 2,000,000 mi of wire in its nation-wide network Of this wire about 400,000 my were in cable, the remainder being single-wire on more than 125,000 mi of pole line. Wire mileage, however, was no longer of real significance because of the general use of high-speed printing telegraph and multichannel methods of operation. For example, carrier systems installed throughout the United States made possible the transmission of as many as 288 telegrams simultaneously over a single pair of wires. A nation-wide telegraph service was provided through about 30,000 Western Union offices and agencies at mid-century More than 200,000,000 telegrams were sent annually, not including a great volume of traffic flowing over private leased wires, ticker systems and press circuits carrying news Western Umon's investment in telegraph plant and equipment exceeded \$350,000,000.

#### TELEGRAPH HANDLING; OTHER SERVICES

Almost from the beginning of commercial telegraph service, it was usual practice to establish large centres as annual relaying points for telegraph traffic. Messages originating in a large area surrounding such relay points were manually transamted to the relay office where they were teceived and recorded on a telegraph blank. This message was moved across the relay office by belt conveyor, pneumatic tube or messenger, and given to a sending operator who transmitted it over a crustit to another relay office serving the point of destination. At the second relay office the message was again received on a telegraph blank and moved across the office to a sending operator serving the office of destination, where it was finally received for delivery.

Reperforator Switching.—A number of proposals were made from time to time for doing away with intermediate manual handlings at relay offices. None of them, however, attained any significant success until 1937. In that year Western Union made an extensive test at Ft. Worth, Tex., of a relaying system in which all moming business was received in the form of perforated tape. The tape fed into automatic transmitters which could be connected by a switching operator to feed any outgoing circuit. The text of the message was printed simultaneously on the perforated tape so that the switching operator could readily read the destination of each message, and connect the transmitter to the destination of each message, and connect the transmitter to the destination of each message, and connect the transmitter to the destination of each message, and connect the transmitter to the destination of each message, and connect the transmitter to the destination of each message, and connect the transmitter to the destination of each message, and connect the transmitter to the destination of each message, and connect the transmitter to the destination of each message, and connect the transmitter to the destination of each message, and connect the transmitter to the destination of each message and connect the transmitter to the destination of each message and connect the transmitters are the each of

Western Union proceeded to design a tape reperforator in which printed characters corresponding to the perforations appeared upon the perforated tape, greatly facilitating the work of the switching operator: Switching centres using this printer perforator were installed in Richmond (1937) and Atlanta (1941). About this time the Postal Telegraph company (merged with Western Union in 1944) developed a system in which all incoming business was also secured on printed perforated tape. In the Postal system, however, each received message tape was form off and physically transported to an outgoing transmitter serving the desired circuit. With the tremendously increased traffic demands of World War II, both systems of reperfonator relay materially contributed toward expediting the huge volume of wartime traffic

Following World Wai II, Western Union started an extensive program of mechanization, and by mid-century had established a nation-wide network of 14 high-speed reperforator switching centres, each handling all telegrams to and from an area of one or more states.

In this new switching system telegrams are typed only at the point of origin and then that through the switching centres to their destinations without manual retransmission. The operation transmitting a telegram from the point of origin simply types a call letter at the beginning of each telegram. That symbol automatically routes the message swiftly to its destination. When the call letter reaches the switching centre a large "electrical brain" automatically selects the wire over which the message transits to its destination. This system vastly improved the speed and efficiency of telegram's services.

Similar switching centres, on a much smaller scale, were widely installed in private-wire networks leased from the telegraph company by government agencies and large industrial enterprises in America.

Subsidiary Services—Most telegraph administrations estabhished subsidiary services such as distributing time signals for controlling clocks and other timepieces to keep them in agreement with a recognized standard of correct time. In the United States Western Union distributes, over a very extensive network of circuits, the noon signals furnished by the Naval observatory. These signals are used to control the operation of master clocks of great accuracy, in all principal cities, which in turn control the performance of thousands of clocks and other timing mechanisms.

Another adjunct to commercial telegraph service is the provision of call boxes whereby a patton may readily summon a messenger who will pick up any telegram which the patron may wish to send, or provide other services The call box is essentially an automatic telegraph transmitter which, when operated by turning a key, sends to the felegraph office code signals which identify the patron. Signals are recorded on a Morse ink-writing register

In the U.S. the telegraph company provides extensive networks supplying to interested patrons quotation services on stocks, bonds, produce, etc, and reports of news and sporting events. These systems are operated in only one direction, the patron having a rectiving-only pruntug telegraph, known as a ticker, service from a single central transmitter at a point where the information is originally assembled.

Early quotation "tickers" were operated by the step-by-step principle described above. In the later stock quotation systems the tickers are operated by the start-stop principle. In such systems an eight-unit code is often used, which provides the usual in addition an impulse which determines whether the character printed shall be a figure or letter. In printing quotations, where shifts from letters to figures and vice verse occur every two or three characters, a considerable increase in output, is achieved by this arrangement as compared with the method in which an entire code combination is transmitted for each shift.

## AUXILIARY EQUIPMENT

Central Office Equipment—In any large telegraph system it is necessary to concentrate operating equipment at certain it is necessary to tencentrate operating equipment at certain points which are called central offices or telegraph centres. These act at sclearing houses for a large area and vary in size, depending youn the volume of traffic their areas produce. Special attention must be paid to design of the facilities in central office buildings, operating rooms must be in large units, adequately provided hight and air. Illumination and proper condition of the air are important factors in increasing speed and accuracy of operators.

The building must provide space for switchboards, testing equipment, power supplies, for the service and maintenance departments, and for test 100ms and lavatones for the operators and staff

Power Supply.-The power required for operation of telegraph circuits must be largely direct current, which is usually not available from commercial sources. It must also be thoroughly reliable Where commercial sources of D C supply are available, sufficiently steady and free from interruption, they are used directly, and booster sets are installed to provide higher voltages when needed. Where only alternating current commercial power is available, it is used to drive D.C. motor generator sets of through tectifiers to charge a storage battery supply, if the local supply is subject to frequent interruptions. To guard against temporary failures of the main source of supply, an emergency source is always furnished-a storage battery or a generator set driven by steam or a gasoline engine. This emergency engine generator must be sufficiently large to provide all telegraph power required and maintain sufficient lights and building service to enable work to be carried on. In larger offices storage batteries are provided to carry the load for an interval between the failure of the main power and the starting of the emergency engine Automatic changeover switches are provided which operate so rapidly that when a failure occurs circuit interruptions are scarcely noticeable

Switchboards—All telegraph wres which enter an office are grouped in a switchbard which also accommodates conductors to all the telegraph apparatus in the office. The switchboard is usually a collection of jacks arranged in groups, one line wire being pinied normally to one operating set. If a temporary change is necessity because of failure of a wire, it is made by means of plugs and the jacks on the switchboard so. The front of the switchboard is a shelf equipped with necessary apparatus for testing wires and locating faults. This test equipment may be associated with any of the lines by means of jacks and plugs.

Line wires and wries to operating sets, before going to the switchboard, are termunated on a distributing frame placed immediately behind the switchboard. This frame has connecting blocks in vertical rows on one ade on which outside wries are terminated, and in horizontal rows on the other side connected to wries from the operating sets. Cross-connecting wires, which may easily be changed if required, are used to interconnect the vertical blocks with the borozontal blocks. On the distributing frame each outside wire has a lightning arrester and fuse. The arrester consust of two small carbon blocks, separated by only a few thousandlis of an inch of air, one side being connected to the line and the lindle office writing or apparatus, by diverting to ground through the air gap voltages high enough to injure the apparatus or employees. Eves are placed in the line election percent any foreign current which may have been picked up by the outside wire from damaging the office instruments.

Message Conveyors.—In any central office means must be provided for carrying messages between different parts of the operaing rooms. Many types of conveyors are in general use, moving belts being the most common. The main considerations are speed and accessibility, with all features eliminated that would tend to lose, mutilate or delay a message. Peaturatic tubes are also used, both for carrying messages within the confines of an office and sometimes for connection with near-by branch offices.

## OUTSIDE PLANT

As early as 1816, when Ronalds demonstrated his telegraph system, he utilized as a line conductor a bare wire covered with glass tubing impregnated with pitch and buried in the ground for several hundred feet. However, for reasons of economy, the early commercial telegraphs were operated with bare wires supported overhead on poles. This open-wire pole-line construction has been very generally used thereafter, and even by the middle of the 20th control will constituted a large portion of outside telegraph plant. Cables, which are groups of insulated wire held together by a common cover or sheath, were introduced early in the century to a limited extent, and their utilisation, both areinfly suspended, and

underground, greatly increased thereafter Open-wire pole-line construction and suspended serial cable are commonly used in open country, but as telegraph lines approach congested areas, cables are generally used underground Underground cable is also used almost exclusively for local distribution within a congested

Overhead Lines.—Poles used to support wives and cables are usually of wood, although steel and concrete poles are sometimes used. They are of such height as to provide a suitable clearance from the ground for the wires or cables. The size of poles required, and the distance they are placed apart, depend upon geographical location and upon the load to be carried. Lines situated where ter or snow is likely to collect upon them require the use of larger poles placed closer together than for lines in locations where ize does not form.

In open-wire construction the bare line wires are supported on insulators, usually of glass or rubber, mounted on juns set vertically in wooden crossaims. On heavy trusk pole lines crossaims are used which are to ft in length, accommodating to pins spaced approximately 12 in apair. These crossaims are securely fastened to the pole, and when more than one arm is used they are vertically soaced about 2 ft. apair.

In general, bare copper wires are used, ordinarily about 0.14 in in diameter, weighing 210 lb to the mile of 0.14 in in diameter weighing 172 lb, per mile. Other sizes are employed to a limited extent, and wires of galvanized iron, bronze and other materials have been used with considerable success. The choice of materials and size is usually dictated by economic considerations.

Cables, when placed on poles, are supported by suspension strands, consisting of high-strength stranded wires. The weight of the cable to be supported determines the strength of suspension strands used, the heavier cables requiring strands having a strength exceeding 18,000 lb Cables are fastened to the suspension strands by various means, and the suspension strands are fastened to the poles by means of small metal clamps.

Conductors in cables designed for telegraph service are of soft diawn copper varying in diameter from 0.036 in to 0.102 in. Otdmarily, cable conductors are separated and insulated by means of paper wrapped spirally about them, although cables having rubber insulated conductors are often used for short distances. The insulated conductors are arranged in pairs which consist of two conductors twisted together or in quads consisting of two pairs twisted together, or four wires in spiral form. These pairs and quads are arranged compactly in layers. Paper insulated conductors are always enclosed in a lead sheath, while rubber-covered conductors may be enclosed in lead or a covering of heavy braid.

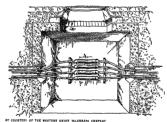


Fig. 18.—cross section of a manhole showing the cable ducts and joint rack

The number of conductors provided in telegraph cables varies, the largest in common use at mid-century being 404 pairs. The

outside diameter of this cable is 28 in. and the weight 73 lb per frequency need be transmitted.

Underground Construction .- Where cables are placed underground within a city, some form of conduit with independent duct space for each cable is usually employed to permit the cables to be readily installed and removed. The ducts are usually of hollow tile, creosoted wood or fibre Iron pipe may be used in special situations. All ducts are 3 in oi more in diameter, and the conduit is buried to a depth of at least 2 ft As the length of cable which can be pulled through a duct is limited, splicing chambers or manholes are provided at intervals of about 500 ft These manholes are at least 3 ft wide, 5 ft. long and 4½ ft deep, and in many cases considerably larger sizes are required. They are usually constructed of brick or concrete with a removable cover (Fig 18)

Cable is pulled into conduits one length at a time, and the ends are spliced together In splicing paper-insulated cables, a foot or more of sheath is removed from the end and a few inches of the insulation is removed from the conductors. Conductors are then joined by twisting, soldering or other means, and the joints are insulated with small paper or impregnated cotton tubes all conductors are joined, the splice is wrapped with strips of mushn and a lead sleeve shpped over it. This sleeve is held at each end to the cable sheath by means of wiped soldered joints

Where cables are laid underground in open country, it is feasible to bury such cables directly in the ground without conduit protection Large machines prepare a trench, lay the cable and cover

the trench in a single operation

Radio Beam .- Between World Wars I and II. considerable experimentation was carried on in applying printing telegraph systems to radio transmission Although operation was successfully achieved, continuity of service left much to be desired because of static disturbances and propagation difficulties World War II saw advances in the art of generating higher and higher radio frequencies which brought a new tool to communications. The short wave lengths made available many more frequency bands, and the short waves are practical for use in reflecting and beaming, as light energy may be beamed. Developments based on these concepts made it possible to establish microwave radio-beam relay circuits, around the curvature of the earth and over terrain pregularities, which are not afflicted with the unreliability commonly associated with long-distance radio work. In these systems the radio transmission is beamed by reflectors and lenses in a line-of-sight path between tall towers located on high points of ground and spaced 20 to 50 mi. apart, depending upon the terrain, thus compensating for the earth's curvature The intermediate towers between terminals serve as unattended relay stations which instantly repeat the received signals, regenerated and redirected to the next tower. Shortly after the end of World War II, several microwave radiorelay circuits were established to give dependably practical trunk line circuits of extremely large message-carrying capacity.

In 1946 Western Union installed a 4,000-mc microwave radiorelay system connecting New York, Phrladelphia, Washington and Pittsburgh and capable of handling more than 1,000 telegrams simultaneously in each direction Time division techniques were developed for dividing the radio beam signals into voice frequency channels and these were further divided into telegraph channels by FM carrier systems.

## THEORY OF TRANSMISSION AND INTERFERENCE

Transmission.-The fundamental requirement of a telegraph system is a source of potential controlled in accordance with the code to be transmitted, which sends sufficient energy through a circuit to operate a suitable receiving device at the distant end. Where interference is present, as is usually the case, the received energy must be sufficiently greater than the interference to enable a signal to be distinguished. The sending source of energy usually consists of a direct current supply, but from what follows, it will be evident that the transmission of telegraph signals requires the use of apparatus and lines capable of transmitting sine wave alternating currents of various frequencies. A communication circuit is thus fundamentally different from a circuit for transmitting power in which direct current or alternating current of only one

In a telegraph system the signals sent are continuously changing in character, and there will be times when several reversals are sent at the highest frequency of transmission for the given circuit The number of such complete reversals per second may be spoken of as the fundamental signalling frequency. Common fundamental signalling frequencies for various circuits are as fol-

ows. Messenger call circuits	2	cycles	per	
Key-operated Morse	6 to 18	",,	",,	"
Automatic telegraph systems	15 to 70	"	"	17
Submarine cables nonloaded	4 to 20	"	,,	"
Submarine cables homoaded	30 to 100	,,	"	"

The alternating current characteristics of signal combinations may be most readily considered by examining a number of typical combinations of signals such as are shown in fig 19, the combinations being assumed to repeat themselves Such combinations may be analyzed by the Jean Baptiste Joseph Fourier method into



FIG. 19 -EXAMPLES OF SIGNAL COMBINATIONS

a series of sine wave components. Analyses of a considerable number of these recurring combinations show that all frequencies from zero to infinity (excluding even multiples of the fundamental signalling frequency) are present in the transmitted signals It is not possible to transmit all these frequencies through the line with unimpaired amplitude and phase relations The voltages and currents originating at the transmitter are modified by any impedance at the sending end of the hne, by the line itself and by

the receiving equipment. The effect of the line resistance and capacity is to reduce the amount of higher frequencies received However, in order to operate a receiving instrument at the distant end of the line, it is not necessary that all frequency components of the original signal be received. In a submarine cable system, which ordinarily is operated with efficient corrective devices to compensate for loss of the higher frequencies, it is usually sufficient to receive frequencies from zero up to about one and six-tenths times the fundamental signalling frequency. In landline telegraph systems, operated with less complex terminal equipment, it is preferable that frequencies from zero to about three times the fundamental frequency be received.

In order to counteract the effect of line capacity in causing loss of signal energy, the inductance of the line may be increased by artificial means known as loading. This is especially successful with long submarine cables. The effect of the inductance is particularly to sustain the higher frequencies. The velocity of propagation is decreased but the signal is received with increased energy and reduced distortion.

Interference.-Telegraph operation is more or less affected by parasitic currents from various outside sources including: (1 earth potentials arising from natural causes; (2) earth potentials arising from electric railway systems, etc; (3) induction from one telegraph 'ircuit to another; (4) induction from power-supply systems. Long submarine cables are more seriously affected by interference than are landlines because of the much lower level of received signal energy on the former. In respect to methods of operation, interference to multiplex presents the most serious problem. Small amounts of potential from extraneous sources result in impairment of the maximum speed at which these circuits may be operated. Large amounts render the circuit inoperative. To mutigate the interference from these parasitic currents, various means may be applied to the telegraph circuit or to the source of the interference if this is an electrical railway or power-supply system. In application to telegraph circuits these mitigative devices may take the form of impedances whose function is to filter out the extraneous current, or of transformers or generators whose function is to interpose in the circuit a potential to counteract power systems, impedances inserted at appropriate points, selection of proper transformer connections and favourable operating methods or transpositions may often be advantageously employed to reduce the inductive influence of the interfering system. Sometimes, however, an increase in the physical separation from the interfering lines is the only practicable remedy.

An interference-free method of transmission is provided by the microwave radio-beam system which is not subject to the same kinds of interference as are landlines and cables. They are not affected by inductive interference, the aurora borealis, static or lightning disturbances. Also ice and windstorms do not affect them as they do line wires.

#### STERMADINE TELECOA" HV

Except for a few river and harbour cables, the first submarine cable was that laid in 1850 between England and France. It was broken shortly after communication had been established but was followed the next year by another, between Dover and Calais, which was successful. The first transatlantic attempt in 1857 was a failure when the cable broke at 2,000 fathoms' depth during laying and could not be recovered However, the Atlantic was spanned in 1858 between Ireland and Newfoundland After about three months' use the cable broke in deep water and had to be abandoned. It was 1866 before the first permanently successful transatlantic cable was laid. In the same year another cable, par-tially laid in 1865, was also completed. These two, with which the U.S. financier Cyrus Field and the British scientist Lord Kelvin were closely associated, were the only transatlantic cables until 1860, when the French laid a cable. Thereafter, with success established, growth of submarine cable systems was rapid; there were 21 spanning the Atlantic by 1928 Subsequently the message-handling canacity of the cables was increased so greatly by technical advances in the art of transmission that no further physical expansion was necessary. Only 15 letters could be sent per minute through the first transatlantic cable and the minimum rate per message was \$100; each message had to be manually rehandled six times. By mid-20th century 2,400 letters per minute could be transmitted instantaneously between New York city and London over a single cable (containing but one conductor) at a maximum charge of 25 cents per word. Transmission was fully automatic, and direct teleprinter service between customers' offices in New York city and London was available on a metered basis. Improvements in the physical and electrical design of cables and terminal equipment continued to make this dependable method of communication attractive in competition with other services.

Construction .- Fig. 20 shows the constructional details of a submarine cable. The conductor is made of copper, stranded or



FIG. 20,-CONSTRUCTIONAL DETAILS OF A MODERN SUBMARINE CABLE

having a central wire surrounded by strips wound spirally. Over this is moulded the insulation. Formerly gutta percha was almost universally employed for the insulator, but deproteinized rubber, both natural and synthetic, later competed successfully with gutta percha, while polyethylene bid fair to supplant both of them. Continuous inductance loading in the form of a thin ribbon or thread of highly permeable nickel-iron alloy wound around the conductor greatly increased the speed at which the later cables could be worked. To protect the insulation at depths where

that from the outside source In application to electric railway or marine borers are found a brass tape is wound around it. Next comes a cushion of jute yarns upon which the spirally wound armour, or sheathing wires, rest. In the deeper portions of the ocean galvanized high-tensile steel wires are used, sometimes individually covered by taired cotton tape or braid. As the depth decreases these are replaced by galvanized wrought iron wires of larger size and the armour gradually is increased in size and weight until, near the shore, a double layer is used. The added protection is necessary to prevent damage from anchors, trawler fishing gear, chafing against rocks, and, in northern latitudes, ice. An outer double wrapping of tarred jute yain or jute tape, steeped in a compound of ter and pitch further preserves the armour from coriosion. The outside diameter of the ordinary deep-sea type of cable is about one inch, and the weight in air about two tons per nautical The shore-end types run as large as three and one-half inches in diameter and weigh as much as 30 tons per nautical mile.

Cable Laying .- It is the usual practice for the manufacturer to lay the cable and test it to ascertain whether the specified electrical characteristics have been met before turning it over to the operating company. The ships used for laying are specially constructed to carry cable in cylindrical tanks built into the ship's structure The largest ship of its kind in the world at mid-20th century was H M.T.S. "Monaich." owned and operated by the British post office. With four tanks and a net coiling capacity of 126,645 cu ft., it was capable of stowing away a cable more than 2,500 nautical miles long The cable is coiled down around a central hub-shaped cone in horizontal layers, starting at the tank wall and coiling in toward the centre. When the cone is reached the cable is run out radially to the wall again, with wedge-shaped strips of wood, called "feather-edges," on either side to protect it from the weight of the layers above, and the process is repeated When paying out the cable it is pulled through a circular hatch in the deck above the cone, several men being stationed in the tank to guard against kinks forming or the cable fouling In loading the vessel, the cable from the top of one tank is led over into the bottom of the adjacent tank, making it necessary only to slacken the speed of paying out when changing over from one tank to the

From the tank the cable passes to the paying-out gear. This machinery for controlling the stress on the cable is placed both at the bow and stern. All long pay-outs are made over the stern, but it is often more convenient to pay out short sections over the bow, as It is often more convenient to pay out stort sections over the now, as the ship can be more easily maneeuverd, and it is to this point that the cable is brought for splicing. The machine consists of a large drum usually about six feet in diameter, around which several turns of cable and the state to provide the necessary friction. On the same shaft is a series for bright of the control of the same shaft is a series of the bright of the cold than series takes and connected to it is a large fan brake. The cable then passes through a dynamometer, which gives an indication of the stress on the cable leaving the ship over the bow or stern guide, as the case may be. It is not uncommon for the stress on stern guide, as the case may be. It is not uncommon for the stress on the cable in paying out in deep water to amount to as much as two tons. In order to check the amount of slack in the cable there is paid out at the same time a taut steel piano whre which is carefully measured and compared with the length of cable paid out When passing over

and compared with the length of cable paid out When passing over fairly smooth bottom the amount of slack rarely exceeds 10%, but can is taken not to leave the cable un a state of tension on an uneven bottom, or asspanded in bights over rocks.

If the compared the control of starts on her long voyage. When approaching her destination the cable is cut and the end buoyed in deep water When this shore end of the cable has been laid out to meet the buoyed deep-sea end, both ends are taken aboard and tested; the final splice is then made and the cable dropped over the bow. During cable laying, testing is carried on continuously by a staff of electricians to detect and report any fault

in the cable. Should the cable develop a fault or break while being laid, the ship is equipped with special means of coping with the trouble. From the results of electrical testing it is possible to arrive at the length of cable being and the fault.

results of electrical testing it is possible to arrive at the length of cable between the ship and the fault develops in a submarine cable it is usually possible to "locate" the fault or break with a fair degree of accuracy by the Wheatstone bridge method, by determining the electrical resistance in ohms, or the capacitance in microparads of the core between the testing point ashore and the point of failure at sea. Know-

ing the characteristics of the cable, it is possible to deduce the distance in miles, which, interpreted in conjunction with the charted route, in miles, which, interpreted in conjunction with the charted route, mahles the navigator of the repair abig to proceed to the vicinity of the trouble and to place a mark buoy within working range. Electrocked the chartest and the place of the property of the chartest and including a single property of the chartest and including a cutting graphed which auto-indicated graphed which alto the chartest and the chartest away one end when it is lifted without the cable has been raised to the surface, it is secured with a rope, or chain stoppen, and taken about Text leads are attribed to determine chain stoppe, and taken aboard Test leads are attached to determine deternate conduction, and the fault is localized. When the line is electrated to the conduction of the conduction of the electrated in the conduction of the conduction of the ship's tanks is spliced on and paid out until all the cable suspended off the bottom is new The ship is then free to go after the cable on the other side of the fault. When this end has been assed and the tests other side of the fault. When this end has been raised and the tests indicate its continuity and sistifactory insulation all the way to the shore station, cable from the ship's tacket on the ship's tacket of the ship's and the ship's tacket of the ship's tacket of the ship's tanks is stoppered off and cut, and the final splice is made on the ship's tanks is stoppered off and cut, and the final splice is made on the ship's deck. The cable is eased over the bow and drops to the ocean

bottom. With electronic aids to navigation such as echo sounding, radar and loran in use, many operations can be carried out in foggy weather which formerly was unlit for repair work.

Simplex Operation.—The simplex method of operating—sending

messages in one direction only—may be employed where the number of submarine cables available is sufficient to make duplex operation unnecessary, or where it is difficult to maintain a duplex balance. With modern methods of transmission it is possible to operate two or more

modern methods of transmission it is possible to operate two or mose sumpler printer channels over calles formerly dupleted, thereby gaining sumpler printer channels over calles formerly dupleted, thereby gaining Duplets,—Duplet operation, or the transmission of messages in both directions at the same time, is made possible by so arranging the recording instruments that while responding to signals from the discretion of the called at which they are located. There are several methods of duplexing, all of which depend upon the use of an artificial line for balancing, as is the case in landfuls dupler operation. The artificial line for balancing, as is the case in landline duplex operation. The artificial line for ocean cable operation must more nearly dupleate the real cable in electrical characteristics and it is therefore designed and built to the cable which it is to balance

Transmission.—In fast automatic printing telegraph operation signals are transmitted by means of a motor-driven transmitter controlled by a perforated paper tape (fig 21). The tape is prepared in

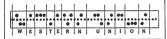


FIG. 21.-PERFORATED CABLE SENDING TAPE

a keyboard perforator by means of which the depression of a single key will perforate the entire combination of dots and dashes corre-sponding to the letter. This tape is then passed through the transmitter in which transmitting contacts for either dot or dash polarity are con-trolled through mechanical levers by the perforations in the tape. The transmitter is operated at the highest speed permitted by the electrical characteristics of the cable. In many cases the speed of the cable per-mits a further subdivision of the carrying capacity through the use of the American multiplex printing telegraph system, thereby providing from two to eight or more channels of traffic, each served by a single transmitter operating through a synchronously operated distributor into the cable

Receiving.—In the old method of receiving submarine cable signals, an extremely delicate galvanometer of the moving-coil type was attached originally to a mirror, and later a siphon recorder, in con-

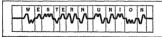


FIG. 22 .- UNDULATING LINE EMBODYING CODE

junction with highly sensitive magnifiers of the pre-vacuum tube era Junction with nightly sensitive magniners of the pre-vacuum tune era (fig. 22). In many areas this was supplianted by electronic amplifiers associated with shaping networks to amplify and improve the shape of the received signals and to filter out extraneous interference. These devices were first used in connection with the high-speed loaded cables

operating on the American multiplex printing system, and usually are associated with that method of operation Reception of multiplex operating on the American multiplex printing system, and usually are associated with that method of operation Reception of multiplex signals involves passing the signals thus strengthened and reformed through a receiving distributor synchronized with the transmitting end, which reconstitutes them into separate channels, after which the

signals are recorded on automatic printers Automatic Relays.—In many cases it is desirable to repeat sig-Automatic Relays.—In many cases it is desirable to repeat sig-nals automatically from one section into another rather than to recor-them Except in short connecting cables a regenerative type of repeater is necessary to overcome signal distortion. This repeater is

nals automatically from one section mode, expenses true type of preparet is pre-easily to overcome signal distortion. This repeater is similar to the regenerative repeaters employed on landines. Billitoosanyy.—G. M. Banes, Egument's Manual of Submarine Cable Testing and Working (London, 1936). Cable Submarine Cable Testing and Working (London, 1931). C. Bright. The Categorian Condon, 1936) and the Cable Communication of the World (London, 1937). D. H. Cameron, Submarine Telegraphy (London, 1937). J. D. H. Cameron, Submarine Telegraphy (1937). J. D. Foughas, Manual of Telegraph Communications of the World (London, 1937). D. H. Cameron, Submarine Telegraphy, 1937). J. F. Herbert, Telegraphy, 1936, J. H. Washing, Telegraphy, 1936, J. Journal of the Frenklik Institute, (London, 1930); E. J. Houston and A. Exmediy, Machine Telegraphy, 1936, 1937 tions, Americar Telegraby after roo years (1944) See also Western Umon Engenering Department textbooks, prepared for the American School of Correspondence, Chicago, III, dealing with various phases of construction, maintenance and operation of telegraph lines and colles, systems, etc. Bell System Technical Journal, Post Office Engenery Journal; Postedways of the Institute of Kando Engueers, Transactions of the American Institute of Electrical Engineers; Western Union Technical Revue

TELEKI, PAL, COUNT (1879-1941), Hungarian politician and geographer, studied jurisprudence and geography in Budapest. After being elected to parliament in 1905 he spent some years in geographical study abroad, and published Atlas zur Geschichte der Kartographie der Japanischen Inseln (Budapest, 1909). He was foreign minister in the cabinet of Adm. N. Horthy (April 1920), and in July 1920 became prime minister. He resigned in 1021 after the first attempt of King Charles to 1 egain his throne, and was appointed professor of economic geography in the University of Budapest. In Feb. 1939 he again became prime minister and remained in office until April 3, 1941, when he killed himself, reputedly because he could not sanction the part Hungary was to take a few days later in the German invasion of Yugoslavia,

TEL EL AMARNA, the name now given to a collection of ruins and rock tombs in Upper Egypt near the east bank of the Nile, 58 mi, by river below Asyut and 100 mi, above Cairo, The ruins are those of Akhetaton, a city built c. 1360 B.C. by Ikhnaton (Amenophis IV) as the new capital of his empire (in place of Thebes) when he abandoned the worship of Ammon and devoted himself to that of Aton; i.e., the sun. Shortly after the death of Ikhnaton the court retuined to Thebes, and the city, after an existence of perhaps only 20 years—of 50 years at the utmost—was abandoned. Not having been inhabited since, the lines of the streets and the ground plans of many buildings can still be traced. The chief ruins are those of the royal palace and of the House of the Rolls; there are scanty remains of the great temple. In the palace are four pavements of painted stucco work in fair preservation. They were discovered in 1891-92 by Flinders Petrie. In the Rolls house were discovered in 1887 by the fellahin approximately 300 clay tablets inscribed with cunei-form characters. They are letters and state documents addressed to Amenophis IV and his father, from the kings of Babylon, Assyra, etc, and from the Egyptian governors in Syria and neighbouring districts. The greater part of them were purchased for the Beilm imissum, but a large number were secured for the British museum. Their contents proved invulsable for the reconstruction of the history, social and political, of Egypt and western Asia during that period.

Hown out of the sales of the hills on the east are two groups of tombs; case group hes 3-½ m. NE, and the other 3 m. So of the cuty. The tombs, all of which belong to the time of Ribhaton, are full of interesting scenes in the peculiar style of the penol, accompanied by hymns to the sun god. The most important tomb is perhaps, that of Meri-Ra, high press of the sun, which has a fande nearly 100 ft long and two large chambers. In the early containes of Molesier rule in Egypt the northern tombs were inhabited by Copts, one tomb, that of Pa-Nehes, being turned into

The tombs and the great steles sculptured on the cliffs which mark the bounds of the city of Akhetaton have been the object of special study by N de G. Daves on behalf of the Archaeological Survey of Egypt The results, with numerous plates and plans, are embodied in a series of memons, Rock Tombs of Bi Amaria (six parts, 1903–60).

TELEMACHUS, in Greek legend, son of Odysseus and Penedope (Odyssey, p-ix, vx-avit, Ygymus, Fab, 127). When he reached manhood he vasifed Pylos and Sparta to make inquiries about has father. On his return, he found that Odysseus had reached home before hum Then father and son, aided by Eumaeus and Philositus, slew the suitors of Penelope (see Owsseus), According to later tradition he married Circe (or Calypso) after Odysseu's death

TELEMARK or THELEMARK, a district of southern Norway, in the emt (county) of Butaberg Area 5,430 sq.m.; pop. (1330) 121,754 It covers the uplands and fjelds of the southward projection of the country, having its highest point in the Gustaffield (6,500 ft.), and contains several large lakes, as Nordsp., Bandaksvand, Tmsjo, Mjosvand and Totakvand. The two first are connected by the Bandaks cand, giving access from the port of Skien to Dalen at the head of Bandaksvand. From Dalen, a read runs northwest; if crosses the fjelds at a helght of 3,05 ft, on the way to Roldal from which branches run to Odde and through Bradandsdal respectively.

One of the finest waterfalls in Europe, Rjukanfos (415 ft.), provides power for nitric acid works, and Ulefos, near the Bandak canal, for pulp mills. Notodden is a growing town with saltpetre works. Skien (qv), the capital, is a port; also Kraguō, Porsgrund and Brevik

TELEOLOGY, in philosophy and biology, means explanation by reference to the realization of some purpose or end (Greek τέλος, an end), contrasted with explanation by efficient causes only. Teleology is one of the oldest, probably the oldest, mode of explanation. Human conduct is nearly always explained by reference to the ends pursued, or alleged to be pursued; and the tendency to explain everything else after the analogy of human behaviour is very old, as old probably as human nature itself. The method of explanation by reference to ends received formal and explicit recognition in Aristotle's list of four causes which included "final" causes. Aristotle, of course, insisted on the importance of discovering the "material," "formal," and "efficient" causes as well as the "final" causes. But during the middle ages the others tended to be ignored more or less, and too much attention was paid to "final" causes even in physical and chemical investigations, which consequently became rather fantastic. The founders of modern science had a hard struggle to instate or reinstate the "mechanical philosophy" at least side by side with teleological explanation. The pendulum naturally swung to the other extreme. Not only physical and chemical phenomena, but even biological phenomena were explained mechanically. Descartes, for example, regarded the lower animals as mere automata. In time. however, it was found impossible to explain biological facts adequately by means of mechanical conceptions only, and teleology of one kind or another has met with increasing recognition in recent times.

See Emergence, Evolution, Organic; Mechanism; Metaphysics; Scientific Method; L. T Hobhouse, Development and Pub bose (1013)

TELEOSTEI. In the classification issued in 1846 by Johannes Muller, the recent hosy fishes were arranged in three subclasses, Dipneusti, Ganodei and Telesster, the last including the great majority of the fishes, all those with a homocorcal caudal fin Subsequent work, especially on fossil fishes, has shown that the ganods are not a natural group, some being related to very primitive fishes, others approaching the telessis, namely the Holoster, which include the recent Anna and Lepsosteus. The extinct Pholoster, which include the recent Anna and Telessteri, and have been included by some authorities in the one group, by others in the other This has led C T. Regan to combine the Holoster and Teleoste to form one subclass, termed Keopterygii. (See Fishiss)

TELEOSTOMI, a name given by some authorities to the bony fishes, either with or (usually) without the lungfishes, in the former sense it is equivalent to the class Pisces, above the

level of the Selachians. (See FISHES )

TELEPATHY was defined by F. W. H. Myers, who invented the word in 1882, as "the communication of impressions of any lend from one mind to another, independent of the recognized channels of sense." It is to be noted that Myers does not postulate that both or either of the minds he mentions should be the minds of living persons; for supernormal communication between the minds of living persons the phrase "telepathy between the living" should in strictness be used, but often "telepathy" by itself is lossely used in this sense. "Thought transference" is a less technical word with the same meaning. (See also CLAIRVOYANCE, PSYCHICAL RESEARCH )

TELEPHONE. In a broad sense, the term telephone or telephony includes the entre art of speech transmission with the many accessories and operating methods which research, development and invention have supplied to facilitate and extend conversation at a distance by electrical means. The telephone was invented in 1896, at Boston, Mass, U SA., by Aleardee Graham Bell (q.v.). His studies of sound and of electricity led him in 1874 to conceive the correct principle of telephone transmission, which he later stated, as follows:

If I could make a current of electricity vary in intensity precisely as the air varies in density during the production of sound, I should be able to transmit speech telegraphically.

The conception of this indulatory or wave-shaped current was Bell's great contribution to the art of communication. Others, notably Charles Bourseul in France (1854) and Philipp Res in Germany (1867), had written of or had attempted electral speech transmission, but had employed the make-and-break principle of the telegraph, and had failed.

In the summer of 1874, while on a vacation trip to Canada, Bell described to his father a form of apparatus consisting of a strip of steel, attached to a membrane, which when actuated by the voice would wibrate in front of a magnet. Theoretically this would produce an undulatory magneto-electric current which would transmit speech, But Bell doubted that the current would be strong enough to be of practical value. For almost a year he made no attempt to construct the superartus.

On June 2, 1875, while working on another of his inventions, he heard the twang of a steel spring over an electric wire. He comprehended immediately that it had been transmitted by an undulatory current strong enough to be useful. He gave his asistant, Thomas A. Watson, natructions for making the first Bell telephone. It transmitted speech sounds the next day, June 3, 1875. Further experiments produced on March 1o, 1876, an instrument that transmitted the first complete sentence: "Mr. Watson, come here, I want you;"

In the United Sates, several other experimenters were working at about the same time on the problem of electrical speech transmission. Prof. Elisha Gray filed a caveat ( $q \circ v$ ) on the subject m the U.S. patent office only a few hours after Bell had filed his telephone patent application. The claims of Gray and others to the invention of the telephone were threshed out in prolonged

litigation, involving some 600 separate suits, which resulted in Bell's patent being upheld and his claims to be the inventor of the telephone established.

Introduction.—Public apathy in the United States and in Oreal Britan and other countries was one of the most disheartening discullies faced by those who were endeavouring to introduce the telephone The development of the telephone business was undertaken by a group of Prof. Bell's backers, under the leadership of Thomas Sanders and Gardiner G Hubbard, whese daughter Bell soon afterward married They began renting or lending telephones in pairs to individuals for local communication The telephoning was all done over a single iron wire connecting the two instruments with ground return circuits. There were no syntch-boards to afford communication among a number of users, calling poor at best In 1878 the first telephone switchboard for commercial service was placed in operation at New Haven, Conn., with 21 subscribers

Those interested in introducing the Bell telephone to public use early adopted the permanent policy of leasing telephones instead of selling them, and granted hieraces to authorized agents or hieraces for the commercial development of the telephone business in many parts of the United States These licensee agencies gradually developed into local exchange systems and ultimately into local operating commanies.

The owners of the telephone patent early incorporated their business, and funds were raised for its progressive development, under the leadership of Theodore N. Vail, who became general manager in 1878 Within ten years after the issuance of the Bell patent the Bell Telephone system had attained an organization approximating its present form. The local systems were gradually brought together into regional companies operating throughout a state or several states The telephone systems of these regional companies were linked together by long distance circuits operated by the American Telephone and Telegraph company This company was originally formed to build and operate the long lines as a subsidiary of the American Bell Telephone company, which had become the parent company of the Bell system by acquiring the ownership of the Bell patents and purchasing stock in the regional telephone companies. Later the American Telephone and Telegraph company exchanged its stock for that of the American Bell Telephone company and became the parent company of the Bell system

About 1881 it became apparent that standardization of equipment and centralized research on improvements were essentials to telephone progress. Accordingly, the Western Electric company was acquired as chief manufacturer and supplier for the Bell system. Western Electric, in turn, purchased or consolidated with the principal Bell system manufacturing licensees of that pernol.

Growth of the Business,-Following the expiration of the basic telephone patents, a large number of independent telephone companies, not affiliated with the Bell system, were established all over the country. In many cases these companies brought telephone service to places in which the Bell system did not operate. Some, however, engaged in competition with the Bell companies in their localities; and it required actual experience of the inconveniences of telephone competition to convince the public of the fact that two telephone companies in a single community are a source of annoyance and unnecessary expense to the telephone-using public. The fact that one had to subscribe for both the competing telephone services in order to be in communication with all of the telephone subscribers in the locality finally resulted in a popular demand for the unification of the telephone service In many communities competing telephone systems were consolidated. Independent companies were afforded facilities for physical connection with the lines of the Bell system. The linking up of these local telephone systems, which are now known as connecting companies, makes possible interconnection among practically all the telephones in the United States. Subscribers of the Bell companies and of the connecting companies are thus alike afforded access over the long distance lines of the Bell system to almost any other telephone anywhere in the United States as well

as in other countries in North America and by radio to overseas On Jan. 1, 1947, the 21 associated companies, which with the American Telephone and Telegraph company make up the Beil system, owned and operated 25,709,000 telephones and 7,501 central offices In addition, the connecting companies, which number nearly 6,000 besides more than 60,000 connecting rural lines, owned and operated more than 5,800,000 telephones and more than 11,000 central offices. The total investment in telephone plant and equipment in the United States was, on Jan 1, 1947, more than \$7,000,000,080, of which \$6,294,000,000 represented the investment of the Bell system During the year ended Dec 31, 1946, the Bell system traffic averaged daily 100,-401,000 exchange conversations and 5,361,000 toll conversations, a total of 105,762,000 In addition, the connecting companies transmitted a daily average of 21,964,000 exchange conversations and 274,000 toll conversations (excluding duplications), a total of 22,238,000 conversations The grand total of telephone messages for the US during that year was about 128,000,000 completed conversations a day. About 580,000 persons were employed by the telephone industry in the U.S., of whom 496,400 were employees of Bell companies. In addition, about 114,500 were employed by the Western Electric company, and more than 10,000 by independent manufacturers of telephone equipment. The Bell Telephone Laboratories, Inc , which conducts research along lines connected with every phase of the electrical transmission of speech, then employed a total of more than 6,000 people

#### DEVELOPMENT AS TO USE

The telephone industry in the United States has attained its present development in response to a rapid growth in public demand for telephone service throughout the country This is illustrated in the following table showing the increase in the total number of telephones in the United States since 1880:

Telephone Development in the United States

	E	nd of	year			Number of telephones	Telephones per 100 population
1880				-		47,900	0.00
1885						155,800	027
1800						227,900	0.36
1895						339,500	0.48
1000						1,355,900	1 76
1905						4,126,000	4.85
1910						7,635,400	8.19
1915						10,523,500	10,39
1920						13,329,400	12.41
1925						16,935,900	14 63
1930						20,201,000	16.36
1935					•	17,424,000	13 64
1940						21,928,000	16.56
1945						27,867,000	21 03
1946						31,611,000	22 37

Coincident with the severe recession, the number of telephones declined between 1930 and 1933, but growth was resumed in the fall of the latter year. The table indicates the extent to which the American people have made the telephone an integral part of daily life. The more telephones in service, the more useful the service to the subscriber, and Americans now depend on it for business, finance and personal affairs, as well as fire and police protection.

# TELEPHONE PLANT IN THE UNITED STATES

The term "telephone plant" includes: (1) the telephone apparatus and wiring at the subscriberty premuser; (2) the central office equipment (with the buildings that contain tt) for interconnecting subscribers' lines; and (2) the sarial and underground wires and cables with their pole lines and conduits, which connect the subscribers' stations with the central offices and the latter with each other, whether they be in the same city or in different cities. Telephone plant includes also radio telephone equipment used to furnish channels between certain points. This plant makes it possible, at the present time, for any user of the telephone service to be connected promptly with any other station of the telephone

system, and to converse easily, by electrical means, with the person called, after the connection is established, regardless of distance The systems which enable this nation-wide service to be rendered are necessarily complex and intricate and they include a multitude of auxiliary devices and appurtenances The following buef description deals only with the principal kinds of telephone

Plant at Subscribers' Premises .- This includes a wide variety of equipment, of which the following classes may be considered typical.

Station Set -This consists of a transmitter, which converts the speech waves in the air into their electrical replicas on the wire. a receiver, which performs the reverse operation of converting the incoming electrical waves into sound waves, an induction coil, which is a form of transformer designed to permit efficient use of a single pair of wires for speech in both directions alternately, without requiring the users to operate a switch to convert from talking to listening or vice versa, a bell or other calling device. a switch hook, to control connection of the station set to the central office line; one or more condensers; and, on certain types of party has arranged to ring only the bell of the particular station called, a relay or a cold cathode tube In the case of dial systems, described later, a pulsing device or dial is also required. In magneto system a hand-operated generator is necessary for signalling, and batteries for operating the transmitter

The apparatus comprising the station set may be assembled in various combinations, of which the most common have been (1) the wall set; (2) the desk stand, and (3) the handset, in which the transmitter and receiver are mounted at opposite ends of a handle. The handset usually rests on a cradle surmounting a base which, in later designs, known as combined sets, includes the bell, induction coil, condensers and other apparatus. These in earlier designs, were generally housed in a separate subscriber set or bell box. The combined set may also include push-button or other type keys to perform various functions as described later under key equipments

The Receiver .- The receiver was the original telephone, for at first a single instrument, placed alternately to the mouth and ear, was used for talking and listening. Continuous development of Bell's basic instrument led to vast improvement in the naturalness of its reproduction of the voice. Fundamentally, it consists of a permanent magnet having pole pieces bearing coils of insulated fine wire, and a circular diaphragm of magnetic alloy supported by the case or shell of the instrument, with its centre close to the ends of the pole pieces, but not in contact with them. Speech currents, passing through the coils, vary the attraction of the permanent magnet for the diaphragm, causing the latter to vibrate and produce sound waves in the air corresponding to the speech currents. Recent improvements in the U.S receiver are new types of magnetic alloys, dustproof case and welded construction. The design of the complete electromechanical system has been continuously improved to provide uniformly better talking quali-

The Transmitter .- Bell himself early pointed the way to improvement of the transmitting function of his telephone by his liquid transmitter in which the electrical resistance of the transmitting element varied under control of the vibrations of the voice. Following the Berliner and Edison transmitters of 1877. based on the principle of the microphone (variable resistance contacts in a battery circuit) came the Blake transmitter, introduced into the Bell system in 1878; the granular carbon type, growing out of an invention by Henry Hunnings; and the "solid back" type, an improved form of granular carbon transmitter, invented by Anthony C. White in 1800. This form of transmitter has been retained in modern sets but improvements, particularly as regards efficiency, naturalness of voice reproduction and better resistance to aging, have resulted from continuing scientific research.

The Station Circuit.-The transmitter and receiver may be connected to the line in various ways by means of the induction coil, and substantial improvements were made, particularly after 1930, not only in the design of the coll itself but in the development and introduction of commercially practicable antisidetone circuits, whereby most of the electrical energy generated in the transmitter is directed toward the distant station, with a minimum entering the speaker's receiver.

Coin Telephone Stations -Generally provided in public or semipublic locations, these include, in addition to the usual station equipment, a coin collector having one or more slots designed to accept legitimate coins and reject slugs or spurious coins. The coms, in passing down their respective slots, strike distinctive gongs, the tones of which permit operators to supervise the deposits Many coin collectors are arranged to hold the coins in suspension in a hopper, with means provided whereby the operator (or automatic devices in a dial office) can either collect or refund the coms so suspended, depending on whether or not the called party is reached

Key Telephone Systems -In business offices and residences. additional telephone facilities in great variety, beyond the scope of a single station set, are frequently employed for greater convenience and utility Various combinations of push-button, turnbutton or lever-type keys, installed on a desk or table, or mounted integrally in the base of a telephone set, can be arranged to perform many combinations of functions, particularly where two or more lines and a number of stations are involved. Thus, an extension telephone may be cut off, a telephone may be connected to any of several lines; a call can be held on one line while one is talking on another, etc

Private Branch Exchange .- This name is applied to a switchboard, generally small but occasionally of very large size, located at the subscriber's premises. It is connected with the central office switchboard by a number of trunk lines and to it are connected the station sets of the subscriber's establishment. The smaller private branch exchanges are capable of being placed on a desk and operated by a clerk who may also perform other duties. Large private branch exchanges resemble central office switchboards. These may be of either the manual or the dial type

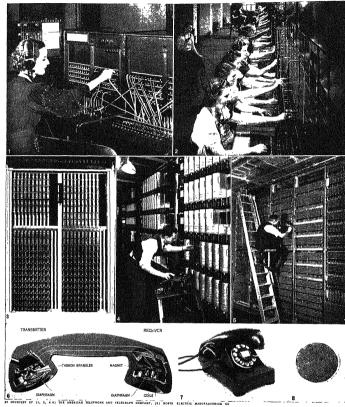
Special Equipment.-Special equipment and arrangements are available to meet unusual requirements of various kinds. Among these are loud gongs or other signalling devices for noisy locations, amplifier equipment for use by the hard-of-hearing, conference systems utilizing loud speakers and paging systems for

public buildings such as hospitals.

Central Office Switching Equipment.-To enable telephone conversations to take place, two station sets must be connected by a pair of wires constituting an electrical circuit called the line If each person having a telephone wished to talk only to one other station, the telephone plant would be very simple. Its complications arise from the necessity of selecting the proper one of millions of telephones, almost anywhere in the world, connecting the calling station to it and providing satisfactory talking conditions. Thus, each call is custom-made and in consequence telephone service is very different from water, gas and electric supply services in which each customer satisfies his demands by merely drawing what he needs from a set of mains.

Whether the switching equipment in the central office is manually operated or of the dial type, it comprises means for connecting to the calling line when the subscriber raises his receiver from the switch hook; means for selecting, on the basis of the subscriber's order for the call, an available path to the called party's telephone, whether that telephone be connected to the same switchboard as is his own, or to some other switchboard in the same city, or whether it must be reached over a trunk line to some suburban point or over a toll or long distance line extending to a more remote place; means for determining whether the called line is already in use; means for ringing the bell at the called station; and finally when signals indicate that the conversation is ended, means for restoring all circuits to readiness for other calls

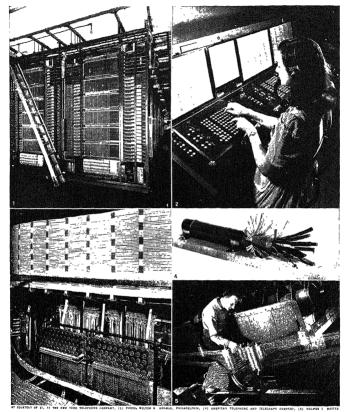
There are certain limits to the number of telephones which can be given service advantageously on one switchboard or group of switchboards in a given building One of these is the economic limit which indicates that, in order to keep down the length and cost of the lines connecting the telephones with the central office, the lines in certain conveniently sized areas should be grouped to



Private branch exchange meterbaard, located on burdness subschiers, premises, for handling calls between telephones on the premises and calls to and from the central office for providing oil asroles not.
 Toll ewitchboard arranged for handling looming long-distance calls
 Alfesting type community dial office for providing oil asroles not-distance.
 Step-by-step dial central office. In this system, used widely in the smaller cities, in rural commonlities and for private branch cochanges, the switches shown respond directly to the pulses from the dials.

- S. A bank of orestsbar switches. This dial system utilizes twin contents of prodous metal, having very short "travel," leaked of moving brashs or wives travelling over a large number of base metal produces of the content of the con

# TELEPHONE

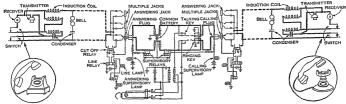


1. Interior of panel dial central office showing typical panel type selecting

- Interior of passel dial central office showing typical panet type selecting apparatus
  paperatus
   One position 4. kype of antibiotopic and with respect also involved the control part of the part of

### soldered connections

coldered connections
Coxxxxx clocks, with his coacxxx units and layer of 19-gauge quads
5 101 parts of saper sult insultated cooper wire, which may vary from
22-105 gauge, are field at 600 feet per minites this is metables called
and the same of



BY COURTEST OF THE AMERICAN TELEPHONE AND TELEGRAPH CO
FIG 1 -- SCHEMATIC DIAGRAM OF TELEPHONE CONNECTION IN COMMON BATTERY MANUAL EXCHANGE

When the suberriber (left) removes his telephone from the cradle on acceptant circuit is completed through his set, the line rather of the cradle on acceptance in the center of the cen

one central office in each area and the several central offices interconnected by trunk lines The number of central offices, their locations, the boundaries of their areas, the type of switchboards and the number and character of the trunk lines are all matters requing careful engineering study and intricate planning, usually far in advance of actual construction.

Historical—The first commercial telephone switchboard, put mto service in New Haven, Conn., on Jan 28, 1878, provided primitive means for accomplishing the fundamental operations of interconnecting subscribers' lines It served 21 stations on 8 grounded lines. In contrast, a modern central office may contain five or more switchboards, each serving perhaps 20,000 telephones on 10,000 lines.

One of the more important developments in manually operated switchboards was that of the common battery system, in which a large battery at the central office replaced the individual batteries previously required at each station to actuate the transmitter This system also permitted elimination of the magnetic generators which subscribes operated by turning a hand crank, thus generating an electric current which caused an annunciator or drop to operate at the switchboard. In contrast, the common battery system permits the subscriber to signal the operator by merely lifting the receiver from its switch hook, thereby lighting a tiny electric lamp associated with his line at the switchboard. The electrical circuit of this type of switchboard is shown diagrammatically in fig. 1, its operation being explained in the text below the figure.

An essential step in the evolution of the manual switchboard was the introduction of the multiple system, wherein a connection to each subscriber's, line appears at intervals along the switch-board so that the line is within reach of every operator. In practice this means one multiple jack per line for every three adjacent operators. This permits any operator to establish a connection directly between any subscriber whose line lamp appears before her and any other subscriber connected with the office. Previously, when the number of subscribers which a single operator could reach was exceeded, trunk circuits were provided between operation. This same syntheboard, but this reduced the speed of service. This can be also also be a subscriber when the content is an experimental content of the speed of service. The same syntheboard, but this reduced the speed of service. The same syntheboard, but this reduced the speed of service. The same syntheboard is a subscriber of selecting devices to assure a high probability that a circuit will be available whenever someone disks the line.

With the introduction of the multiple system it became necessary to develop a buy test, to determine whether or not a line, with which connection was desired, was already in use through a connection made at some other part of the switchboard. In the

common battery manual system the operator performs this test by touching the tip of a connecting plug to the jack of the desired line. If the line is busy, a click is heard in the operator's receiver. In the dual system the busy test is made automatically

Buddings:—Telephone buildings are usually specially designed to house the telephone plant. They range in szer from small onestory structures to huge multistory combination office and equipment buildings. Uniform equipment layouts are followed wherever possible but each building is individually planned to meet the needs of the area it is to serve including provision for economical and orderly enlargement to eare for future requirements.

Telephone Lines .- Telephone lines connect (1) each telephone to a central office; (2) each central office in a city to every other central office in that city; and (3) all cities, towns, villages and community centres, by means of a vast network of wires. These wire lines are of two forms-cable and open wire. Cable consists of insulated copper waes, twisted in pairs and assembled into a core which is covered with an envelope of lead alloy About 04% of the telephone wire mileage in the U.S. is in cable placed either underground or suspended aerially by means of steel strand attached to poles Open-wire lines consist of bare wires, generally of copper or steel, attached to glass insulators supported on pins m crossarms attached to the tops of poles. The lines in a city area may be divided into two classes. (1) subscribers' lines connecting the subscribers' stations to a central office; and (2) trunk lines which connect the offices together. In a typical city installation, a rubber-covered pair of wires, known as the "drop" wire, runs from the subscriber's premises to a cable terminal. In densely built blocks the connection is frequently made by wires attached to the walls of buildings. From the cable termmal, the line is continued toward the central office in a small cable, containing from 25 to 100 pairs of wires and known as "block" cable, which connects with the larger "feeder" cables that run as directly as practicable to a central office. In densely built areas the feeder cables are generally placed in underground ducts; elsewhere they are placed overhead.

As the result of the cable development work described in a later section, telephone cables containing many hundreds of pairs of wires are now available and are employed in the more congested districts. A cable of the type which is used for main feeder routes may contain as many as 2,121 pairs of 36-gauge wires. The installation of the subscribers' cable distribution plant, consisting of block cables, and main and subsidiary feeder cables is preceded by a careful engineering study of the present and probable future demand for telephone service in order that the plant may be so planned as to cnable these domands to be adequately met with over-all economy.

Tunk cables usually contain larger wires than subscribers' cables In large mentopolitan districts, where there are many central offices, the number of trunk circuits required is very large; sometimes as high as one runk circuit for each eight subscribers' lines. Trunk routes are usually double-tracked, 1e, 1wo groups of circuits (one for traffic in each direction) are ordinatily required between each pair of central offices, except where tandem or intermediate switching is employed. To provide adequate transmission efficiency in the case of the longer trunk circuits, it is frequently economical to "flaud" then, as described in a subsequent section. The longing coils usually are usually as the contraction of the case of the longer trunk circuits, it is frequently economical to "flaud" then, as described in a subsequent section. The longing coils usually are usually as the contraction of the case of the longer trunk circuits and the contraction of the case of the longer trunk circuits and the contraction of the case of the longer trunk circuits and the contraction of the case of the longer trunk circuits and the contraction of the case of the longer trunk circuits and the contraction of the case of the longer trunk circuits and the contraction of the case of the longer trunk circuits and the case of the longer trunk circuits and the case of the longer trunk circuits and the case of the longer trunk circuits and the case of the longer trunk circuits and the case of the longer trunk circuits and the case of the longer trunk circuits and the case of the longer trunk circuits and the case of the longer trunk circuits and the case of the longer trunk circuits and the case of the longer trunk circuits and case of the longer trunk circuits and case of the longer trunk circuits and case of the longer trunk circuits and case of the longer trunk circuits and case of the longer trunk circuits and case of the longer trunk circuits and case of the longer trunk circuits and case of the longer trunk circuits and case of the lon

Toll and Long Distance Lines.—The network of toll and long distance lines which interconnect some poopoc communities in the US, utilized at the beginning of 1947 approximately 20,00,000 ml, of copper wire on over 20,000 ml, of route. About 55% of the wires were in cable with the remainder on open-wrie lines. Starting with a cable placed in 1950 between New York city and Philadelphia, Pa., the intercity cable plant grew into the country-wide network shown on fig. 2. The central transcontinental cable route linking the sastem and weeken networks was completed in 1924. Most of the intercity wires are works was completed in 1924. Most of the intercity wires are quenches above the voice range are utilized for transmission, as discussed in a subscenent section. Also these wires are extended incussed in a subscenent section. Also these wires are extended to the contract of

sively used to provide telegraph circuits.

A large part of the toll cable construction employs paperinsulated conductors, usually 36 mils in diameter, weighing 201 lb to the mile (19 B and S gauge). In the construction of this type of cable, two wires, each insulated with dry paper, are first twisted together to form a pair. Then a quad is formed by twisting two pairs together. The twisting aids in the prevention of cross talk or overhearing between the pairs. Each quad furnishes three talking paths when used for voice circuits-two "physical" circuits and one "phantom" circuit, the latter resulting from a combination of the two physical circuits. The quads are formed together and enclosed in a metallic sheath. Toll cables range in size from a few quads to approximately 150 quads. Two 44-quad cables, if arranged for both voice and carrier transmission (see below, Examples of Improvements), could furnish about 800 talking circuits or even a greater number of telegraph circuits. A toll cable with a suitable protective covering such as jute or spirally wrapped steel tape is buried in the ground. Only storms or floods of most unusual severity can interrupt service with construction of this type. In passing through cities, the cable is usually placed in underground ducts. Loading coils are connected in each voice telephone circuit a little more than a mile apart and at intervals of about 45 miles repeater stations for amplifying the speech currents are placed along the route. The carrier circuits in paper-insulated cables operate over nonloaded pairs and repeater stations for amplifying the carrier currents are spaced at about 16-mile intervals. In addition to the paper-insulated cable conductors a new type of structure exclusively for carrier use has been introduced and is being employed extensively in new construction. The conductors in this new structure as described in a subsequent section are arranged coaxially.

#### EXAMPLES OF IMPROVEMENTS

Many times during the period that elapsed after the invention of the telephone, scientific research and againering development not only found the way out of difficult situations which threateast to humper the growth of telephone service but, in advance of immediate, seeds, they often created new instrumentalities which, in turn, led to further extensions and improvements of the service.

Cables.—Telephone cables not only provide a means for placing a large number of telephone circuits compactly either overhead or underground, but they enable the lines to be carried

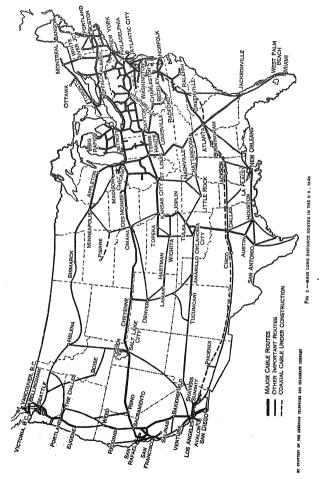
across the beds of rivers and other waterways. In the cables first employed, single wires with a ground return were used and the wires were insulated with either gutta-percha or rubber. It was soon found, however, that such cables were not well-suited for telephone purposes. After experiments with many kinds of insulating materials it was found that dry paper was the best for telephone cables. This discovery and the concurrent development of means for encasing the paper-insulated wires in a metallic sheath or tube which protected them from moisture laid the foundation for the modern telephone cable Research and development covering many materials and processes made it possible gradually to increase the number of pairs of wires in a fullsized cable for subscribers' lines, from a maximum of 50 in the year 1888 to 2,100 in 1939. This great progress resulted in a greatly increased effectiveness of utilization of the space in underground ducts in addition to other marked advantages. The increase in the number of pairs in a single cable was accompanied by a reduction in the size of the copper wires, those used in the 2,100-pair cable, for example, weighing only about 4 lb, per wire mile, while those used in the so-pair cable of 1888 weighed about 25 lb. per wire mile

In order to realize the maxmum use of carrier frequencies in the toil plant it became apparent to telephone engeneers that a new type of conductor would be necessary. Consideration of this problem led to the development of the coaxual unit consisting of a cylindrical copper conductor surrounded by a copper tube. The copper conductor is held in place by polyethylene disk insulators. This coaxal unit is suitable not only for carrier telephone transmission but for television transmission as well. A cable containing both coaxial units and quads is shown in fig. 4 of Plate II. Coaxial cables over heavy routes usually include eight coaxial units, Six and sometimes four units are employed on the lighter routes.

Loading .- For some time prior to the year 1900, it had been known to those technically skilled in the art of telephony that the transmission efficiency of long telephone circuits could be improved by increasing their electrical property known as the "uniformly distributed inductance." Numerous investigators sought unsuccessfully to simulate the beneficial effect of increasing the uniformly distributed inductance by introducing, into the circuit, inductance concentrated, or lumped, in the form of coils. However it was reserved for Prof Michael I. Pupin of Columbia university, New York, to discover, in 1900, that the proper spacing of the coils along the telephone circuit was the key to the solution and it was from failure to establish this that earlier workers had failed. The proper spacing of the inductance coils along a telephone circuit is referred to as "loading." Loading, which now is applied exclusively to cable circuits, reduces the attenuation of the waves of speech current in the circuit. To indicate its practical value, it can be stated that, under favourable circumstances, a loaded cable circuit is as good a conductor for telephonic currents as would be a nonloaded circuit of conductors weighing about eight times as much

Satisfactory loading also requires that the loading coils should have very low energy loses in their magnetic cores and their copper windings, and that their inductances should be uniform and stable. The toroidal-shaped cores of modern loading coils make use of a powdered magnetic alloy; having the mdivodual particles suitably insulated and then compressed under very high pressure, after which a suitable heat treatment is applied to develop their optimum magnetic properties. The present standard Bell system core materials is an alloy of nickel, (rion and moly)-denum known as "moly)denum permalloy," one of a series of permalloy materials discovered by G. W. Elmen of the Bell Telephone laboratories. The progressive improvement of magnetic core materials has permitted very large reductions in the size and cost of loading coils since 1935, while also making moderate improvements in their performance characteristics.

Repeaters.—As the telephonic currents pass over the line they decrease in strength, so that after travelling a distance which varies with the character of the line, they become too weak to actuate the telephone receiver properly. The idea of inserting one or more repeaters in a line for the purpose of reinforcing or



amplifying the telephonic currents from some local source of energy is almost as old as the telephone itself, but many years elapsed before the quest for a satisfactory repeater culminated in success. The solution of this problem involved the production of a repeater element which, when actuated by weak telephonic currents, is capable of emitting greatly strengthened currents without appreciable loss in the clearness of voice transmission A socalled "mechanical" element was used commercially in 1904 but this presented inherent limitations owing to the mechanical mertia of the moving parts. A satisfactory solution of the problem was found about 1914 by improving and utilizing the three-electrode vacuum tube in which the weakened speech currents control a local source of energy by means of a practically weightless stream of electrons. The three-electrode vacuum tube of Lee De Forest, prior to its development for use in telephone repeaters, was employed for radio telegraph reception. In the form in which it was used for that purpose it was not suited for telephony. A large amount of research and development work was required before a satisfactory tube could be produced.

Continuing development work looking toward improved efficiency in vacuum tubes used in telephony resulted in many improvements. To illustrate, the life of the vacuum tube most commonly used in 1917 was about 1,000 hours. Tubes of a new type first introduced in 1938, have a life of fully 70,000 hours, which is equivalent to about eight years of continuous operation. In addition, the first cost was reduced by more than one-half and the power required to heat the tube filaments was also reduced to less than one-half of that required in 1917. The amount of testing needed to secure good operation was likewise decreased. This research also led to new types of tube with four and five elements which are especially adapted for use in carrier and radio systems. The very large use of vacuum tube repeaters is shown by the fact that in 1944 there were about 175,000 voice and carrier repeaters using about 600,000 vacuum tubes in the telephone plants in the U.S.

The repeater element would have been of lutle use without the concurrent development of efficient and convenient circuits and annulary equipment to enable the repeater element to be associated properly with the line circuits. The development of a satisfactory repeater has also carried with it the necessity for extensive investigations of the characteristics of telephone lines is which the repeater must work. Prominent among such auxiliary equipment are the equalizer which compensates for the poor line characteristics at various frequencies and the transmission regulator which automatically compensates for the large variation in line loss due to temperature variation.

Carrier. -Practically all of the long distance routes shown in fig. 2 have been greatly increased in message-carrying capacity by the application of carrier telephone systems. These are called "carrier" systems because of the basic principle whereby the frequencies ordinarily involved in voice transmission vary or modulate a higher frequency current which then may be said to carry the telephone currents by which it is controlled. The ordinary voice telephone frequencies, about 200 to 3,000 cycles, are in effect transposed to a frequency band of equal width in a different and heretofore unused part of the frequency scale. By bringing about a suitable reaction with a carrier current of, say, 7,000 cycles, the voice frequencies of 200 to 3,000 cycles can be transposed to frequencies of 7,200 to 10,000 cycles. At the distant end of the circuit the latter currents are restored by a process known as demodulation to the original 200 to 3,000 cycle frequencies. By the use of additional and higher frequency carrier currents other messages can be transmitted simultaneously over the same circuit.

Carrier systems and associated equipment have been the subject of continuous study and development by communications research people. It was, in fact, during experiments of the carrier principle applied to telegraphy that Bell made his original discreyer, Applied commercially first to open-write circuits, in 1758, to transmit four additional messages over a pair of wires, carrier telephone systems are now available in varied types and capacities depending on the needs in the particular case and on the type of line structure on which applied. Open-wire systems commonly

provide 1, 3, or 15 additional circuits over one pair of wires The cable system utilizing two pairs of nonloaded 19-gauge conductors provides 12 circuits. Two coaxial cable units provide for up to 480 telephone circuits or for a television channel.

As a consequence of the very large line losses involved due to the necessity of using nonloaded conductors and very high frequencies, the carrier development has made even more necessary than in the previously mentioned voice frequency system the need for transmission equalizing arrangements, automatic transmission regulating systems, and other associated equipments and circuits. The individual amplifiers used on these systems, for example, provide amplification for the entire band of frequencies ranmitted and not only must give very high amplification but must be extremely stable in performance.

Switching Systems .- In the continual improvement of manually operated switchboards, the tendency was naturally toward the provision of automatic devices to relieve the operators of their more routine functions. The accomplishments in this direction became more marked after the introduction of common battery operation with lamp signalling. Parallelling this development, considerable progress was made in the field of fully automatic, or "dial" switching systems. U.S. patents covering such a system were first applied for in 1879, but the system which they described never became a commercial success. In 1889, however, A. B. Strowger invented a system which was subsequently improved by others and is in wide use under the name "step-bystep" system The original Strowger system employed push buttons at subscriber stations. The subscriber station dial with finger wheel was invented in 1898 by Alexander E. Keith and the brothers, C. and C. J. Erickson Other automatic systems, containing important features contributing greatly to the success of automatic switching, appeared both in the U.S. and elsewhere Independent telephone manufacturers played important parts in these developments.

The Bell system became actively engaged in the development of automatic switching equipment prior to 1900. After exhaustive inquiry, in its effort to determine fundamentally the type of machinery best suited to the needs of the larger cities, a large trail installation of semiautomatic equipment was made in 1914, leading to the installation in 1921 of the first completely automatic exchange of the "panel" type, so called because of the appearance of the switch frames used. This system employs switching mechanisms operated by common control circuits. In the step-by-under control of the subscriber's dial, whereas in the panel system the dial impulses are registered in common control circuits known as senders, which in turn control the setting of the switches. The system provides flexibility and efficiency essential to the needs of the larger cities.

The application of dial telephones grew rapidly until, in 1947, both 138, of the telephones in the US and about 15% of the telephones in the US and about 15% of the telephone in the Boll system were operated on a dial hasis. Considering as earch led to the development of a bascally new switchings greaten, known as "crossbar," from the appearance of the switches used. This system also operates on the common control basis similar to the panel system. The first complete exchange of this year was placed in service in 1938. This system, designed originally for the larger cities and hence arranged to work readily with type was placed in service in 1938. This system, designed originally for the larger cities and hence arranged to work readily with existing paule type offices, presented so many advantages as compared with earlier systems that its basic principles were gradually applied to other fields. Thus, in 1943 the first large application of crossbar equipment to the handling of long distance calls was placed in service. There was also in 1947 a trend toward the use of crossbar principles in the smaller exchanges and even in cities already having considerable step-by-step equipment.

Another important development was the application of automatic switching to very small communities. By 1947 nearly 1,000 of these 'community dial offices' had been installed in the Bell system alone, most of them in outlying or rural localities. Many of these small exchanges were of the step-by-step type, but there were also a number of types of "all-relay" equipment produced by various smanufactures. The introduction of these com-

standing step in the telephone industry's program for improving rural telephone service.

The foregoing are but a few of the many improvements brought about by development and research. Among others may be mentioned transoceanic telephony; telephotography (q v ), which enables pictures to be reproduced at distant points; dialing of toll calls, and automatic ticketing, which consists of automatic equipment for recording on a ticket calls dialed to short-haul toll points, thus permitting the completion of such calls by fully automatic means without requiring the services of an operator for billing purposes, and crossbar tandem equipment, which is a modern version of the tandem principle, developed originally for manual systems, whereby traffic between offices on opposite sides of a large city, for example, is handled through an intermediate switchboard which acts as a clearing house for these relatively small amounts of traffic, handling them more efficiently than if direct paths were provided and thus reducing the number of trunks required

Extension of Long Distance Communication.-The first long distance conversation took place in 1876 over a line two miles in length between Cambridge and Boston, Mass. Conversation by telephone became possible in 1880 between Boston and Providence, RI, and in 1884 between Boston and New York city The long distance lines from New York reached Chicago, Ill, in 1892 and in 1911 were extended to Denver, Colo. Salt Lake City, Utah, was connected with the eastern seaboard in 1913 In 1915 the first transcontinental telephone line was opened between New York and San Francisco, Calif. As public demand for long distance service grew greater, a second open-wire line across the country became necessary and in 1923 a southern transcontinental line was opened to service through New Orleans. La., and El Paso, Tex., to Los Angeles, Calif. A third open-wire line across the continent was opened in 1927 by way of Minneapolis, Minn, to Seattle, Wash, and Portland, Ore, The fourth open-wre line was established in 1930 between St. Louis, Mo., and Los Angeles using a route somewhat north of the southern transcontinental line in passing through Holbrook and Kingman, Ariz The reliability of the long distance telephone service was substantially enhanced by the placing of many of the important lines, such as the central transcontinental, in underground cables which are practically stormproof. A start was made in 1944 on a second transcontinental cable which was to follow a southern route from New York through Atlanta, Ga., and Dallas, Tex., to Los Angeles. Out of a total of about 105,307,000 miles of Bell system telephone wire on Dec. 31, 1946 (consisting of 86,384,000 mi. of exchange wire and 18,923,000 mi. of toll wire), 61%, or 64,203,000 mi., was in underground cable; about 34%, or 35,704,-000 mi., was in aerial cable; and the remainder, 5,400,000 mi. was in open wire.

The most populated sections of the U.S. in 1945 were largely covered by the spreading network of telephone cables and other important routes shown in fig. 2. Telephone messages can now be transmitted entirely through cable from Bangor or Ellsworth, Me., in the extreme northeast to San Diego, Calif., in the west, 3,900 mi. In the New York-Philadelphia section, seven cables provided facilities in 1944 for about 2,940 telephone conversations and 540 telegraph messages simultaneously.

Canada was brought into communication with the U.S. many years ago and in 1945 the eastern toll cable network extended to Montreal, Quebec, Toronto and London, Ontario. Three telephone cables under the Florida straits between Key West and Havana, Cuba, providing three talking circuits, were opened to service in 1921 making it possible to talk between the North American continent and Cuba, A fourth cable equipped with three-carrier channels was placed in service in 1931, In 1942 the total number of telephone circuits was increased to ten by replacing the threechannel carrier system with a seven-channel system. In 1927 communication was established over land lines to principal cities of Mexico. Communication to Fairbanks, Alaska, by land line was established in 1042.

munity dial offices in place of manual switchboards was an out- trons resulted in the transmission by radio of intelligible speech from Arlington, Va., to Hawan on Sept. 30, and to the Eiffel tower in Paris, France, on Oct. 21. In 1927 with the co-operation of the British post office the first commercial overseas circuit was opened, making possible telephone connection between anyone in the US and anyone in England and Scotland In 1931 radio stations were established on the Pacific coast which furnished service between the US and the Hawaiian Islands, Philippine Islands, Netherlands Indies and Japan Facilities established in New Jersey in 1930 and at Miami, Fla, in 1932 provide service between the US. and most of the countries in Central and South America Radiotelephone service is available between the United States and 68 countries and territories throughout the world Of these, 48 are reached by direct circuits and the 20 others through connecting wire lines or radio links.

Facilities in the US are available for telephone service by radio to suitably equipped ships operating in both the Atlantic and Pacific oceans. Radiotelephone service is also given to large numbers of vessels engaged in harbour and coastwise operations

Radio is used in the US telephone plant for short distance toll circuits between locations where the use of wire would be unusually difficult. Examples are service to Smith and Tangier Islands in Chesapeake bay, and a 12-channel system between Cape Charles and Norfolk, Va. Portable radiotelephone equipments are used in emergencies such as floods or hurricanes to bridge gaps in the regular toll circuits until normal service can be restored.

To determine further the field of usefulness of radio in the telephone plant, work was begun in the summer of 1945 on a trial of a microwave relayed radio system between New York and Boston. In 1946 came the first installations of mobile radiotelephone service providing two-way telephone communication between the land telephone system and motor vehicles both in urban areas and along intercity highways

Communications in War,-World War II saw a revolutionary change in military communication facilities both as to magnitude and variety. This in a sense reflected the extraordinary progress in the communications art made in the 20-year period after World War I. In this period occurred almost the entire development of the radiotelephone facilities, of carrier systems both telegraph and telephone, and of such allied systems as telephotography and wire networks for the interconnection of radio broadcasting stations.

Communications played an important part in the success of the European invasion in 1944. The magnitude of the telephone net-work involved is evidenced by the fact that during the period from D-day (June 6, 1944) to March 1945, the U.S. army in Europe employed 820,000 mi. of field and assault wire, 239,900 mi. of spiral 4-carrier telephone cable, 294,000 telephones and 17,740 switchboards. In addition use was made of the permanently installed telephone plant in the countries invaded In forward combat zones, radiotelephone was used extensively for communicating with tanks and other vehicles, with scouting groups carrying portable radio sets, and for establishing communications in advance of the time when wire facilities could be placed. Radio also served for communication with aeroplanes.

Communications were also an important adjunct in the naval operations of World War II. For example, in one landing operation against a Japanese-held stronghold in the Pacific in 1944 the U.S. navy used about 800 warships equipped with 48,166 telephones. These shipboard telephones were connected by some 5,000,000 ft. of telephone cable of various sizes. The 48,166 telephones are equal to the number serving a city about the size of Flint, Mich., or Youngstown, Ohio.

Telephone research and manufacturing organizations were expanded during the war years and their efforts were almost wholly devoted to supplying the communications needs of the armed services of the U.S. and its Allies.

## TELEPHONE IN VARIOUS COUNTRIES

The introduction of the telephone and the development of the In 1915 experimental work by Bell system research organiza- business in countries other than the U.S. will be briefly outlined

in the following paragraphs. The expansion of international telephone communications in Europe, the recent development of long distance telephone cable facilities in the various European countries, and statistics reflecting the status as of Jan. 1, 1947, of telephone development throughout the world will be presented in

the remaining sections of this article, Great Britain .- Earnest efforts were made by the early backers of the telephone in the US to introduce it to use in Europe Bell himself visited England and Scotland on his wedding trip m 1878 in the hope of developing a demand for the telephone in his native country Queen Victoria congratulated Bell upon the success of his invention and offered to purchase a pair of telephones, but the inventor made her a present of two instruments especially done in ivory. This assisted in bringing the telephone to public attention and in 1879 the first telephone exchange was opened in London with seven or eight subscribers. Several companies were established for the purpose of introducing the telephone in various parts of the United Kingdom, but in 1880 the British courts held that the telephone system was legally a telegraph system within the meaning of the acts of parliament making the telegraph a monopoly of the postmaster general. The British post office thereafter issued licences on a royalty basis to several private companies, which were ultimately consolidated into a single large company. Licences for the establishment of

cutes and several such systems were established.
In 1896 the post office bought the long distance lines throughout the United Kingdom and after that the privately owned telephone company confined its activities to the operation of local exhanges. The post office, however, began establishing its own local telephone exchanges in Londom in 1902 and these were connected with the company's system. Upon the expiration of the company's hence on Dec. 32, 1911, the post office acquired till telephones in Great Britain with the exception of the numicipal systems at Hull and the Channel islands of Gorensey and Jersey. Upon the establishment of the Irish Free State the British post office transferred to the Free State to British post office transferred to the Free State to British post office transferred to the Free State to British post office transferred to the Free State to British post office transferred to the Free State to British post office transferred to the Free State to British post office transferred to the Free State to British post office transferred to the Free State to British post office transferred to the Free State to British post office transferred to the Free State to British post office transferred to the Free State to British post office transferred to the Free State to British post office transferred to the Free State to British post office transferred to the Free State to British post office transferred to the Free State to British post of British Free British Brit

municipal telephone systems were also issued to a number of

tem in southern Ireland.

In most of the continental countries, as well as in Great Britain, the telegraph system was already a government monopoly when the telephone was introduced The government telegraph officials in continental countries, apparently regarding Bell's invention as a possible competitor of the telegraphs, were, therefore, reluctant to encourage it. In most cases, moreover, the government officials did not feel justified in undertaking the risks of attempting to develop this new means of communication. The usual procedure, therefore, was to allow the private companies to do the pioneer work of bringing the telephone into use under licences imposing more or less restrictive conditions. However, as the potential factors of telephone communication gradually were appreciated, most of the governments on the continent took over the company-operated systems and the telephone service was thereafter administered along with the postal and telegraph system. Motives of military preparedness unquestionably actuated government officials in taking steps in the early days of the tele-phone to secure full control of all means of communication.

Germany.—In Germany the telephone was a government monopoly from the very beginning. Helmich von Stephan was posimaster general of Germany and manager of the Imperial Telesembs at the time the telephone was first brought to public notice. He was an active administrator, founder of the Universal Postal Union, and was quick to grap the possibilities of the new invention. In 1877 he wrote enthusiastically to the imperial chanciden, Prince Bignarck, of experiments in the establishment of color, Prince Bignarck, of experiments in the establishment of suggested that the telephone be utilized as an adjunct of the telegraph service in rural post offices where there was not sufficient tuffic to require the services of a trained telegraph operator. The first publicuses of the telephone in Germany was along these lines which, it will be noted, differ from its early utilization in the U.S. In the JU.S. exchange service between persons in, the same com-

munity was the basis of the early public service, the local areas being gradually linked by long distance hies In Germany, on the other hand, the toll lines came first as a substitute for the more expensive telegraph facilities Later, however, the German government introduced exchange service in Berlin, Hamburg, Colome, Frankfurt, Breslau and elsewhere

A like policy of government ownership from the first was followed in the German states of Bavaria and Wurttenberg, where the telephone systems were operated by separate state administrations until 1900 when they were transferred to the administration of the Rechtspostministerium. In 1939, Germany had more telephones in source the name of the control of the Rechtspostministerium.

telephones in service than any other country except the U.S. France and Switzerland.—In France the telephone was first exhibited at the Paris World's Fair in 1878, where it attracted little interest In the following year, however, representatives of American telephone manufacturers approached the French telegraph authorities with a view to securing permission for the establishment of telephone service in Paris The French telegraph officials were unwilling to undertake the development of telephone service themselves, but granted concessions on a royalty basis to several different telephone companies. These concessions were passed about from one concern to another until in 1880 they were all consolidated in a single company called the Société Générale des Téléphones Public telephone service was opened by this company in Paris early in 1881. The French government established telephone exchanges at Reims, Roubaix and Tourçoing in 1882 and in several other commercial centres during the next few years. The private company also established exchanges in some other cities besides Paus, but in 1889 its entire system was taken over by the French government, which has operated the telephone service throughout France from that time. The French telephone system has been developed to a much greater extent in Paris than in the less densely populated sections of the country.

In Switzerland a concession was granted by the government for the establishment of a privately owned telephone system at Zurich in 1880; and the government itself opened exchanges in Basle and Berne during; 1881 and a year later at Geneva, Lausame and Winterthur. After that the government proceeded rapidly with the establishment of new exchanges and purchased the private system at Zurich upon the expiration of the franchise. After 1886 the government itself operated all telephones in Switzerland and the service has been developed to a greater extent than in many other European countries.

Belgium and the Netherlands.—In Belgium concessions were granted to a number of private companies which established telephone systems at various cities, but these properties were bought by the government at the expiration of their respective franchises and after 1896 the telephone was administered as a government monopoly throughout the country. In the Netherlands a number of concessions were issued, several of the most important ones being ultimately consolidated in a single company which also enjoyed the right to establish interurban telephone lines. The competition of these lines with the government telegraphs, however, led the authorities to acquire the interurban telephone lines upon the expiration of their licences. Municipal telephone systems were established in various Dutch cities succeeding those of the private company Later the government adopted a policy of acquiring these local municipal networks with a view toward the ultimate creation of a single government system operating throughout the country.

Austria and Italy.—In Austria concessions were early granted to private companies for the establishment of telephone services at Vienna and a number of other important cities. Long distances at Vienna and a number of other important cities. Long distances the services of the constructed by the telegraph authorities, who also opened their first local exchanges in 1887. Subsequently the concessions were bought in by the government and the telephone business became a government monopoly. Much the same course was followed in Hungary. It alzy granted a large number of concessions for local telephone companies and telephone competition was insugurated in a number of the important cities. Ultimately, however, the disadvantages of competition became apparent and consolidation took place, either voluntarity or at the instance of

and placed upon a uniform basis surrounded by somewhat onerous conditions In 1892 the conditions surrounding these concessions were liberalized, but Italy nevertheless failed to keep pace with other great powers in the development of telephone service. After various legislative attempts to encourage the private companies the government in 1907 adopted the policy of buying certain of their systems from time to time. With the accession of the fascist régime, however, there was a return to private ownership in Italy, territorial concessions for the operation of local telephone systems in various sections of the country being granted to private interests while the government maintained the operation of the long distance lines

Scandinavia .- The Scandinavian countries have gone further than any other European community in the development of telephone service. In 1880 the International Bell Telephone Co of New York secured local franchises for the Norwegian cities of Oslo and Drammen In the following year local telephone companies undertook the establishment of exchanges in other cities and a competitive system was even opened for service in Oslo In 1886 the two systems were consolidated and the Bell exchange in Drammen was later acquired by a local company The telephone soon came to hold much the same place in Norwegian rural life as it does in the sparsely settled districts of the US, and although the government did not encourage the construction of lines which would compete with the government telegraphs, the development of telephone networks throughout the rural districts went on apace. Ten years after the introduction of the telephone into Norway it had extended to almost every village, and even the small towns were surrounded by lines reaching far into the open country. This remarkable development was secured by local enterprise, independent telephone companies being formed in almost every town or village, and in this respect the Norwegian development was a marked contrast to that obtained in France and Italy. The construction of long distance lines in Norway was finally undertaken by large stock companies and ultimately the state took up the policy of acquiring the more important local telephone systems upon the expiration of their respective franchises. The greater part of the telephone business in Norway, particularly in the larger cities, in 1947 was operated by the government.

In Sweden, the telephone attained a higher degree of development than in any other European country. The International Bell Telephone company opened exchanges in 1881 in Stockholm, Gothenburg and Malmo. A couple of years later mutual telephone associations were established in many rural communities throughout Sweden and the Stockholm General Telephone company was established under the leadership of enterprising Swedish engineers to compete with the Bell company. The two systems were finally consolidated; but later telephone competition was renewed m Stockholm, the government opening an exchange system to compete with that of the General Telephone company In 1918 the government acquired the company's system and the considerable duplication which resulted from the competitive situation in Stockholm was later eliminated. The Swedish capital, however, remains the best developed city, from a telephone standpoint, in the world outside of the U.S.

In Denmark the telephone was introduced and developed by private enterprise and in the year 1947 more than 95% of the Danish telephones were owned and operated by private concerns.

Spain.-Spain entered upon a new era of telephone develop ment in 1024 when a concession was granted to the National Telephone Company of Spain, a subsidiary of the International Telephone and Telegraph Corporation of New York, for the development of a nation-wide system to supersede the pre-existing gov-ernmental and privately owned telephone services which had attained only a relatively limited development. The new company entered energetically upon the task of providing Spain with an up-to-date telephone system, the equipment being of Spanish manufacture so far as conditions permit. Within a very short time after the concession was granted, telephone communication was established across the Straits of Gibraltar by submarine cable connecting the Spanish wire system with telephones installed in

the municipal authorities In 1883 the concessions were regularized the zone of Spanish military occupation in Morocco. As of 1945, subsidiaries of the International Telephone and Telegraph corporation also operated telephone systems in Cuba, Puerto Rico, Mexico, Chile, Argentina, Brazil, Peru and Uruguay, but the Spanish company was taken over in 1945 by the government of

Telephone development in the rest of the civilized world may be summarized with the statement that while some sort of telephone service is to be found almost everywhere, the facilities have attained a relatively high development in the English-speaking dominions of New Zealand and Australia Japan, in 1939, had more telephones than any other country in Asia, but with the greater part of the facilities confined to a few large cities.

# DEVELOPMENT OF TELEPHONE LINES IN EUROPE

Particular attention has been directed to the extension and improvement of long distance facilities in Europe, especially as regards the circuits linking up the various countries on the conti-



FIG 3 .- DISTRIBUTION OF THE WORLD'S TELEPHONES, JAN. 1, 1947

nent. Much of the impressive progress that was made in international telephone communication on the continent of Europe after World War I may be attributed to the activities of the International Advisory Committee on Long Distance Telephone Communication. This committee was formed as a result of an international conference at Paris in 1923, at which delegates from Belgium, France, Great Britain, Italy, Spain and Switzerland assembled at the invitation of the French Post, Telegraph and Telephone administration This conference proposed

that a consulting committee should be formed which should undertake to unify as far as possible the practices of the various European telephone administrations bearing on international telephone communication, and should gather statistics and prepare technical recommendations to be submitted to the telephone authorities of the participating countries. Nineteen nations accepted the recommendations of the Paris conference of 1923 and their delegates assembled at Paris the following year to form the International Advisory Committee on Long Distance Telephone Communication. A constitution was prepared and a subcommittee appointed to prepare the agenda for the next conference. The recommendations of the preliminary conference were considered and some additional matters were discussed, particularly a proposal for a standard transmission unit and proposals relating to rates for in-

ternational messages. In 1925 the International Advisory committee held its second meeting, at which representatives of European telephone manu-



facturers were present. Transmission and inductive interference problems were added to the subjects to be studied. Much was later done by way of developing recommended standards of service and instructions for the operation of international circuits. Engineering problems in particular received exhaustive consideration and much attention was given to the question of suitable rates and classes of service. The opening of commercial tele-FIG. 4-OWNERSHIP OF THE phone service from the U.S. to

WORLD'S TELEPHONES, JAN. 1, 1947 England in 1927, to continental Europe in 1928, and the rapid subsequent expansion of this service to other countries and of similar services between other continents emphasized the importance of good engineering and transmassion standards to a truly world-wide communication service. The work of the International Advisory committee was accordingly broadened to include matters of world-wide significance; and beginning in 1929, the communication interests in countries outside of Europe became affiliated with the committee's activities.

Among the countries represented were China, Japan, South Africa, Netherlands Indies, US, Mexico, Cuba, Argentina and Chile.

Further recognition of the importance of long distance telephony was accorded by resolutions which were adopted at the 1925 Congress of the International Chamber of Commerce at Brussels, and at the later conventions of the same organization

This recognition of the importance of long distance telephone communication, supplemented by the concrete recommendations of the International Advisory committee, helped stimulate the European telephone administrations to take advantage of recent improvements in telephone equipment, notably as regards the increased efficiency of long distance telephone cables made possible by loading, the development of the vacuum tube repeater, the application of carrier systems and by other advances in the telephone att.

Long distance telephone cables were extensively introduced in the various European countries until in 1945 they provided not only an effective long distance service within the individual countries but likewase an effective international long distance telephone cable system for the continent as a whole Through the medium of intercontinental circuits and systems on other continents a world-wide system was made available.

Status of the Telephone Throughout the World, 1946.— Figs. 3, 4 and 5 indicate the status of the telephone throughout the world at the latest date for which comprehensive statistics covering practically all countries were available in 1947. At the end of 1946 there was a grand total of 54,650,000 telephones in service in all telephone systems throughout the world Approxmately 38% of all the telephones in the world were then in the

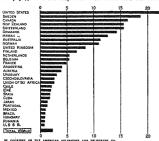


FIG. 5.—TELEPHONES PER 100 POPULATION, JAN. 1, 1947

U.S., the total for that country being 31,611,000. At the same date Europe had 15,750,000 telephones, or about 29% of the world's total.

Of these, 3,976,936 (March 31, 1946) were in the United Kingdom, 1,997,335 were in France, and Sweden had (Jan. 1, 1946) 1,144,673. The remaining telephones were distributed among the centinents of Asia, Africa, Oceania, South America and North America visitation of the United States. Canada had 2,073,000. Of the remainder, 1,378,000 were in South America, 1,541,000 in Asia (more that three-fifths of which were in Japan), 59,000 in Africa and 1,850,000 in Oceania (Including about 875,000 in Astralias and at March 3,17,477,785,000 in New Zeland).

In proportion to population the U S. had, on Jan 1, 1947, 2-23, telephones per roo population. The world as a whole had eithe same date 2.32 telephones for every roo inhabitants. At the end of 1945, Sweden had 18.64 telephones per roo people At Jan. 1, 1947, Canada had 16.33, Switzerland 15.57, New Zealand 15.57, Denmark 14.33, Hawau 12.60, Austraha (June 30, 1945) 11.22, Norway (June 30, 1945) 10.94, Dilted Kingdom (March 31, 1946) 8.43, Finland 6.78, Netherlands 5.41, Belgium 5.37 and France 4.03.

The U.S. has, however, not always been in advance of Europe in number of telephones. In 1885, about ten years after the telephone shorth, there were, to be sure, 155,800 telephones in the U.S, or almost twice as many as in Europe. Nevertheless, by the beginning of 1892 Europe had attained a total of about 254,000 telephones, which placed it ahead of the U.S. where there were then only 239,300 telephones Europe maintained its lead over the U.S. in telephone totals by a comfortable margin for nearly serve years thereafter, but in the latter part of 1898 the U.S. again passed Europe and the margin of U.S. leadership increased after that time. On Jan 1, 1947, the U.S. had twice as many telephones as all of Europe.

Among the South American nations Argentina had a development of a of telephones per roo people, or go,ooo telephones, at the end of 1946 Brazil then had 439,500 telephones, so that to gether these countries accounted for almost three-fourths to to 1378,000 telephones in South America Chile's 133,000 telephones amounted to 2.07 for each 100 of population.

Japan had a development of 1.27 telephones per 100 people at March 31, 1947.

as Marm 31, 1947.

As regards distribution of telephones with respect to the size of communities, it may be said that in general the smaller size of communities, it may be said that it is considered to the size of the size

In the U.S., no one city embraced more than 7% of the country's telephones. Yet, the three large urban centres of New York, Chicago and Los Angeles had in the agerteste far more stations than the top ranking telephone system in the world outside of the United States. New York, at Jan. 1, 1947, had 38 84 telephones for every roo inhabitants; Chicago 35,98 and Los Angeles 36 88, Washington, D.C., 4,10.8 and San Francisco 444.8. Stockholm had 39 of per roo inhabitants, Copenhagen had 27,94, 605 22.17 and Zurích 28,79. Toronto, Can, had 33,10 telephones per reop people, Brussels had 16.04, The Hague had 17.10 and Vienna had 8 93. Tokyo had 3.14 telephones for every coppulation, Melbourne had 15,94 and Rio de Janeiro had 7.68. Mexico, D.F., had 6.87 and Havana had 7,08.

In respect to telephone conversations during the year 1946, the latest period for which comparative data covering various countries were available by 1947, the U.S. had a total of 4,2,80,000.

On. The figures for telephone conversations included both local and toll, or long distance conversations. So far as they relate to the U.S. they cover completed messages only.

Americans, during the year 19,69, used the telephone 50.7. times per capita, while Canada, Sweden and Demmark during the year 1945 had 2649, 258.4 and 252.2 conversations per capita, respectively. For the year ended June 30, 1045, Norway and Australia had 152.3 and 102.6 conversations per capita, respectively. There were 130.5 telephone conversations per person during the year 1946 in Switzerland, 123.3 in Finland, 44.2 in Belgium and 36.0 in France.

Much has already been accomplished toward the integration of telephone communication facilities not only in countries like the U.S., Canada, Sweden and elsewhere, but also in regard to international communications on the North American and European continents and by overseas radio circuits between continents. The day is still not here when anyone anywhere in the world can communicate by telephone with anyone else anywhere in the world. Progress in extending the range of telephone compoint to further progress at a rapid pace

ideal measurably nearer to accomplishment. Present indications point to further progress at a rapid pace.

Britzionarerv—Aithur W. Page, The Bell Telephone System (New York, 1941), Frederick Lehad Rhodes, Beginning of Telephony (New York, 1941), Frederick Lehad Rhodes, Beginning of Telephony (New York and London, 1927), John Mills, Sygudis and Systein in Relational Communication (New York, 1948), H. Frender (ed. Hearth and the Communication (New York, 1948), H. Frender (ed. Hearth and Telephony (New York, 1948), Frender (ed. Hearth and Telephony (New York, 1948), Frender (ed. Hearth and Telephony (New York, 1948), R. Bradield and W. J. John, Telephone and Foor Transmission (New York, 1949), J. A. Flending, Johnson and Electronics (New York, 1949), J. Frending of Telephony (New York, 1948), R. Bradield and W. J. Standield and W. J. Standield and W. J. Standield and W. L. Standield and W. ses and M. Standield and W. Standield and Wasses and M. Standield and W. Standield and Wasses and M. Standield and W. Standield and M. Standield and W. Standield and M. Stan W A Edson, Hyper and Olivahaja Prequency Engineering (New York, 1943); S A Scheklund, Electromagnetic Wares (New York, 1943); F Framan, Radio Olivaneeri, Handshoo (New York, 1943); See also Bell Telephone Quarterly, Bell System Freimad Journal, See also Bell Telephone Quarterly, Bell System Freimad Journal, Bell Laboratories Record; Electronics, Electrical Communication, Journal of the Institution of Electrical Engineer (London); Post Office Electrical Engineers Journal (London), Proceedings of the Institute of Radio Engineers, Transactions of the American Institute Initiatie of Katto Engineery, Transactions of the American Insular of Electrica Engineers (Including biblography published as part of paper entitled "Communications—Past and Present," B. Ghearaft, 1934); Published in vol. 1940; Published in vol. of America (W. S. G.) Biography (New York).

Elisha Gray and the Telephone,1-The first U.S. patent rights to a complete electrical device presumed capable of transmitting speech were granted on March 7, 1876, to Alexander Graham Bell. But at the time that patent was granted Bell had no, yet succeeded in transmitting articulate speech by means of the instrument therein described. That telephone consisted (as shown by his description and illustrations) merely of two tele-

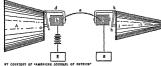


FIG 6 -TRANSMITTER (LEFT) AND RECEIVER (RIGHT) ILLUSTRATED IN BELL'S FIRST TELEPHONE PATENT, GRANTED MARCH 7, 1876

phone receivers, one designed to be used backward as a transmitter (fig. 6). The variable-resistance microphone type of transmitter, now universally used, was invented later (1877) by Emile Berliner and Thomas Edison as described below,

At one point in his patent Bell stated excellently in a single sentence the principle of the telephone as follows: "Thus when electrical undulations of different rates are simultaneously induced in the same circuit, an effect is produced exactly analogous to that occasioned in the air by the vibration of the inducing

munication during the past few years nas, however, brought this bodies" He went on to claim "The method of, and apparatus for, ideal measurably nearer to accomplishment. Present indications transmitting vocal or other sounds telegraphically as herein described

The device for transmitting such sounds which he described and illustrated in detail was the pair of telephone receivers, one of them performing the function of a transmitter It was this device to which his patent applied, not the principle upon which

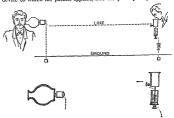


FIG 7 .- TRANSMITTER (RIGHT) AND RECEIVER (LEFT) OF GRAY'S CAVEAT, FILED THE SAME DAY AS BELL'S APPLICATION FOR A PATENT

he stated it to be based. For it is one of the fundamentals of patent law that only physical or practical embodiments of inventions are patentable, not abstract ideas, scientific principles, or phenomena of nature

Bell's application for a patent reached the patent office on Feb 14, 1876 On the same day Ehsha Gray filed what was known as a caveat, a type of document which is no longer used in patent procedure The caveat was in essence a formal notice of intent to perfect and file an application for a patent Gray's caveat, like Bell's application, described an electric telephone, fully as completely and explicitly as did Bell. Except for the pure accident of difference of procedure, the papers of Bell and Gray would have been of the same type, both applications for a patent or both caveats. The two men were on the same footing, neither having constructed, nor of course, successfully used, the instrument he was describing.

But more important than the difference in form was the difference in content of the two documents Grav's transmitter was not, like Bell's, a receiver operating in reverse. It is shown in fig. 7, enlarged in the lower right corner. To the chaphragm of Gray's transmitter was attached a rod, the lower end of which dipped in water. Vibrations of the diaphragm made by the voice of the speaker changed the immersion of the rod and thus the electrical resistance of the transmitter. The significance of this will be recognized by noting that the modern transmitter, invented in 1877 by Berliner and Edison, also utilized fluctuating electrical resistance as its principle of operation.

Bell had also briefly mentioned in passing the possibility of this type of transmitter in his own application but did not develop the idea nor even claim it as his own. Mere mention of a possible invention does not, of course, itself constitute an invention One must describe in detail, as Gray did for the liquid transmitter and as Bell did for the receiver-type transmitter, a practicable device for putting the idea into effect.

To Bell, however, goes full credit for first transmitting speech electrically in the U.S. On March 10, 1876, his assistant, Thomas A. Watson, heard over the wire Bell's now famous exclamation, "Mr. Watson, come here, I want you." The story is well known, having been retold in motion pictures and over the radio. A noteworthy point is that the transmitter which Bell used on this occasion (see fig. 8) was not the receiver-in-reverse on which his patent, granted three days before, gave him priority, but resembled very closely the liquid transmitter described and illustrated in such complete detail in Grav's caveat.

<sup>&</sup>quot;The following indicates the point of view of those who believe Eliaba Gray is entitled to share with Bell the credit for the invention of the telephone



FIG 8 --- TRANSMITTER WHICH BELL USED ON NARCH 10, 1876

by compromise out of court and the compromise given legal standing by a consent decree. In that compromise the Western Union which had purchased Gray's rights agreed to surrender these rights to the Bell company and retire from the telephone field in return for a substantial consideration. Thus the Bell company became the owners of Gray's rights during the life of the latter's patents

The Receiver -The receiver was at first the original telephone, for a single instrument, placed alternately to the mouth and the ear, was used for talking and listening. Later, two receivers constituted the telephone, either one of which could be used as transmitter and the other as receiver. Bell's first attempt to construct a receiver was made in June 1875. A reproduction of this instrument, made by Bell himself, is in the museum of the Bell laboratories in New York city. Similar receivers were previously made by Elisha Gray in 1874. He had demonstrated them before scores of competent electrical engineers and physicists in the U.S. and in England. On one of them he secured a British patent in July 1874, and a U S. patent in July 1875, 19 months and months respectively before Bell's first telephone patent of 1876. Continuous development of the receiver led to vast improvement in the naturalness of its reproduction of the voice.

The Transmitter .- Bell had a clear priority on the receiver type of transmitter, Elisha Gray had an equally clear priority on the liquid transmitter, at least in the United States. But the loosecontact microphone type of transmitter, perfected by Berliner, Edison and others listed below, had been devised, though naturally in a rather primitive form, by Philipp Reis of Germany in

having been attained with Gray's type of transmitter, he continued in his preference for the receiver type of transmitter. It was the only type which he exhibited at the Centennial exhibition in 1876, in his second telephone patent (no 186,787 of Jan 30, 1877) he resterated his preference for this type, and telephones made in 1878 by his assistant, Watson, for subscriber use (fig 9) were of this type In fact it was not until 1881 that he even disclosed his famous exploit of March 10, 1876 Up to that time he had kept it completely secret

In 1881 the so-called Dowd case was concluded This was the only occasion when the claims of Bell and Gray came into direct conflict in court It was settled

FIG. 9 .-- A TELEPHONE DESIGNED BY THOMAS A. WATSON IN 1878 FOR SUBSCRIBERS' USE. NOTE THE TWO RECEIVERS, EITHER ONE OF WHICH WAS TO BE SPOKEN INTO, THE OTHER APPLIED TO THE EAR

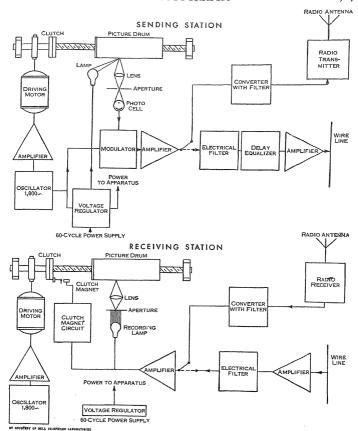
In spite of Bell's first success 1861 The fact that Reis thus transmitted speech electrically was attested by the written testimony of a dozen or more reputable men of science, who successfully participated in telephone conversations using Reis' instruments at that time In 1865 Dr Stephen Yeates of Dublin improved the performance of Reis' transmitter by causing a drop of water to adhere to the contact points while the transmitter was operating This antedated Gray's liquid transmitter and Bell's reproduction of it by more than ten years (See also Electricity; Microphone or Telephone TRANSMITTER, RADIO, SOUND; TELEGRAPH.)

BIBLIOGRAPHY —Patent 174,465, entitled "Improvements in Telegraphy," granted March 7, 1876, "Dowd Case Record," vol 1, pp published descriptions of at least three other receivers, prior to any of these four But though they performed some of the functions that the modern receiver performs, the differences in principle on not warriers are: Spathing Telephone Interferences, Ethica Gray's Case, pp. 6, 9, 10, 42, 61, 52, 63, U.S. Patent Office (1880); "Dowd Case Record, by the control of the Control of transmit speech will be found in Deutsche Industrie Zeitung, pp. 184-185 (Chemnitz, April 17, 1862), and Dingler's Polytechnisches Je to Custimute April 17, 1997, and Imperer Folyscensises closing, the Constitution of the Constitution of the Constitution of the Constitution of the German Austrian Telegraph Association, vol 5-9, pp. 5, 55, 56 (1630) Des Neue Buck der Erfridungen, vol. 2, 9, pp. (1872), Pikko, Der Neuers Apparate der Aksatik, pp. 94 ff. (1865), Court DiMoncel, The Eleghone, The Mitrophone and The Florida. graph, p 59 (1879).

TELEPHOTOGRAPHY, the electrical transmission of pictures, a branch of telegraphy sometimes called facsimile, dates back to Alexander Bain, who, in a British patent in 1843 outlined the principles involved. Workers in this field have included Arthur Korn in Germany, Edouard Belin in France and many others In the United States, Bell system engineers in the 1020s and 1930s made important advances in the machines and methods for transmitting pictures over telephone circuits. Work after 1935 by various groups in the U.S. led to machines of compact form with electrical features permitting satisfactory operation over long radio paths

The basic idea is to scan or examine an original picture, one elemental area after another, represent the shade or tone of each area by an electric current, and reproduce at the receiver each such area in its proper relative position. Modern machines scan the original by optical methods. Light reflected from the surface of an illuminated spot or elemental area enters a light-sensitive device, known as a photoelectric cell, which produces an electric current having a value proportional to the intensity of the light The original picture is moved at a uniform rate of speed and in a manner to be completely examined by the scanning light. As this light moves over the different portions of the picture, a current of varying value but of the same polarity is produced by the photoelectric cell. This is later converted into an alternating current of a character suitable for transmission over wire circuits or by radio.

Receivers of great variety have been devised. In one form the received currents cause a stylus or marking point to strike the record medium, such as moving paper, and make permanent marks. Other machines depend on the chemical or heating effects of electric currents and with these a stylus is always in contact with the surface on which the image is being recorded. Still other receivers employ photographic methods and the incoming electric current controls the intensity of a beam of light falling on moving sensitive film or paper. The first two methods have been



TELEPHOTOGRAPH OR ELECTRICAL FACSIMILE SYSTEM SCHEMATIC OF ARRANGEMENTS FOR SENDING AND RECEIVING

ments, and the received record is sometimes referred to as a black and white picture. In the third case the original may be a photograph having many tone values and the receiver produces the various shades of the original to give a record suitable for

reproduction in newspapers by the usual half-tone process A modern system is illustrated in schematic form in the figure. The original picture or record is wrapped around a drum at the sending station. This is usually rotated at a speed of about 100 revolutions per minute. It is moved along its axis under the scanning light by a nut engaging a lead screw having a patch about 100 threads per inch. The original is therefore scanned at the rate of 100 lines per inch using a lens and an aperture which serve to focus the reflected light from an area about one one hundredth of an inch across onto the photoelectric cell. Thus, each square inch of the picture may be considered as being divided into 10,000 elemental areas. As shown, the currents generated in the photoelectric cell vary or modulate the intensity of an alternating current produced by an electric oscillator having a normal frequency of about 1.8co cycles per second. As indicated it is amplified and, if the picture is to be transmitted over a long wire line, is passed through an electrical filter and a delay equalizer to put it into the best form for transmission over a circuit of this type. If, on the other hand, the picture is to be transmitted over a radio link, the alternating current of varying magnitude is passed through an electronic device called a converter, which changes it to an alternating current of varying frequency but of constant magnitude

The receiving station is provided with a drum and mechanism similar to that at the sending station. A sensitized film or paper is wrapped on the drum which is rotated at the same speed as the sending drum and in the proper phase, that is, the joining edges of the original as wrapped on the sending drum pass the scanning spot at practically the same instant that similar edges of the record film or paper wrapped on the receiving drum pass under the recording stylus or light beam When pictures are received over wire circuits the currents are amplified, passed through a filter to select the proper frequencies, and to a recording lamp of spetial design which emits light in proportion to the intensity of the exciting current This light, as the drum rotates and moves along its axis, completely exposes the recording film or paper. When the picture is received over a radio link, the picture current passes through a converter which changes the current of varying frequency to a current of varying magnitude to control the intensity of the recording lamp as was done for wire circuits. A special circuit for the control of a clutch magnet permits the receiving drum to be started in step or properly phased with the sending drum.

A frequently used picture size is 7 in, x II in. Pictures as large as 12 in, x 171 in. are sometimes handled. A common transmitting speed is 11 sq.in per minute or about 1,800 picture elements per second. For this speed of operation an electrical circuit capable of transmitting a band or group of frequencies at least 1,000 cycles wide is required. A wider band may be required for some transmission methods.

It is common practice to send from one original to a number of receiving stations, and machines which rotate at the same speed and cover the same picture area in a given time will work together though the received picture actually differs in size from the original. For simplification, machines are sometimes designed to be used either as senders or receivers

The distribution by telephotography of pictures of news value has now become an important service rendered by press associations to newspapers and others, and thousands of pictures are transmitted by this method each year. In the U.S. a nation-wide private wire network has been established exclusively for this purpose. Other private wire networks are used alternately for telephony or telephotography. News pictures are also frequently transmitted over ordinary telephone connections.

World War II emphasized the importance of the transmission of pictures by radio. Difficulties usually experienced in radio transmission have been overcome to a large degree by using the

used for transmitting line drawings, sketches and written docu- form of frequency modulation or frequency shift described above and shown in the figure

Many special arrangements and mechanisms have been devised by telegraph engineers for handling ordinary telegrams by fac-simile or telephotograph methods. These usually employ a form of record paper known as "teledeltos," in which the mark or impression results from an electric current passed through this paper from a stylus. (See also Photography; Telephone; Tele-(R. D. P.)

TELESCOPE, an optical instrument employed to view dis-

tant objects (Gr τήλε, far, σκοπείν, to see).

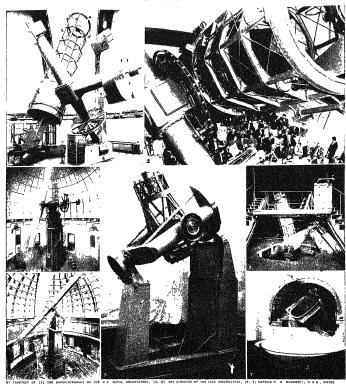
Early History.-The telescope was invented in Holland about 1608. The credit has been attributed variously to three individuals, Hans Lippershey and Zacharias Jansen, spectacle makers in Middelburg, and James Metius of Alkmaar (brother of Adrian Metius, the mathematician). The common story is that Lipper-shey, happening one day while holding a spectacle lens in either hand, to direct them toward the steeple of a neighbouring church, was astonished on looking through the nearer lens to find that the weathercock appeared nearer. Accordingly he fitted the lenses in a tube to preserve their relative distance and thus constructed the first telescone

Telescopes were made in considerable numbers and found their way over Europe soon after their invention. Galileo states that, happening to be in Venice about May 1609, he heard that a Belgian had invented a perspective instrument for making objects appear nearer and larger. The day after his return to Padua he made his first telescope by fitting a convex lens in one end of a leaden tube and a concave lens in the other end. A few days afterward, having succeeded in making a better telescope, he took it to Venice, where he communicated the details to the public, and presented the instrument itself to the doge Leonardo Donato The senate, in return, settled him for life in his lectureship at Padua and doubled his salary, which was previously 500 florins. Galileo devoted much of his time to improving the telescope. He conquered the difficulties of grinding and polishing the lenses, and soon succeeded in producing telescopes of greatly increased power. His first telescope magnified three diameters; he soon made instruments magnifying 8 diameters, and finally one magnifying 33 diameters.

With this last instrument Galileo discovered in 1610 the satellites of Jupiter, and soon afterward the spots on the sun, the phases of Venus, and the hills and valleys on the moon He demonstrated the revolution of the satellites of Jupiter round the planet, and gave rough predictions of their configurations, proved the rotation of the sun on its axis, established the general truth of the Copernican system as compared with that of Ptolemy, and fairly routed the fanciful dogmas of the philosophers These brilliant achievements, together with the immense improvement of the instrument under the hands of Galileo, overshadowed in a great degree the credit due to the original discoverer, and led to the universal adoption of the name of Galilean telescope for the

form of instrument invented by Lippershey.

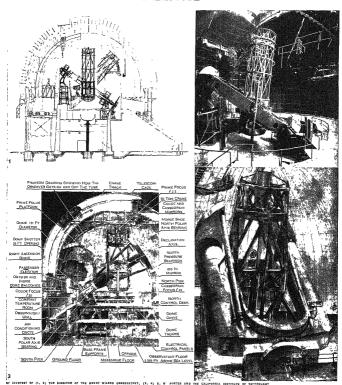
In the Galilean telescope the object glass is a convex lens and the eyepiece concave. Johann Kepler was the first to explain the theory and some of the practical advantages of a convex eyepiece in his Catoptrics (1611). The first person who actually constructed a telescope of this form was the Jesuit, Christoph Scheiner, who gives a description of it in his Rosa Ursina (1630). William Gascoigne pointed out one great advantage of the form of telescope suggested by Kepler, viz, the visibility of the image of a distant object simultaneously with that of a small material object placed in the common focus of the two lenses. This led to his invention of the micrometer and his application of telescopic sights to astronomical instruments of precision. It was not till about the middle of the 17th century, however, that Kepler's telescope came into general use, and then, not so much because of the advantages pointed out by Gascoigne, but because its field of view was much larger than that of the Galilean telescope. The first powerful telescopes of this construction were made by Christiaan Huygens, after much labour, assisted by his brother. With one of these, of 12 ft, focal length, he discovered the brightest of Saturn's



BY COURTESY OF (3) THE SUPERINTEN

# TELESCOPES IN LARGE OBSERVATORIES

- Deminion Astrophysical Seberators, Vitefaria, B.C. Relikuling telescope models of the control Conference of C
- 5 A 1/20th seals model of the 200-in, selecces is process of starmily for an experiment of the control of th



THE WORLD'S TWO LARGEST TELESCOPES

- Lectional drawing of 100-in. Islambop, doms and building, Mount Witton observatory, Calif. This shows observing positions and platforms, optical combinations and electric elevator for removing mirror for symmistic standard combinations and electric elevator for removing mirror for symmistic symmistic standard combinations. The symmistic standard combination of the symmistic symm

- Calif The drawing shows the telecope cut away along a vertical plane through the pairs alie, and as It appears to the observer, with explanatory notes giving esteads and the property of The tube weight about 140 tents, the entire instrument 500 tons and the rotating domes 1,000 tons.

satellites (Titan) in 1655, and in 1659 he published his Systema originally educated for the church, Short attracted the attention Saturnsum, in which was given for the first time a true explanation of Saturn's ring, founded on observations made with the same instrument.

The sharpness of image in Kepler's telescope is very inferior to that of the Galilean instrument, so that when a high magnifying power is required it becomes essential to increase the focal length. G D Cassini discovered Saturn's fifth satellite (Rhea) in 1672 with a telescope of 35 ft. and the third and fourth satellites in 1684 with telescopes made by Campani of 100 and 136 ft focal length Huygens states that he and his brother made object glasses of 170 and 210 ft focal length, and he presented one of 123 ft. to the Royal Society of London Adrien Augout (d. 1691) and others are said to have made telescopes of from 300 to 600 ft focus, but it does not appear that they were ever able to use them in practical observations. James Bradley, on Dec. 27, 1722, measured the diameter of Venus with a telescope whose object glass had a focal length of 2121 feet. In these very long telescopes no tube was employed. They were termed aerial telescopes

Reflecting Telescopes .- It was not until the middle of the 18th century that these unwieldy instruments were supplanted by the achromatic telescope. Meanwhile the refracting type of telescope had a rival in the reflecting telescope invented by Sir Isaac Newton. It was, in fact, Newton who discovered what was the trouble with the refractor, which led to the need for excessive length. It had been supposed that the only imperfection in the image arose from the error known as spherical aberration, and the efforts of opticians were concentrated on devising lenses of suitable forms of curvature to correct this. In 1666 Newton discovered the different refrangibility of light of different colours, and he soon perceived that the fault of the refracting telescope was that the light of different colours followed different paths. so that if, for example, the telescope was focused sharply for blue light-the green image would be altogether out of focus and blurred He over-hastily concluded from rough experiments (Optics, bk. 1, pt. ii, prop. 3) "that all refracting substances diverge the prismatic colours in a constant proportion to their mean refraction." If this were true no combination of refracting substances could bend the path of the light without introducing colour, and therefore no improvement could be expected in the refracting telescope. He therefore turned his attention to the construction of reflectors. The form now known as the Gregorian reflector had been proposed by James Gregory in 1663; but he had not succeeded in constructing the instrument practically.

Newton, after much experiment, selected an alloy of tin and copper for his specula, and he devised means for grinding and polishing them. He did not attempt the formation of a parabolic figure on account of the probable mechanical difficulties, and he had besides satisfied himself that the chromatic and not the spherical aberration formed the chief fault of previous telescopes. Newton's first telescope so far realized his expectations that he could see with its aid the satellites of Jupiter and the horns of Venus. Encouraged by this success, he made a second telescope of 61 in. focal length, with a magnifying power of 38 diameters, which he presented to the Royal Society in Dec. 1671. A third form of reflecting telescope was devised in 1672 by Cassegrain. No further practical advance appears to have been made in the design or construction of the instrument till the year 1723, when John Hadley (best known as the inventor of the sextant) presented to the Royal Society a reflecting telescope of the Newtonian construction, with a metallic speculum of 6 in. aperture and 62s in. focal length, having eyepieces magnifying up to 230 diameters. The instrument was examined by Pound and Bradley, the former of whom reported upon it in Phil. Trans., 1723

Bradley and Molyneux, having been instructed by Hadley in his methods of polishing specula, succeeded in producing some telescopes of considerable power, one of which had a focal length of 8 ft.; and, Molyneux having communicated these methods to Scarlet and Hearn, two London opticians, the manufacture of telescopes as a matter of business was commenced by them. However, it was reserved for James Short of Edinburgh to give practical effect to Gregory's original idea. Born at Edinburgh in 1710 and of Colin Maclaurin, professor of mathematics at the university, who permitted him about 1732 to make use of his rooms in the college buildings for experiments in the construction of telescopes In Short's first telescopes the specula were of glass, as suggested by Gregory, but he afterward used metallic specula only, and succeeded in giving to them true parabolic and elliptic figures.

Achromatic Telescopes .- The historical sequence of events now brings us to the discovery of the achromatic telescope The first person who succeeded in making achromatic refracting telescopes seems to have been Chester Moor Hall, a gentleman of Essex. He argued that the different humours of the human eye so refract rays of light as to produce an image on the retina which is free from colour, and he reasonably concluded that it might be possible to produce a like result by combining lenses composed of different refracting media. After devoting some time to the inquiry he found that by combining lenses formed of different kinds of glass the effect of the unequal refrangibility of light was corrected, and in 1733 he succeeded in constructing telescopes which exhibited objects free from colour

The principal development of the achromatic refractor is due to John Dollond who invented it independently (Phil Trans, 1758) In principle his object glasses were of the pattern mainly used at the present day; viz , convex lens of crown glass combined with a concave lens of flint glass The concave lens is of less power than the convex so that the combination converges the light as a single convex lens would do; but the flint glass having much wider difference of refractive index for light of different colours, is able to correct the colour dispersion introduced by the more powerful crown lens. A triple objective, consisting of two convex lenses of crown glass with a concave lens of flint glass between them, was introduced in 1765 by Peter, son of John Dollond. This type is also employed in some modern telescopes.

The difficulty of making large disks of glass of the required transparency and homogeneity limited the aperture that was obtainable. The reflecting telescope was brought back into favour by William Herschel, who greatly developed the art of making mirrors of speculum metal. This is a hard brittle alloy of copper and tin, containing about one part (by weight) of tin to two of copper. It is difficult to cast and anneal, but will take a high degree of polish and has a moderately high reflecting power, which drops from about 70% in the red to 50% in the violet. Herschel's telescopes were much in demand for they were of better quality than any previously made. His two most famous telescopes were the 20-ft. telescope of 19-in. aperture, and the great 40-ft. telescope of 48-in. aperture He discovered the planet Uranus in 1781 with a 7-in, reflector, which enabled him to detect that its image, unlike the point image of a star, had a perceptible disk, Uranus had been observed with other telescopes on many previous occasions and taken to be a star In 1845 Lord Rosse erected the Parsonstown reflector of 6-ft. aperture; this was made possible by his great improvements in the technique of casting specula No larger speculum mirror has been made. With this instrument the spiral structure of the spiral nebulae was discovered.

The refracting telescope was brought back into favour in the first quarter of the 19th century after Joseph von Fraunhofer, who had learned from the younger Guinand how to make glass, succeeded in casting several disks of glass of excellent quality and in making lenses from them, computing the curves himself. The desire for greater and greater light-gathering power led to the construction of lenses of larger and larger aperture, culminating in the 40-in, refractor of the Yerkes observatory. Disks of ontical glass of so great a size, free from strains, striations, veins, bubbles and other troublesome defects are extremely difficult to cast and anneal. To keep aberrations small, the focal length must be great (that of the Yerkes refractor is 62 ft.), making the telescope unwieldy in use and requiring a large dome to house it. A practical limitation on size is moreover imposed by the impossibility of eliminating flexure from the lens, which must necessarily be supported only at the rim.

For instruments of larger aperture, the astronomer has perforce been compelled to revert to the reflecting telescope. The de-

velopment of the silver-on-glass mirror has avoided the difficulties inherent in the use of speculum metal. The discovery of a simple chemical process by which a thin film of silver could be deposited on a glass surface was due to Justus von Liebig; the application of this discovery to glass mirrors and the methods of making and testing such mirrors were due primarily to Jean Foucault in the 1860s The glass disk must be subjected to a long process of annealing in order to relieve all internal strains, but defects such as bubbles, veins or poor transparency are immaterial as the light does not pass through the disk. The disk is first ground and polished to a spherical shape, it is then converted into a paraboloid by the progressive reduction in the radius of curvature from the edge to the centre. The paraboloidal mirror is free from the spherical aberration of a spherical mirror The amount of material to be removed in the parabolizing is extremely small and tests are necessary after each spell of figuring, the mirror being allowed to acquire a uniform temperature before a test is made

The largest disk which has been successfully cast is of 200-in. diameter for the great reflector mounted at the top of Mt Palomar in California. This disk was made of a special pyrex glass with very high silica content and low coefficient of expansion. It was annealed for ten months; if it had been made of ordinary plate glass the annealing would have had to be extended over nine years. The low coefficient of expansion of the pyrex glass is an advantage when using the telescope, as the position of the focus does not change so much with change of temperature as with a mirror made of plate glass.

A freshly prepared silver film has a high reflectivity exceeding 90% throughout the visible spectrum. But on the short wave length side of 4.500 angstroms, the reflectivity falls at first slowly and then rapidly to a minimum value at 3,200 angstroms, at which wave length the film is practically transparent. The film tarnishes easily, with decrease in its reflecting power, but it can be readily replaced by direct deposition from a suitable chemical solution, which is poured into a bath formed by the mirror itself and a suitable edge band,

A process has been developed for coating glass mirrors with a film of aluminum by a vacuum distillation process. On exposure to the air the aluminum film rapidly oxidizes, giving a hard and fairly durable reflecting layer. The reflectivity of the aluminum film is nearly as high as that of a freshly deposited silver film and is free from the large fall in reflectivity in the ultra-violet of the silver film. The aluminized mirror has proved specially valuable in the investigation of celestial spectra in the ultra-violet region

The large mirror is supported at the back by a complicated series of counterpoised levers; by proper design, deformation of the mirror by flexure can be entirely avoided. The size of reflectors appears to be limited only by consideration of the expense, not only of making the mirror, but of providing a mount for its practical use. The expense increases, roughly speaking, proportionally to the cube of the aperture.

Introductory remarks on the general use of astronomical telescopes will be found under Astronomy: Practical Astronomy.

### THEORY OF THE TELESCOPE

It is important to realize that magnifying power is not the only quality, perhaps not even the chief quality, desired in a telescope. We have to pay attention to: (1) magnifying power; (2) resolving power; (3) light-grasp; (4) a wide field of good definition; and (5) suitability for making accurate measurement. Not all of these can be developed to perfection in the same instrument, and accordingly telescopes of different design are employed for different purposes. For example, the ordinary field glass is useless for viewing the stage in a theatre; and accordingly an opera glass is employed which gives a more brilliant though smaller image.

In general, resolving power and magnifying power go together, It is little use making the object appear larger if we do not at the same time sharpen the image so that greater detail may appear. We might be content to increase the resolving power (ie., sharpen the detail in the image) without magnification if that were possible; but optical laws forbid an increase of resolving power without a corresponding increase of magnification. The magnifying power of a telescope can be understood by reference to the theory of geometrical optics alone, to explain the increase of resolving power, reference must be made to physical optics (the wave theory of light) Light does not consist of strictly linear 1ays, but of a wave disturbance which tends to spread and blur any image that is being formed; this tendency to spread is not cured by any perfecting of the figures of the lenses and mirrors, but only by increasing the aperture so that a wider area of wave front is taken in and concentrated into the eye pupil The resolving power of a telescope (free from ordinary optical defects) is simply proportioned to the diameter of aperture of the object glass or mirror. But in order that the beam filling the object glass may be narrowed down on emergence from the telescope so as to enter the eye, the magnifying power must be not less than the ratio of the aperture of the telescope to the aperture of the eye pupil; if lower power is used an outer ring of the object glass is left unused so that its effective

aperture and resolving power are reduced. Refracting Telescopes,-In its simplest form the telescope consists of a convex lens (object glass) which forms an image of a distant object at its focus. This ing course of RAYS image is then magnified by another small when the eye lens is lens (eyepiece) which is used just as an CONVEX (OR POSITIVE) ordinary magnifying glass is used The



object glass is of long focus F, and the eyepiece of short focus f, and the ratio F:f is equal to the magnifying power of the telescope Since eyepieces are inexpensive it is usual to provide a number of them, so that different magnifying powers can be used, it may be noted that the smallest eyepieces have the highest power

The combination just described is Kepler's form of telescope The course of the rays is shown in fig. r. In Galileo's form the eye lens is concave (or negative), and is placed so as to intercept

the rays from the object glass before they reach the focus (fig. 2). This form gives an erect image, whereas in Kepler's telescope objects are seen upside down unless a second erecting eyepiece or prisms are added. In stellar observation we do not Fig 2,-- DIAGRAM SHOW much mind the inversion of the image and Kepler's form is always preferred.



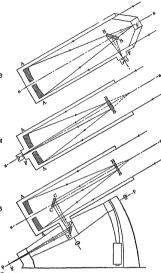
ING COURSE OF RAYS WHEN THE EYE LENS IS CONCAVE (OR NEGATIVE)

In all modern instruments both the evepiece and object glass are compound, consisting of at least two lenses. A single eye lens would generally give good enough definition at the centre of the field of view, but all the outer parts would be out of focus. Two well-known types of double eyepiece, the Huygens and the Ramsden, give a large flat field of view. The construction of eyepieces for the telescope and for the microscope is essentially the same problem. (See MICROSCOPE.) The use of two lenses in the object glass is necessary in order to correct the defect of colour dispersion already mentioned. In spite of improvements in the manufacture of optical glass, practically the same crown and flint glasses as those used by John Dollond in 1758 are employed in the largest modern telescopes. As a result of what is termed "irrationality of dispersion" no combination of crown and flint lenses will completely get rid of colour dispersion Accordingly in practice the achromatism is made as perfect as possible for the part of the spectrum that will chiefly be employed, viz., near the yellow light for visual work, and in the blue and ultra-violet for photographic work. For this reason separate telescopes are used for visual and photographic work

By using three lenses to form the object glass photovisual telescopes can be made sufficiently achromatic for all parts of the spectrum. The additional surfaces and thickness of glass, however, involve some loss of light; and the combination has the great drawback that its focal length changes very rapidly when the temperature drops at nightfall

Reflecting Telescopes .- The following are the various forms of reflecting telescopes:

The prime focus telescope is represented in fig. 3. This is the most efficient arrangement since the parabolic concave mirror AA focuses the light to a point on the axis as without the introduction of additional optical surfaces. Although the prime focus telescope came into prominence through the zoom. telescope, where the observer indes in a small cage suspended rigidly in the centre of the tube at the focus, this arrangement has also been used with smaller telescopes for direct photography when maximum efficiency is tequired.



FIGS 3-5 -- (3) PRIME FOCUS AND NEWTONIAN TELESCOPE (4) CAS-SEGRAIN TELESCOPE, (5) COUDE TELESCOPE

The Newtonian telescope is also represented in fig. 3. The only difference from the prime focus arrangement is that a flat mirror is used to bring the focus outside the telescope tube. The advantage of this form is that the focus F is readily reached by an observer located on a platform separate from the telescope.

The Cassegrain telescope is represented in fig. 4. The convex hyperbolic mirror BB which has a common axis with the concave parabolic mirror AB decreases the convergence of the rays from Ab Durnign the light to a focus at F behind the mirror AA. Since the effective focal length is the distance from F to the point where the rays ropiceted backward from F to BB extend and intersect the parallel incident rays, the focal length can be made much longer than the natural focal length of mirror AA.

The Gregorian telescope differs from the Cassegrain only in that the hyperbolic secondary mirror is replaced by a concave elliptical mirror placed on the opposite side of the prime focus point of mirror AA from where the Cassegrain mirror is placed. Although the Gregorian telescope was hastorically important, practical dificulties in making the elliptical mirror have caused this form to be abandoned in modern instruments in favour of the Cassegrain.

The Coudé telescope, represented in fig 5, has the advantage that the focus is brought completely outside the telescope. This is frequently accomplished by two flat mirrors, although one to three flat mirrors are employed on some forms of the Coudé arrangement As shown in fig 5, two flat mirrors CC and DD reflect the converging beam in such a manner that the focus is located at the base of the polar axis pp The convex hyperbolic mirror BB is similar to the Cassegrain form except that it is more convex and is located nearer to the prime focus point which causes the rays to come to a focus much farther from mirror BB. Since the focus remains at a fixed point regardless of the direction that the telescope is pointed, it becomes possible to use instruments to analyze the light that otherwise would be prohibitively heavy or exceedingly sensitive to the changing gravitational flexure experienced at the other focal positions. Since some light is lost at each mirror reflection, this system is less efficient, however, the advantages of the fixed focus often make this arrangement the most desirable A large fraction of modern astrophysical studies are made with this telescope arrangement.

Most modern reflectors are made so that they can be used alternatively in the Cassegrain, Newtonian or Could form by insetting alternatives small mirrors. But when used in the Cassegrain mane, different convex mirrors can be employed, giving different equivalent focal lengths. The mirror usually has an aperture star of about 9.5 Thus, for instance, a reflector of 5-ft. aperture may have a focal length of 25 ft. when observations are made at the primary or Newtonan focus. It may also be used as a Cassegrain for direct photography or for spectroscopic observations at a secondary focus near the lower end of the tube, with an equivalent focal length of 7.5 ft. The equivalent focal length of the Coulds arrangement may be 200 ft.

Photography.--When a photograph is to be taken the eyepiece is removed and the photographic plate is placed in the focal plane of the object glass or mirror. It is not a question of adding a camera to a telescope, but of turning the telescope into a camera, the main lens or mirror of the telescope acting as the lens of the camera In visual observation it is no great drawback if the definition falls off in quality toward the outside of the field of view, because the observer cannot pay minute attention to more than one object at a time; but in astronomical photography it may be a great advantage to have objectives giving good definition over a wide field many degrees in diameter This makes severe demands on the skill of the designer in correcting the various aberrations of the lens system, which usually increase rapidly with the distance from the centre of the field of view In general, a doublet, consisting of two similar pairs of lenses separated by a wide interval, is employed. The problem of constructing these wide-angle lenses is essentially the same as that of constructing a good camera lens for terrestrial photography (where a wide field is also necessary); and indeed a good portrait lens can be usefully employed in celestial photography. The fact that the whole instrument is of insignificant size is irrelevant when speed and not magnification is the main essential As is well known in terrestrial photography the speed depends on the ratio of the aperture to focal length, and not on the absolute dimensions of either; and this ratio can be made greater in a doublet than in an ordinary refractor or reflector.

Mounting.—In order that a telescope can be pointed to any desired point in the sky, it must be provided with two independent motions. The mounting of the early telescopes was of the altraimuth type, in which the telescope could be moved in altitude or in azimuth. In Sir Frederick Heischel's large instruments, for example, the telescope was suspended between two wooden faminevorks and missed or lowered in altitude by means of ropes and pulleys; the whole of the mounting was capable of being turned in azimuth. The disadvantage of this type of mounting is that to "follow" as air in its diurual motion across the sky the telescope must be continually moved both in altitude and in azimuth. The equatorial type of mounting, now universally used for large instruments, was introduced early in the 19th century; the main axis of the mounting is adjusted to be parallel to the axis of the earth and the telescope can be turned both about this axis, called the polar sais, and about a perpendicular axis, called the declination axis. When the telescope set upon a star, a uniform rotation of the polar axis at the rate of one revolution per sidercal day is all that is necessary to keep the star stationary in the field of view. The uniform continuous rotation can be given by clockwork controlled by a governor or some other ap-

be given by deckwork controlled by a governor or some other ap-propriate means or, more simply, where an alternating current supply of properly regulated frequency is available, by synchronous motor the property of the second of the property of the property of the tree difference from at the equational mountain grain to the tree difference from a difference of the property of the property to property of the property of the property of the property of the telescope being curred on a glout cross aux, mounted in this cadel the telescope being curred on a glout cross aux, mounted in this cadel of this type. In the second form of mounting, known as the German mounting, the polar axis is also supported at each end but the telescope is a mounted at the side of the polar axis on the dedunction has and of the property of the p

The English mounting is to be preserved not large newly instruments, because the bearings do not have to carry the additional load of a massive counterpose, and both ends of the polar axis are supported. The disadvantage is that a portion of the sky around the north pole cannot be observed. For the mounting of the great zool- nelecope, this disadvantage was avoided by making the upper bearing of the polar axis in the form of a gigantic househoe, 46 ft in diameter, enabling the telescope to be pointed enterly to the north pole.

Relative Advantages of Refractors and Reflectors.-Each type of instrument has some advantages not possessed by the other, and they are really complementary to one another in their uses. There are practical limitations to the aperture of a refractor, and for a given practical limitations to the aperture of a refractor, and for a given aperture the refractor is not so compact as the reflector because of its much greater ratio of focal length to aperture. The refractor is ideal for astrometric purposes, where precise measurements of position are required, its focus is less liable to change with changes of temperature than is that of a reflector With a refractor, a larger flat field of good definition can be obtained than with a reflector

The reflector has the advantage of compactness so that for a given The erhector has the avoyantage of compactness 80 that for a given appriare a much smaller dome is required. It is also more versatile appriare a much smaller dome is required. It is also more versatile by using different Casseguin mirrors. For all purposes where great light-taghtering power is required the reflector is ideal. It is also much more suitable for the observation (either visually or by photography) of funct extended objects, such as fann rebulke, for which a small ratio of lating extended objects, such as family nebulate, for work on a small rando of local length to appeture is required. Being perfectly achronatic, it work. It has the disadvantage that the images at a small distance from the axis suffer from the optical defect called comas, so that it gives only a small field of good definition; for this reason, and because of the changes of focal length with temperature, it is not to be recommended. for precise astrometric work

Composite Telescopes.-The previously described reflecting telescopes have all possessed a concave parabolic mirror that can produce a sharp focus in the absence of other lenses or mirrors. In order to avoid the natural aberrations of these systems, several new types of telescope were invented to greatly reduce or eliminate these disadvantages. In composite systems the mirror is unable to produce a good focus when used without the other elements. There are several im-

portant types

The Schmidt telescope, developed in 1931, uses a spherical mirror AA (refers to the general position of the milior shown in figs. 3-5) and a weak lens having a cross section as shown in exaggerated for and a weak mas daving a cross section as snown in exaggerated form in § 6. Since the mirror As is sphereal the prime focus image is blurred by spherical aberration. The corrector SS produces small deviations to the unceful light rays of an amount to exactly offset the spherical aberration of the mirror AA. To yield high definition over a wide field of view the corrector SS is ulways placed, a distance above the prime focus as the numror AA is below, which requires a telescope twice as long as the foral length of the mirror AA.

The Richey-Cretien and Schwartsschild telescopes are generally similar to the Cassegrain except that the mirrors are neither conic

sections nor spheres.

sections nor spheres.

The Maksutov telescope, developed in 1944, is basically similar to
the Schmidt telescope except that the aspheric thin lens is replaced by
a deep concave spherical meniscus lens that performs the same function
as the Schmidt corrector lens.

Although the focal surface is curved for most of the composite telescopes go that it is necessary to use film or thin glass plates bent to the proper curvature, these telescopes can be made with great optical speed and wide field of view, making them of great usefulness for photography of faint objects.

The 200-in. Telescope. The following are some details of the 200-in. telescope, the largest telescope ever constructed at the time of its

The telescope tube is in the form of a rigid hollow square centre section, with a strong rigid ring at each end. Each ring is attached to the central section by eight stiff 20-in diagonal I beams. The lower ring carries the mirro; and cell, weighing 30 tons. The mirror cell is

a cylindical box of welded steel, strongly braced, nearly 20 ft in dameter and weighing 10 tons. The upper cage carries a cylindrical housing, in which the auxiliary parrors are mounted, 22 ft in diameter and 12 ft high. The tube, excluding the nurror cell and upper cage, and 12 ft high. The tube, excluding the nurror cell and upper cage, in the upper cage can rapidly be brought into position for use by remote electrical control, the murrors which are not in use are swing back against the walls of the enclosing cylinder. The telescope can be dead at the punnary focus, with focal ratio 3; and focal length styling the companion of the companion o

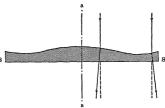


FIG. 6 .- ELAGGERATED CROSS SECTION OF A SCHMIDT CORRECTING LENS

of 267 ft; or in the coudé form, with focal ratio 30 and equivalent focal length of 500 ft. The observer, when making observations, is focal length of 500 ft carried on the telescope

focal length of 500 ft. The observer, when making observations, a scried on the telescope in the form of a horselon, 46 ft in diameter and 4 ft thick. At the throat it at 2 ft wide, topering to nothing at the ends. It has a complicated system of internal bracing to give the necessary suffices and weight 170 tons. The thrust bearing at the lower necessary suffices and weight 170 tons. The thrust bearing at the lower necessary suffices and the property of the control of the system of the control of the system of the control of the system of the control of the system of the control of the system of the control of the system of the control of the system of the control of the system of the control of the system of the control of the system of the control of the system of the control of the contr

The thatming of mousing the content per and outbook waits with a factor and the content of the c The outer covering is formed of steel plates of 4-in thickness, each weighing one ton, pressed into the correct spherreal curvature and steeping the control of the correct spherreal curvature and steeping. An inner plating of aluminum panels is fitted, leaving a steeping. An inner plating of aluminum panels is fitted, leaving a steeping. An inner plating is pumped out from the dome and the double walls of the building is pumped out from the top of the dome and the double walls of the building is pumped out from the top of the dimension of the control of the double walls of the do

dimeter and 15 ft. high forms of telecoper (other than equitorial) BILLIOGRAFIVE—Shedda Charles and Exertifications—So who Obsassavione, where Illustrations are given For a survey of the technical details of construction of telescopes and general instrumental equipment of a large observatory, see Gall, History and Description of Vorte, 1929. J. Dampon and A Conder, Lunettes of Telescopes (Shalledphia, 95) G. Dimitorif and J Baker, Telescopes and Accessories (Philadelphia, 1945; London, 1949). (D. G., A. S. E. H. S. 13, A. B. ML.)

TELESTLLA, Greek poetess, a native of Argos, one of the so-called nine lyric muses According to the traditional story, when Cleomenes, king of Sparta, invaded the land of the Argives in 370 ac, and siew all the males capable of bearing arms, Telessila, dressed in mer's clothes, put herself at the head of the women and repelled an attack upon the city of Argos. Of Telessila's poems only two lines remain, quoted by Hephaston, apparently from a Parthenion, or song for a chorus of maidens. Ser Pausiphas it, oa, 8, Plutarch, De Virtus, Multes um, 8, Clement of Alexandra Stromdai, tv, 10, p 531; Beigh, Poetae Lyrici Graeci, un; and especially Macan, Herodein ur-out, 13, 62 et seq. and notes.

TELESIO, BERNARDINO (1586-1588). Italian philosopher and natural scenetist, was born of noble parentage at Cosenza near Naples in 1508. After studying at Milan, Rome and Padus, he be against actack upon the study and Aristoclelanism which are the study of the study

Telesio was the head of the great south Italian movement which protested against the accepted authority of abstract reason, and sowed the seeds from which sprang the scientific methods of Tommaso Campanella and Giordano Bruno, of Sır Francis Bacon and René Descartes. He proposed an inquiry into the data given by the senses, from which he held that all true knowledge comes. Instead of postulating matter and form, he based existence on matter and force. This force has two opposing elements heat, which expands, and cold, which contracts These two processes account for all the diverse forms and types of existence, while the mass on which the force operates remains the same. The harmony of the whole consists in this, that each separate thing develops in and for itself in accordance with its own nature while at the same time its motion benefits the rest. The obvious defects of this theory. (1) that the senses alone cannot apprehend matter itself, (2) that it is not clear how the multiplicity of phenomena could result from these two forces; and (3) that he adduced no evidence to substantiate the existence of these two forces, were pointed out at the time by his pupil, Francesco Patrizzi His system is a forerunner of all subsequent empiricism, and marks the period of transition from authority and reason to experiment and individual responsibility. Besides the De Rerum Natura, he wrote De Somno, De his quae in aere fiunt, De Mars, De Cometis et Circulo Lacteo, De usu respirationis, etc.

TELESPHORUS, bishop of Rome from about 126 until about 137 St Itenaeus says that he suffered martyldom.

TELETYPESETTER is a name designating a group of devices for automatically operating slug line casting machines by means of code-perforated tape. The two principal units are (1) the perforator, having a keybaard similar to that of a typewriter, which is used to prepare code-perforated tape; and (2) the operating unit, which use this tape to operate automatically a slug line casting machine. Copy to be set in type is transcribed by the teletypesetier perforator operator into code-perforated tape. The code perforations in this tape provide all of the necessary controls for operating the keyboard of the line casting machine to select the matrices for composing the slugs and also for operating the elevator and controlling the duplex rail, simulating manual operation of the composing machine keyboard.

The operating unit, which is applied to slug line casting machines of Intertype, Linotype, or Linograph manufacture, manipulates the keys of the line casting machine keyboard under the control of the code-perforated tape prepared on the keyboard perforator. By the use of the teletypesetter operating unit controlled by tape, the output of the composing machine is increased over manual operation 50% to 100%, since the tape is fed automatically through the operating unit and the line casting machine is kept in continuous operation. The only attention required by the line casting machine is that slugs must be removed, and when the roll of tape is schasated a new one must be inserted.

Operation over Wires .- By the use of teletype printing tele-

graph apparatus, teletypesetter tape can be prepared at one point and transmitted over wires to be reproduced at any number of points, at any distance. The teletypesetter tape produced by the keyboard operator is run though a telegraph transmitter which translates the punched code combinations into groups of electrical impulses and transmits them over the wires. At the receiving station these electrical impulses operate simultaneously reperforators which reproduce the transmitted teletypesetter tape and teletype printers which typewite line for line copies of the galley proofs to be made from the type set by the received tape.

TELEVISION. The word "television" seeing at a distance, by common acceptance has come to mean the essentially instantaneous transmission, either by were or radio, of moving scenes and pictures it must be distinguished from the telescopes an optical instrument, by means of which a scene is viewed from a distance; from fassimie, which is the electrical transmission of still pictures; and from the simple transportation of moving picture films of a scene ta a distant point for reproduction.

Essentially three steps are involved in television, namely: (t) the analysis of the light image into electrical signals, (2) the transmission of the electrical signals to the points of reception; and (3) the synthesis of a visible reproduction of the original image from the electrical signals.

### HISTORY OF TELEVISION

The first practical means for analyzing a picture into a form suitable for electrical transmission was the Nipskow disk, proposed by P. Nipkow in 1884. This scanner consists of a circulai disk having a number of small holes arranged in a spiral about its centre as shown in fig. 1. A scanning disk is placed at the image plane of the potch-up device and at the viewing area of the receiver. As the disk rotates the holes move across the image field in succession, sweeping out a pattern of parallel lines. A light-sensitive cell, for example a large silver-caesium phototube, it coincide behind the disk in the pick-up device. In moving across cone element of the picture at any one time to reach the light-institute element of the picture at any one time to reach the light-time that is not accordance with the content of the picture, and produces a corresponding fluctuation in the current output of the tube

The varying current from the phototube is made to modulate a radio transmitter in much the same way that the varying current from a sound microphone modulates the transmitter of a radio broadcasting station. The television transmitter is also modulated with a timing, or synchronizing signal which may be in the form of an electrical pulse occurring each time a specified point on the scanning disk ussess a stationary index mark.

A radio receiver receives the signal from the transmitter and converts the modulated radio frequency signal into an electrical wave train which is identical with the signal supplied to the trans-

Sceneed image, field on the state of the sta

FIG. 1.-NIPKOW DISK FOR AN 18-LINE PICTURE

mitter Circuits then divide the output signal from the receiver into two parts, namely a synchronizing signal and the video signal. The video signal, as the name implies, carries the information about the light distribution in the original image by reproducing the current fluctuation of the phototube at the transmitter.

The video signal, after suitable amplification, controls the light output of a brilliant light source. A gaseous discharge lamp (eg., a crater lamp) whose brightness is proportional to the current supplied to it, actuated by the

video signal may serve as the light source, or the lamp may be of constant brightness and a light valve, such as a Kerr cell, controlled by the amplifier output be used to vary the light output of the light source.

A Nipkow disk rotates in front of his light source. The rate

and phase of rotation of the disk is controlled by the synchronizing signal in such a way that an aperture in the receiver's disk is at all times in the same relative position with respect to the

image area as the corresponding one in the disk at the transmitter. Since there is a one-to-one time correspondence between the positions of the apertures in the transmitting and receiving disk, and a similar correspondence between the amount of light passing through the respective apertures, a reproduction of the image at the transmitter will be seen in the plane of the disk at the receiver

Although the fundamental principles of mechanical television were laid down before the beginning of the 20th century, practical application of them was impossible before the invention, in 1907.

of the thermionic amplifier by Lee De Forest.

In the period from 1910 to 1930 considerable work was done in the field of mechanical television and many improvements were suggested. Successful demonstrations of television transmission were given by 1. L. Bard in Enghand and C. P. Jenkins in the United States in the early 1920s. These early demonstrations were more in the nature of silbioutets, but before the end of the decade half-tone pictures were presented by the above-named inventors, by E. F. W. Alexanderson and others.

The mechanical television system outlined suffers from a number of serous objections. Some of the important limitations are: (i) it is optically very inefficient; (a) mechanical components rotating at high speeds are involved; and (3) a high intensity light source which can be varied at the high frequences required for a good picture is very difficult if not impossible to realize in

practice.

In spite of the many improvements which were made on the basic mechanical system outlined, the limitations stated in the preceding paragraph were so formidable that I was never developed beyond the experimental stage. Nevertheless, various modifications of this system, which included lens dusks, mirror druns, etc., to increase the optical efficiency and reduce the size of the scanning means, and improved light sources and light valves to increase the brightness of the reproduced image, were used in many very successful experimental television transmissions. Thus work was invaluable in keeping alive the not inconsiderable interest in television developed the continuation of the continuation of the stage of the s

Although the extensive research on mechanical systems eventually Ber to the obtaining under very special laboratory conditions, of pictures whose quality and entertainment values were well above the essential minimum required of a practical television system, the final solution to the television problem was found in a rather different direction, namely through the use of

electronic pick-up and reproducing tubes.

As early as 1905 Boria Resung proposed the use of a Braun cathode-ray the as a means of reconstructing television images, and demonstrated by experiment that this was feasible. In 1911 and the state of the state o

Television developed rapidly under the impetts given it by the new electronic pick-up and viewing devices. By the latter part of the 1930s, just before World War II, regular programs were been considered to the 1930s, just before World War II, regular programs were being a considerable of the 1930s, just before World War II, regular programs were being a Chenectainy, N.V., Philadebbia, Pac, Chicago, III, and San Panaciso, Calif., in the United States; in England by the BBC Transcript, and also from a number of points in continental Europe. In the United States and England many thousand home receivers were in private hands and were in regular use receiving these programs. Frogram material included: sporting events, such as the outdoor pick-up of robtall, baseball and tennis, and indoor pick-up of hoxing, wreetling and hockey, news events, studio production of plays, denor excisias, musical shows and general enter-

tainment features as well as moving-picture film programs.

During the war years, 1940–45, commercial televasion activities were drastically curtailed However, research in the field of televasion conhuned because of its potential military value. After World War II television progressed at an accelerated pace, This is illustrated by the fact that before the end of 1953 there were 328 television stations in operation in the United States, serving more than 27,000,000 sets. In addition, more than 3,000,000 sets were in use in the remainder of the world, with regular television broadcasts in about 20 countries.

## THE FUNDAMENTAL PROBLEMS OF TELEVISION

The ordinary concept of a picture or image is that of a surface over which there is a more or less continuous distribution of varying light and dark, the distribution changing smoothly with time to conform with motion in the picture. Here the brightness is a function of the three independent variables, x, y and t, where x and y are the horizontal and vertical position of any point on the picture and t is the time. Obyously, such a distribution cannot be transmitted over a single electrical communication channel where the current or voltage transmitted is a function of time only.

In order to overcome this fundamental difficulty it is necessary to take advantage of certain physiological and psychological limitations of sight to reduce the amount of information which must be transmitted. These limitations are the finite resolving power of the eye and the persistence of vision. If a picture is subdivided into a large number of small elements, each element being uniformly shaded, the picture will still appear continuous, provided the elements are so small that they are not resolved by the eye. This procedure is, for example, employed in the making of half-tone reproductions. Thus a picture composed of a finite number of discrete elements is entirely satisfactory for viewing.

The illusion of continuous motion can be obtained, as is done in the case of moving pictures, by forming a series of static pictures in rapid succession, with each picture differing slightly from the preceding to correspond to the motion which has taken place in the scene during the interval between pictures. From this it will be evident that the information necessary to reconstruct a completely statisfactory visual representation of a scene which includes place to the continuous properties of the control of the values of a finite number of picture elements at a finite prigning conditions required for the transmission of moving pictures over an electrical communication change are the reformance.

The problem of analyzing a picture into information suitable for electrical transmission and later resynthesis does not have a unique solution. However, the process known as scanning is the only one which by the 1950s had proved to be satisfactory, and is

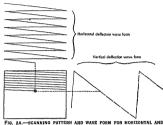
the only one that will be discussed in this article.

The process of scanning is that of exploring the image area by means of a sensitive analyzing element which moves in a continuous or discontinuous line covering the entire surface of the picture. In general the size of the sensitive exploring element is equal to or smaller than a picture element. The analyzing element as equal to or smaller than a picture element. The analyzing element as epocates either directly or indirectly an electrical signal which corresponds to the brightness of the area of the image at which it is located. As the analyzing element traces out the scanning pattern over the surface of the picture the electrical signal varies, forming a characteristic complex wave known as the video signal,

At the picture reproducer or receiver the reproducing elament moves over the viewing area in a scanning pattern which is geometrically similar to that at the transmitter. The brightness or its equivalent (i.e., optical transmission, reflectivity, etc.) of the reproducing element is a monotonic function of the instantaneous amplitude of the video signal. The motion of this element is so synchronized with that of the exploring element that when the instantaneous amplitude of the video signal associated with a particular point in the picture being transmitted reaches it, the reproducing element is at the corresponding point of the viewing area. Therefore a reproduction of the picture being transmitted is formed on the viewing area of the receiver.

One form of television scanning and means for reproduction has already been outlined in connection with the Nipkow disk.

Scanning patterns are characterized by the type of path described by the exploring and reproducing element. Thus somal scanning patterns are used in many detecting devices, while PPI radar uses a radial scanning pattern Parallel line scanning, almost exclusively, is used in television. Here the element sweeps out a series of straight parallel, nearly horizontal, lines covering the



VERTICAL DEFLECTION FOR SEQUENTIAL PARALLEL-LINE SCANNING

picture area. This pattern is obtained by displacing the element rapidly across the area in the horizontal direction and returning it even more rapidly to its original horizontal position. At the same time the element is moved slowly in the vertical direction so that many horizontal sweeps occur in the time it takes for it to cover the height of the picture. This is followed by a quick vertical return. If the horizontal and vertical displacements are plotted as a function of time they yield sawtooth waves which rise gradually and fall abruptly. The ratio of the horizontal to the vertical frequency of these waves is equal to the number of horizontal lines making up the pattern This type of scanning pattern is frequently designated as a raster.

The raster is characterized by the number of lines it contains, the ordering of these lines, and the repetition rate or frame frequency. In simple scanning the lines are laid down in sequence (fig. 2A). However, considerable advantage results from laving down the odd-numbered lines first and then the even-numbered lines. This is known as interlaced scanning and is illustrated in fig. 2B.

The scanning pattern at transmitter and receiver, the exploring and reproducing elements and the communication channel connecting them are symbolically illustrated in fig. 3.

With interlaced scanning the reproducing element moves over the area of the viewing field along slightly different paths twice during each frame. Therefore the field frequency is twice the frame frequency. The former determines the flicker frequency while the latter determines the repetition rate for continuity of

motion. In practice it is found that the flicker frequency must be two or more times the minimum repetition rate required to give the illusion of continuous motion if flicker is to be reduced

below the visual threshold. The illusion of continuous motion is obtained for a great many subjects with a repetition rate of 16 frames per second; however, some subjects show discontinuity



FIG. 2B .- SCANNING PATTERN FOR INTERLACED SCANNING

when the repetition rate is as low as this. The moving-picture in-

frame frequency) will equal the 60-cycle power line frequency which is standard for most of the United States For similar reasons a repetition rate of 25 frames per second was adopted for Great Britain to conform with a 50-cycle power system.

The number of lines making up the scanning raster determines the vertical definition of the picture. This is obviously true because two picture elements cannot be closer together in the vertical direction than the line spacing. It is, therefore, desirable to have as many lines per frame as is practical. However, other considerations, which will be discussed below in this section, indicate that there are both practical and fundamental advantages in keeping the number of lines to a minimum. The visual acuity of the human eye depends, of course, upon the brightness of the scene observed. However, a practical value of one minute of angle for a scene brightness which is high enough to cause no discomfort or fatigue is useful in estimating the number of lines required. Moving picture experience has indicated that the ratio of viewing distance to vertical height of picture should not be greater than eight, which corresponds to an angle of about seven degrees This in turn means that the number of lines should not be fewer than about 500 Television standards in the United States call for a ratio of horizontal line frequency to frame frequency of 525 However, the raster does not have the full 525 lines because some lines (5%) are lost during the vertical return time

The size of the exploring and reproducing element is related to both vertical and horizontal definition. For the present discussion, however, it will be assumed that the scanning element size is so small that it does not appreciably degrade the resolution

Neglecting the effect of the scanning element size, the horizontal definition is determined by the frequencies which can be transmitted through the communication channel. A signal frequency  $f_o$  corresponds to  $2f_o/(f_oN_v)$  black and white dots along a line, where  $f_0$  is the frame frequency and  $N_0$  the number of lines in the scanning pattern. This is the finest pattern of dots, or number of picture elements, that can be transmitted with a band width for

Finally it can be shown that the complex wave corresponding to the video signal formed by a real picture on the pickup device can be represented by a sum of simple waves of the type just



On the basis of the above, the frequency band required to transmit a rectangular picture having a vertical to horizontal aspect ratio of 3.4 and equal definition in the two directions can

be estimated as follows. the maximum number of black horizontal bars in a pattern of black and white bars is  $\frac{N_v}{2}$  where  $N_v$  is the number of lines in the raster. The number of vertical bars having a spacing equal to these will be  $\frac{4 N_v}{3 2} = N_h$ . Therefore the channel will have to transmit all the space of the

will have to transmit all frequencies up to the cutoff frequency  $f_o = N_h N_v f_o = \frac{4}{6} N v^2 f_o$ . For a 525-line picture the frequency band

is about 5,000,000 cycles. A more precise treatment leads to a slightly smaller required band width. Thus a 4- to 41-mc. band has been shown to be sufficient and is used in television broadcasting in the United States.

For the preceding discussion a simple image area, exploring element, communication channel and reproducing element were used to represent what is in actuality a very complicated electrical system. This was sufficient to establish some of the fundamental properties of television systems and to interpret optical requirements in terms of electrical characteristics. However, the representation must be expanded before any description of the physical components of the system or of its operation as a dustry adopted 24 frames per second, which was found to be the physical components of the system or of its operation as a satisfactory. In the United States a television repetition rate of 30 whole can be presented. A block diagram of the principal comframes per second was adopted as standard. The somewhat higher ponents of an electronic television system is given in fig. 4. The frame frequency was selected, not because it is required for con-tinuity of motion, but in order that the field frequency (twice camera, an amplifier chain which includes the monitoring and corsignal generator and the camera deflection generators

The complete television transmitter also includes an FM (frequency modulation) sound transmitting unit. Since this unit is essentially the same as the conventional FM broadcast transmitter it will not be further described in this article

The television receiver is shown in fig 4b It includes the antenna and radio frequency amplifier, the converter or mixer, the intermediate frequency amplifier, the second detector, the video



BLOCK DIAGRAM OF TRANSMITTER (a) AND RECEIVER (b)

amphifier and the viewing device. Associated with it are also the synchronizing separation circuits and the deflection generator for the viewing tube A separate intermediate frequency amplifier is provided for the sound channel, which is followed by a conventional FM discriminator and limiter and sound output system

In succeeding sections the various components making up the system will be discussed individually in some detail and only the general functioning of the system as a whole will be outlined in

The pickup camera consists of an objective lens for imaging the scene before the camera onto the pickup tube, the pickup tube itself, the preamplifier and the deflecting voke for moving the exploring element over the image area Several forms of pickup tubes are commonly used for television broadcasting. These include the iconoscope, the orthicon, the image iconoscope and the image orthicon A description of these tubes and the principles of their operation will be given in a later section

An optical image of the scene being televised is formed on the sensitive area of the pickup device or camera. This area is scanned by the exploring element and a video signal is generated corresponding to the light image. The video signal as generated by most pickup devices is extremely small, representing only a fraction of a microwatt of power or a few millivolts. Before the signal can be used to modulate the television radio transmitter it must undergo an amplification in voltage of nearly 1,000,000 times It also must have added to it the timing pulses needed to synchronize the receiver, and must be corrected for certain defects generated by the pickup camera. The amplification is ac-complished in several steps. To begin with, the preamplifier at the camera raises the level up to the point where it can be conveniently transmitted through a cable The signal is next amplified to monitoring level. Here the synchronizing signal is added and any correction of spurious signal is made. Also, in general, at this point monitoring viewing

tubes are provided which reproduce visible images of the scenes picked up by each of the cameras used for transmission of the program, so that the program manager can select which camera signal to use and otherwise direct the program.

The signal at monitoring level is still only a few volts and msufficient to modulate the transmitter. It is, therefore, further amplified to bring it to the several thousand volts required for modulation of the radio fre- Fig. 5 -- VIDEO SIGNAL: (G) AS quency carrier. The transmitter OBTAINED FROM PICKUP, (b) includes, in addition to the modulator, a carefully controlled oscillator and power amplifier which synchronizing signal



AFTER BLANKING OUT RETURN-LINE SIGNAL AND INSERTING BLACK LEVEL; AND (c) AFTER ADDING

recting units, the radio transmitter and antenna, the synchronizing generate the constant-amplitude radio frequency carrier oscilla-The modulator is arranged to vary the amplitude of this tion oscillation so that its envelope corresponds to the video signal

The modulated signal is then filtered through a special coaxial network to produce the single side-band radio frequency signal which is radiated from the transmitting antenna The frequencymodulated radio signal carrying the sound which is to accompany the picture is in general broadcast simultaneously from the same antenna.

As has already been pointed out, a frequency band of about 42 mc is required to carry the video information A carrier modulated with this signal would normally occupy a band width of o mc in the radio spectrum However, the single side-band filters reduce the band needed to about 5 mc. To this is added another megacycle to accommodate the sound channel and to ensure frequency separation between sound and picture, and between



TELEVISION CHANNEL

adjacent television channels, sufficient to prevent interference Thus a television channel must be 6 mc wide, with the video and audio signals distributed in it as shown in fig 6.

Obviously, a radio frequency signal of this band width must be transmitted at relatively high carrier frequency television is broadcast on short

waves, the channels lying in the radio spectrum above 40 mc. In the United States in 1953 12 television channels had been assigned by the Federal Communications commission between 54 and 216 mc., and 70 additional channels in the 470-800 mc, portions of the radio spectrum These frequency assignments are listed below.

Allocation of Communication Channels to Television (1953)

Channel regacycles				Channel megacycles			
54-60	channel	no.	2	180-186	channel	no.	8
6066	channel			186-192			
66-72	channel	no.	4	192-198	channel	no.	io
76-82	channel			198-204			
82-88	channel	no	6	204-210			
174-180	channel	no	7	210-216	channel	no	13
meracycles							
470-890 Ultrahigh-frequency channels 14-83							

Even the lowest frequency assigned to television is in the veryhigh-frequency part of the spectrum and its propagation characteristics are quite different from those of ordinary sound broadcast. The most important difference is that ultrahigh-frequency radiation is subject to almost no reflection or refraction by the air or the ion layers of the upper atmosphere Consequently, it is propagated in essentially straight lines. The service area of a television transmitter is, therefore, limited to the line-of-sight distance between the transmitting antenna and receiving antenna Actually the boundary of the service area is not sharp. However, the signal strength falls off very rapidly when the line-of-sight distance is exceeded. The line-of-sight distance d in miles can readily be calculated from the relation;

$$d=1.2(\sqrt{h_T}+\sqrt{h_R})$$

where  $h_T$  and  $h_B$  are the heights in feet of the transmitting and receiving antenna, respectively.

The receiving antenna is usually a modification of the conventional short-wave dipole. It is connected with the receiver by a transmission line designed especially to carry the high-frequency signal. At the receiver, the signal is combined with the signal from a local oscillator through the converter tube to form the intermediate frequency signal. The intermediate frequency signal resembles the original radio frequency signal in that it is a carrier oscillation whose amplitude is modulated (single side band) with the video wave. The intermediate carrier frequency is, howrier, being in practice in the neighbourhood of 45 75 mc

The intermediate signal is amplified and then rectified at the second detector The output of the second detector has a wave shape which is the same as that of the video signal at the pickup camera, but also includes the synchronizing signal The synchronizing signal is separated from the video signal by suitable filters and used to control the deflection generator which moves the scanning element in the viewing tube The video signal itself is supplied to the control grid of the viewing tube and governs the brightness of the scanning element. The various steps in the chain of events occurring between the pickup of the scene and its reproduction on the screen of the viewing tube will be discussed in greater detail in succeeding sections, in connection with descriptions of the various components making up the system.

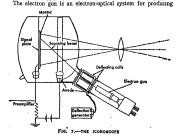
### TELEVISION PICKUP DEVICES

With the resumption of active public television broadcasting at the close of World War II a number of different types of pickup devices were available for this service. The principal types employed were the image orthicon, the orthicon, the iconoscope and the dissector tube. They are listed in approximate order of their sensitivity

All of these pickup tubes make use of photoelectric emission in converting the light image of the subject being televised into an electrical signal Photoelectric emission is the release of electrons from a surface when light or other radiation is incident on it. Almost all conducting materials exhibit this property to some extent However, certain complex chemical surfaces are very active in this respect, and it is these that are used in pickup tubes. The two most commonly employed photoelectric emitters are surfaces composed of caesium, caesium oxide and silver and surfaces composed of antimony, silver and caesium. The former have a high response to red light and a lower response to blue with a minimum response in the green portions of the spectrum. The second surface described has a very high blue response and low red sensitivity. In addition to the tubes listed above, the Vidicon, whose operation is based on the photoconductive effect and which found extensive application in industrial television in 1953, merits closer consideration.

The manner in which the photoelectric phenomenon is applied in the various types of pickup tubes is of course different, leading to different performance characteristics. Therefore, the construction and operation of each of these tubes will be described individually.

Iconoscope.-The iconoscope consists of an electron gun producing a fine electron beam and a photosensitive mosaic enclosed in a highly evacuated glass envelope. External to it is a magnetic deflecting yoke, with its driving circuit, which deflects the electron beam and a video amphier which raises the level of the output signal before supplying it to the television transmitter (fig. 7).



ever, much lower than that of the original radio frequency car- an extremely narrow, well-defined electron beam which impinges upon the mosaic in a spot a few thousandths of an inch in diameter A simplified diagram of the electron gun, together with its optical analogue, is illustrated in fig 8. Essentially this gun consists of two groups of electron lenses, formed by coaxial cylindrical electrodes. The first lens group, which includes the thermionic cathode and the control grid, concentrates the electrons from the cathode into a narrow bundle called the crossover. Optically, the crossover is the analogue of the exit pupil of the first lens system. The second lens images this crossover upon the

> The electron beam from the gun is deflected vertically and horizontally by varying magnetic fields produced by the deflect-



TICAL ANALOGUE

ing yoke, in such a way that the spot moves over the mosaic in a series of straight parallel lines forming the scanning raster. In the course of one frame period the entire surface of the mosaic is explored by the scanning spot. Figuratively speaking, the mo-

saic is the retina of the pickup tube It consists of a thin sheet FIG 8 -ELECTRON GUN AND OP. of mica or other dielectric, coated on one side with a conducting film known as the signal plate and on the other with vast numbers of minute silver globules or elements. Each of these globules is photosensitized with oxygen and caesium; also, each globule forms a condenser with the con-

by a signal lead which passes through the walls of the tube. When light falls on the mosaic the illuminated elements emit photoelectrons charging the condensers of which they form a part In other words, the action of the light is to cause the elements to acquire a positive charge which in turn traps an equal negative charge on the signal plate As the scanning beam passes over each element in turn, it returns it to an equilibrium potential releasing the stored charge. This change in charge of the elements induces a corresponding change in charge in the signal plate, and

ducting signal plate. The signal plate is connected to an amplifier

thus causes a current to flow in the signal lead. It will be noticed that photoelectrons are emitted by the silver elements during the entire time they are illuminated, and that the charge is stored until the scanning beam returns to discharge the element. This storage principle is characteristic of the iconoscope type of pickup tube, and results in an enormous gain in sensitivity over a nonstorage system. For example, with a scanning disk pickup, which is a typical nonstorage system, the photocurrent corresponding to one picture element only flows, in any one frame time, for a time equal to one frame period divided by the number of elements in the picture frame, while for the storage system the current flows for the entire frame time. Since there are about 350,000 picture elements in a television picture, this means there is available 350,000 times as much charge to represent a picture element in a storage device than in a nonstorage pickup system.

The mechanism by which the elements are returned to equilibrium in an iconoscope is quite complicated. Beam electrons. striking the elements with a velocity corresponding to about 1,000 v., cause them to emit secondary electrons in excess of the beam electrons If an element is at a negative potential with respect to the electrode in the tube which serves as collector of secondary electrons, more electrons leave the element than are supplied by the beam and the element becomes increasingly positive. increase in positive charge continues until the element reaches a potential such that most of the secondary electrons (which have only a few volts emission velocities) are turned back to the element and the current which leaves it equals the beam current arriving. This is the equilibrium potential of the element and, for a typical photosensitized silver element, may be one or two volts positive with respect to the secondary emission collector. If the element is more positive than this, the secondary emission current leaving will be less than the bombarding current and the

element accumulates negative charge until it reaches equilibrium. This method of establishing equilibrium for the elements has

Into method of establishing equilibrium for the elements has two important consequences (1) all of the returning secondary electrons do not reach the element from which they were emitted but instead are redistributed over the entire surface of the mosaic, and (2) the mean potential of the elements is relatively high with respect to the collector electrode with the result that the photoemission is to some extent inhibited.

As a result of the first effect some signal is lost because of a masking effect of the redistributed electrons. Furthermore, a spurious signal, termed "black spot" or "shading," arises from the nonuniformity of redistribution over the mosaic

The second effect reduces the efficiency of the mosaic as a photoemttet, which is undestrable, but it also leads to a response characteristic whose rate of increase of signal decreases with nocreasing light. The tube, therefore, does not become saturated or block at very high light levels. It is interesting to note that the eye has a somewhat similar characteristic.

Orthicon.—The orthicon is a beam scanning pickup tube employing a storage-type mossic simular to that of the iconoscope The electron gun, however, is arranged to produce a low-velocity electron beam, instead of the 1,000-V-velocity beam used in the iconoscope Fig. 9 illustrates the arrangement of components in an orthicon

When a photosensitized surface of the type used for the mosaic elements is bombarded by a very low-velocity beam the secondary



FIG 9 -- ORTHICON WITH MAGNETIC DEFLECTION

emission ratio is less than one; in other words, more electrons will arrive than leave. Under these conditions an insulated element becomes increasingly negative under bombardment until its potential becomes such that the beam electrons are repelled and can no longer reach the element. This potential is the equilibrium potential of the elements and is approximately equal to that of the cathode of the gun. This equilibrium potential is entirely modependent of the collector field in the vicinity of the element.

In darkness, the target or mosaic of the orthicon is driven to its equilibrium potential by the beam and electrons no longer reach its surface. If an area of the mosaic is illuminated, photoelectrons are emitted by the elements on which the light falls and these elements accumulate a positive charge with respect to their equilibrium condition. When the seaning beam passes over these elements is returns them to equilibrium potential, releasing the accumulated charge. This change of charge produces the video signal just as in the iconoscope. This mode of operation has several important consequences; thus there is no redstribution of electrons over the mosaic and consequently no spurious signal or black spot. Furthermore, the photoemission is saturated so that the photoediscion of electrons over the mosaic and consequently no issuit of signal resulting from the discharging or short-circuiting action of redstribution electrons; and the signal output is strictly propertional to the indent Illumination over the range of stable opera-

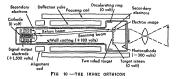
The first three items mentioned represent a superiority over the iconoscope. The Increase in efficiency results in about six to eight times greater sensitivity; that is, the orthicon will produce a satisfactory picture with one-sixth to one-eighth of the light required by an iconoscope. Freedom from shading or black spot eliminates the need of elaborate correcting circuits at the transmitter.

The fourth characteristic is to some extent disadvantageous, since at high light levels the tube becomes unstable as a result of the elements accumulating so large a positive charge that the

secondary-emission natio becomes greater than unity and equilibrium cannot be re-established. This means that care must be execused by an operator of an oithicon to avoid high light brightnesses great enough to produce instability.

The linear response characteristic makes it necessary to add contiast-correcting circuits to the amplifier chain to obtain a picture with pleasing tonal gradation. The CPS-Emitron, an orthicontype tube, was extensively used in England in the 1950s.

The Image Orthicon.—The image orthicon, as the name implies, includes the low beam-velocity gain and a storage-type mean. In addition, it has one stage of secondary emission image intensification and also a secondary emission multiplier to amplify the signal output. The use of these two types of multipliers to gether with the orthicon principle leads to a micreise in sensi-



tivity over the normal iconoscope of several hundred Fig. 10 illustrates the construction of the image orthicon

The image section consists of a photocathode upon which the light image falls and an electron lens system which focuses the electrons from the cathode onto the mosaic or target

The target is a very thin film of special glass which is sufficiently conducting so that there is an interchange of charge between the two sides The electron image from the photocathode falls on one side of the target while the opposite side is scanned by a low-velocity beam Close to the target on the image side is a fine-mesh screen (1,000 meshes per inch) which is positive by one or two volts with respect to the equilibrium potential of the This screen collects the image secondary electrons from the target, causing a positive charge to accumulate at areas where the image electrons strike the target. The very close spacing of the screen makes it possible to have a strong collector field at the target when the latter is at its equilibrium potential and at the same time to operate the screen at a small enough positive potential so that the target cannot, even under very intense illumination, be driven so far positive that its operation becomes unstable.

The low-velocity scanning beam removes the stored charge and returns the target to equilibrium exactly as does the beam in the orthicon. However, instead of obtaining the video signal from a signal plate as with the orthicon and iconoscope, it is obtained from the beam electrons which are turned back from the target. This electron flow is modulated by the inverse of the video signal, The returning electrons are directed into a secondary emission multiplier. The complex chain of operations involved in the process of converting a light image into a video signal in the image orthicon makes possible very high sensitivity. Some of the contributing factors are the high photoelectric sensitivity that is obtained with an image cathode as compared with the photosensitivity of a mosaic; the secondary emission intensification of the electron image at the target; the high efficiency of the low-velocity scanning beam; and the amphiication of the video output by the signal multiplier. Other important characteristics of this pickup device are the decreasing response as the light intensity increases (similar to the iconoscope rather than the orthicon), making the tube operative over a tremendous range of light values; freedom from shading or black spot since there is no redistribution of beam electrons; a relatively low maximum signal-to-noise ratio which means that while a good picture can be obtained at very low light levels, even at very high light intensities some noise may be visible in the picture.

the scene is low. Its sensitivity exceeds that of a camera film and approaches that of the eye. The great range of light values over which it is operative means that it is useful in following an outdoor scene-for example, a sporting event-from noon to well after sunset It has been important in televising indoor events, such as banquets, public meetings, etc , in normally lighted rooms Compared with an iconoscope the image orthicon will transmit a picture with less than one one-hundredth of the minimum light required by the tormer to reproduce the same scene

An image intensifier section has also been combined with the iconoscope to take advantage of the sensitivity increase resulting from the more effective photocathode and the secondary emission gain obtainable in this way This type of image multiplier iconoscope has been more widely used in England than in the United

States A signal multiplier in combination with the simple orthicon has also given good results, although it has not seen much service in actual television broadcasting.

The Dissector Tube.-The dissector tube differs from those described above in that neither electron beam scanning nor the storage principle is employed. The tube consists of a photocathode, an electron lens system for forming an electron image of the electrons from the cathode, deflecting means for moving the electron image horizontally and vertically, an aperture in the focal plane of the electron image and a secondary emission multiplier. The arrangement of the elements is shown in fig. 11.

As the electron image is swept across the aperture, electrons from it pass into the multiplier, where the electron current is intensified. The aperture size is so selected that it equals a picture element of the image, and the electron image is moved by the deflecting system in such a way that the aperture sweeps over

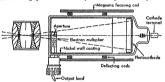


FIG. 11 --- THE IMAGE DISSECTOR

the image in a conventional interlaced scanning raster. The multiplier thus receives the photocurrent from each picture element in succession and the amplified output of the multiplier constitutes the video signal. The response of this type of pickup device is strictly proportional to the light intensity and it has no tendency to saturate or become unstable at high light levels. The picture reproduced by such a tube is completely free from shading or other spurious effects. However, the sensitivity of the dissector tube is much lower than any of the devices described in the preceding paragraphs because it does not employ the storage principle. Compared with the iconoscope, several hundred times as much light is needed to generate an equivalent picture with a dissector tube Therefore, its application is limited, in general, to projected pictures and well-illuminated studio scenes.

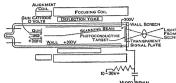
The Vidicon.-The four pickup tubes described above depend for their ability to generate a video signal upon photoemission. The Vidicon, while retaining the fundamentally important storage principle, differs in that it employs another photoelectric phenomenon, namely, photoconductivity.

Photoconductivity is the property of certain semiconductors and insulators of becoming more conducting when light is incident upon them. Cadmium sulphide, amorphous selenium, antimony trisulphide are a few examples of insulating photoconductors which, in varying degrees, are suitable for the light-sensitive target of a Vidicon camera tube

The construction of the Vidicon is shown schematically in fig. 12.

The image orthicon is very valuable wherever the light level of The light sensitive target is a thin film of photoconductive material deposited upon a transparent conductive layer which coats the glass end window of the tube The photoconductor is selected to have a spectral response suitable for the application in which the tube is to be used It also must be a material having a very high resistance in darkness.

An electron gun is mounted in the other end of the tube. This



OF AMERICA FIG 12.-THE VIDICON

gun is similar to that employed in an orthicon and produces a fine beam of electrons which reach the target with low velocity The beam is focused and deflected with magnetic fields produced by coals suitably disposed around the outside of the tube.

In operation, the conductive layer under the photoconductive target is made slightly positive with respect to the cathode of the gun As the electron beam from the gun scans the surface of the target, each element of area swept over is driven to cathode potential. As soon as the beam moves away from an area it starts charging positive due to the flow of current from the backing layer through the photoconductor. The rate at which a given area changes potential, and consequently the total charge accumulated during a frame time, depends upon the resistance of the photoconductor and consequently upon the intensity of light falling on When the beam returns to the area in question, the accumulated positive charge is neutralized by electrons from the beam as the area is driven back to equilibrium. The change of charge induces a corresponding change of charge in the backing layer. The current to effect this change of charge flows through the signal lead connecting the backing layer with the external circuit. The fluctuations in the signal lead current constitute the video signal.

It is evident from the foregoing discussion that the photoconductor is storing useful information from the incident light at each point of the target during the time of each frame. In fact, the operation of the Vidicon may properly be compared with that of the orthicon by merely substituting the internal photoeffect of the photoconductor for the photoemission of the latter.

The Vidicon has the advantage of extreme simplicity and can, consequently, be made very small. While this form of pickup device has the potentiality of very high sensitivity, in its state of development in the 1950s it was less sensitive than the image orthicon. Its sensitivity is adequate for average viewing, particularly where the device is used for industrial television, for which application the tube is eminently suited.

Sensitivity of Pickup Devices,-Without additional information, it might be thought that any one of the pickup devices described in this section could be used at any light level, however low, simply by increasing the gain of the amplifier which follows

However, there exists a fundamental limit to the sensitivity of each type of pickup device which determines the minimum light level for which a satisfactory picture can be obtained irrespective of the subsequent amplification. This limit arises from the fact that it is impossible to produce a current or voltage which is free from spurious fluctuations. When the video signal generated by a pickup device falls below a certain level, it will be masked by the spurious fluctuations.

These fluctuations are caused by the granular nature of elec-

tricity. A small current flowing in an electronic device or vacuum tube cannot be considered as the flow of a continuous medium, but rather as the motion of randomly distributed individual electrons. On this basis it can be shown theoretically (and confirmed experimentally) that associated with an electron current there will exist a fluctuation current whose root mean square value is proportional to the square root of the electron current Also, the conduction electrons in a metal or other conductor are in theimal equilibrium with the material itself and their random heat motion gives rise The root to a small voltage across the terminals of a circuit mean square value of this voltage is proportional to the square root of the resistance of the circuit and the square root of its absolute temperature Both the voltage fluctuation from resistors and the fluctuation in an electron current depend, furthermore, upon the frequency band transmitted by the circuit involved The root mean square value of each is proportional to the square root of the frequency band width Therefore, in a circuit or system where maximum sensitivity is sought, the band width should be the minimum compatible with other requirements pickup devices, vacuum tubes and amplifiers involve the flow of electron currents and resistive circuit elements these spurious fluctuation effects are basically unavoidable.

It might be pointed out that these fluctuation effects also are present in sound systems. They give rise to a his superposed on the desired audio output, an effect commonly known as "noise". This terminology of sound engineering is carried over into television engineering and the spurious fluctuations described above, although producing visual effects, are termed "noise."

In the reproduced picture noise appears as fine speakles or flakes of black and white scattered over the picture area and, when severe, makes the scene appear to be in the midst of a snowstorm. Even when the noise is not sufficient to mask the picture, it detracts from the quality of the reproduction. As the ratio of signal-to-noise increases the noise becomes less apparent until eventually it as below the visual threshold For a 500-line picture a signal-to-noise ratio of 30 to 50 yields a reproduction for which the noise is not in eventually sufficient for the first production for which the noise is not in eventually and the second of the picture as the signal-to-noise ratio of 30 to 50 yields a reproduction for which the noise is not in eventually sufficient for the picture as signal-to-noise ratio of 30 to 50 yields a reproduction for which the noise is not in eventually sufficient for the picture as signal-to-noise ratio of 30 to 50 yields a reproduction for which the noise is not in eventually sufficient for the picture and the picture and the picture are signal-to-noise ratio of 30 to 50 yields a reproduction for which the noise is not in eventually sufficient for the picture as the picture as the picture as the picture as the picture as the picture are the picture as t

It is interesting to note that in motion-picture practice an exact counterpart of "noise" exists in the grainness of a film. When weved from a distance which permits a goo-line resolution, the "sgnall-conse ratio" for commercial 35-mm motion-picture film is, in general, approximately 30 to 40. Therefore, a direct comparison between the sensitivity of a motion-picture film and a television pickup device is possible. The figure of ment most suitable for the purpose is

$$S = F^2/BA$$

where F is the F-number of the lens required, B the brightness of the scene (in foot-lamberts) and A the area (in square niches) of the film or sensitive target. The area of one frame of 3.5-mm. Him 3a + 4 in monor-picture studio practice employs a scene brightness of 500 foot-lamberts with an F/2 lens. This yields a figure of ment  $S = \frac{1}{N}$  for motion-picture film.

For the type 1850-A iconoscope the target area is about 17 in. and, to obtain the signal-to-noise ratio referred to above, a scena brightness of 500 to 1,500 foot-lamberts with an F/5.6 lens is required. A maximum figure of merit  $S=\frac{1}{2}\sqrt{10}$  can therefore be assigned to this type of pickup tube.

An orthicon with a 4 in.<sup>2</sup> target uses an F/2 lens and a brightness of 60 foot-lamberts which gives an estimated figure of merit of  $\frac{1}{3}$ . However, because of the character of the signal from the orthicon, a more realistic figure of merit is  $S = \frac{1}{13}$ .

The image orthicon has a figure of merit  $S=\frac{1}{2}$ , which is higher than any of the deviese mentioned above, including motion-pitch tent film. Here the target area is  $1 \circ 1n^2$  and with an F/2 lens a scene brightness of  $2 \circ 100$ -lamberts is required. This yields a figure of merit of 2, but this value takes no account of the character of the signal.

The image dissector tube, although capable of yielding an excellent picture, has a figure of merit of only  $\frac{1}{150,000}$  because no storage is involved.

### TELEVISION TRANSMITTING EQUIPMENT

Video Amplifier -The electrical signal generated by any of the pickup devices described in the preceding section is extremely weak, amounting at most to a few microwatts Before this signal can be used it must be greatly amplified. In order not to deteriorate the signal, the noise or spurious signal from the amplifier must be reduced to a minimum. As has already been pointed out, the frequency band covered by the video signal extends from frame frequency or 30 cycles to 4 or 5 mc or more and the gain of the amplifier must be constant over this hand. Furthermore, the phase shift through the amplifier must be a linear function of frequency. This requirement means that all the haimonics comprising the complex wave of the video signal must be delayed equally in time so that the signal will pass through the amplifier without distortion Compared with the ordinary audio amplifier. with a band width of 5,000 to 10,000 cycles, the video amplifier, with a band width nearly 1,000 times greater and the added requirement of constant time delay, presents some very special prob-

The amplification of the video signal is carried out in several steps At the pickup camers there is a preamplifier consisting of several stages which brings the signal level up to the point where it can be transmitted through a cable without loss in the signal-to-noise ratio. This cable carries the signal to the voltage amplifier where the level is again increased to a value high enough to actuate the viewing tube at the monitor. In this amplifier such special signals as those required to correct for shading, the synchronian signal (discussed in detail below) and the blanking signal are introduced.

After leaving the voltage amplifier the signal is again amplified to bring it to the level required by the radio transmitter which is to broadcast the picture.

Frequently this fundamental amplifier chain is supplemented by other amplifiers for practical reasons, such as location of equipment, supplementary monitoring, switching, etc.

The technical aspects of the design of the video amplifier are beyond the scope of this article and the reader is referred to the many publications on the subject for detailed information. Some of the salient features are the following the video amplifien is a vacuum tube amplifier having interstage coupling networks which are based on the circuits used in ordinary resistance-coupled amplifiers.

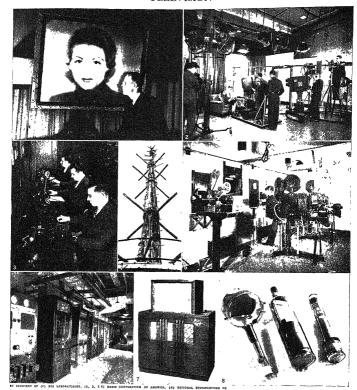
Radio Transmitter.—The television radio transmitter is simlar in principle to the conventional radio transmitter, but is modified in design in order to handle the very wide frequency band required for the video signal.

Insamuch as a band width of several megacycles is involved the transmission must be in the very-high-frequency or ultrabledfrequency region of the radio spectrum. Actually, television broadcasting in the United States in the 1950s was carried out in 2 very-high-frequency channels and 70 ultrabligh-frequency chan-

nels, each 6 mc, wide.

As with sound broadcasting, the video signal is transmitted as
a variation or modulation of the amplitude of an electrical oscillation whose frequency is constant. This frequency, who is
called the carrier frequency, determines the location of the transmission in the radio spectrum.

If the amplitude or envelope of a carrier wave is made to vary in proportion to a video signal having frequency components from to to 4\frac{1}{2}\text{ mc.} and the resultant complex wave is analyzed for its frequency content, it will be found to be composed of a band of frequencies extending from 4\frac{1}{2}\text{ mc.} above the carrier to 4\frac{1}{2}\text{ mc.} blow the carrier frequency. These two bands of frequencies, bying above and below the carrier, are known as side bands. It is sound broadcasting, the channel required would be twice the frequency band control to the frequency band control to the frequency band control to the frequency band control to the frequency band of the frequency band control to the frequency band of the band with single-side-band transmission the frequency band width of the radio channel required to transmit the carrier and one side band With single-side-band transmission the frequency band width of the radio channel required to transmit the video signal is equal to that of the video signal. This expedient is used in television



- A februion maps prospected by the Kinescope

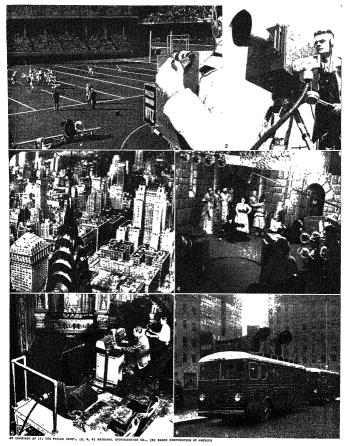
  1 Television maps prospected by the Kinescope

  2 Television studio. Comments have double optical system. One is used
  to enable operator to view some that is being bleavised,

  5 Engineers in the control room of the NBO experimental television
  activated in the Control room of the NBO experimental television
  activated in the DAD building, New York. The component in the forethere is the program director, facing a "list-back" microshene
  used during rehearsal to communicate with the studio orew and cast
  and during rehearsal to communicate with the studio orew and cast

  A Television enterna of Empire State building

  5 In comments of the Control of
- theatre Instead of showing up as an enlarged Image the film is focused on an loonoscope camera which ploks up the optical picture and transforms it to electrical impulses
- And the second section of the second section of the second section that second section
- 7 Home type projection receiver
- 8 Television pick-up tubes (left to right) iconoscope, orthicon and image



TELEVISING AND TELEVISION EQUIPMENT

- Outdoor pick-up of football game
   A television camera for outside locations
   Proture as reproduced by television receiver.

- Production of "The Pirates of Penzance" for television
   Projector for theatre television
   Mobile television unit

ransmission in order to make possible locating a greater number of televasion stations in a given region of the radio spectrum Ortolously the video signal modulating the carrier can be applied so hat a signal corresponding to white causes an increase in the molitude of the carrier, or so that a white signal causes a decrease in mightude. The former is known as positive modulation, the later as negative modulation. There are advantages and disadvanages to each of these systems Interference is more destructed frequery and the properties of the prop

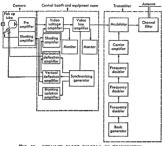


FIG 13.-DETAILED BLOCK DIAGRAM OF TRANSMITTER

ation is used in the United States and most of the rest of the vorld, while positive modulation is employed in England and in rance

The components of a typical television broadcast transmitter es shown in fig 13. The carrier frequency is obtained from a untra-crystal controlled oscillator. Inasmuch as it is difficult to btain the required high frequency directly from such an oscil-tor, the relatively low frequency output of the primary oscil-tor passes through several frequency multipliers which bring he frequency up to that specified for the carrier. The carrier is nea amphified by several sharply tuned radio frequency amplifier ages. When it has reached transmission power level it is supplied to the modulator stage where it is modulated with the video gnal. The modulated radio frequency signal then passes through filter which removes the unwanted side band. From there the gnal goes to the antenna from which it is midtated.

The antenna used for television broadcasting may be one of a umber of types. They differ from ultrahigh-frequency sound roadcasting antennas only in that they are not as sharply tuned ceause of the wide band of frequencies needed for peture transission. As in the case of the video amplifier, the great band width volved has presented many difficult problems in the development of the transmitter. It has necessitated the development of special ower tubes, designed in such a way that they are part of the axial line circuit of the transmitter with a minimum of inter-lectrode capacity so that they can be easily neutralized. For orther information in this field the reader is again referred to re literature on the subject.

Synchronization and Deflection—As has already been ointed out, the reconstruction of the television picture at the serior requires that the scanning beams of the pickup and lewing devices be in canct synchronism. Therefore, in addition providing generators which will produce the current and voltage waves needed to deflect the beams, means must be provided ar synchronizing the two.

The beams in both the iconoscope and viewing tube are deected by the magnetic field produced by electromagnetic coils in a yokes about their necks. Since the spots are required to move

at a uniform velocity across the mosalc and fluorescent screens respectively, and to return rapidly to their original position, the current wave shape supplied to the yokes must be asw-toohed, rising slowly to its maximum value and falling rapidly. The frequency of the saw-toohed were for horizontal deflection is about 15,000 cycles, for veitical deflection foe cycles (for interlaced scanning). Where the impedances of the yokes are essentially inductive the current wave shape can be obtained simply by applying a voltage pulse to them, the duration of which equals the scanning beam return time. The voltage pulse for this purpose is generated by a relaxation oscillator in combination with a suitable shaping circuit and amplifiers. Vertical and horizontal oscillators of this type are required at both the transmitter and receiver

Synchronization can be effected in two different ways. Both of them depend upon the use of a timing pulse which is transmitted

as part of the total picture signal.

One method employs a relaxation oscillator which is very sensitive to a triggering pulse during the time just prior to its generating its own pulse. The oscillator is adjusted so that its free-running speed is slightly lower than the required frequency It is, therefore, in its sensitive condution at the time of arrival of the synchronizing pulsés, so that the latter traggers it off.

The second method employs an oscillator whose output pulse frequency is proportional to the voltage applied to a control element of the oscillator. The control voltage for the oscillator is obtained by electrically comparing the time relation between the output pulse electrically comparing the time relation between the output pulse leads the synchronizing pulse. If the output pulse leads the synchronizing pulse, the control village will be in the direction to slow the oscillator requency control will be in the direction to increase the oscillator frequency

This automatic frequency control synchronizing system is less sensitive to random interference than that depending upon the

triggering action of a timing pulse.

The synchronizing signal is generated by a special circuit at the transmitter, ranged to produce a very accurately shaped pulse. This pulse is added to the video signal in the direction of black, so that the complete signal from the transmitter contains the synchronizing information Fig. 14 illustrates the wave shape of the synchronizing pulse used in the US as authorized by the Federal Communications commission. The pulse is also supplied to the deflection generator for the pickup device.

Since the synchronizing signal is in the direction of black, it can be used to bias off the scanning beams at the pickup tube and viewing tube during the return time, and thus to prevent deterioration of the picture quality by spurious lines. This procedure is known as blanking.

### TELEVISION RADIO RECEIVER

The television signal is received on a short-wave antenna and carried by a transmission line to the receiver. The antenna may be an ordinary half-wave dipole, consisting of a straight horizontal (for the horizontally polarized radiation used for television in the United States) conductor whose length is equal to one-half a wave length of the carrier. The conductor is divided in the centre and the two ends of the transmission line are connected across the break. The simple dipole just described is quite selective in response and, therefore, if the antenna is to be used to receive signals from the several channels in a television band it is advantageous to use an antenna having a broader response. Where the receiver is at some distance from the transmitters, it is frequently helpful to employ a reflector behind the dipole. The reflector used with a pair of dipoles consists of a pair of straight conductors approximately half a wave length long located between 0.2 and 0.25 wave length behind the dipole. Such a reflector increases the sensitivity of the antenna in the forward direction and reduces the effect of interfering signals coming from behind the antenna.

Where the receiver is on the fringe of the service areas of the transmitters from which pictures are desired, it may be necessary to use more elaborate antennas which have higher gain. The rhombic antenna has been found valuable for this purpose.

Care must be exercised in the selection of the antenna site, particularly in an environment of tall buildings, bridges, etc. This is because there is the possibility that radiation reflected from such structures may reach the antenna. Because of the greater distance travelled by the reflected signal, it will produce a second image displaced slightly with respect to the image of the direct signal. When such a double image, or ghost, occurs it can in general be

The audio carrier and side bands which accompany the video signal are also mixed at the converter with the sine wave from the local oscillator to form an IF audio signal. The separation between the IF video carrier frequency and the IF audio carrier frequency and the original frequency will be the same as the carrier separation of the original

radio signal, namely 45 mc. A frequent alternative is to amplify the sound signal along with the video signal in the video IF amplifier

Frequently one or more stages of radio frequency amplification precede the converter stage. This serves to increase the sensitivity of the receiver, and also acts as a shield to decrease radiation from the local oscillation through the receiving antienan.

Filters directly following the converter separate the audio and video signals and channel them into the audio and video intermediate amplifiers

From this point on the audio system is identical to that of a conventional FM receiver (see RADIO RECEIVER) and will not be discussed further in this article

The IF video signal is amplified by several stages of intermediate frequency amplification. Since the output of the converter is only a few microvolts and a signal voltage of 2 to 5 v should be available for the second

detector which follows the intermediate amplifier; the over-all gain of this amphitier must be almost 1,000,000. For an audio-frequency intermediate amphifier, this could be obtained with two or three stages; however, where an extremely wide band of frequencies is involved, the gain per stage is much lower and a well-made undeo intermediate frequency amphifier will employ five stages.

The second detector rectifies the IF video signal so that a low

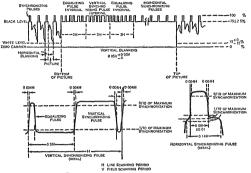


FIG 14 -- WAVE FORM OF SYNCHRONIZING SIGNAL

completely overcome by moving the antenna a few feet one way or another.

The transmission line carrying the signal from the antenna to

The transmission line carrying the signal from the antenna to the receiver may, in areas where the signal strength is great, simply be a twisted pair (similar to a twisted lamp cord) insulated with material which has relatively low electrical losses. Where the signal staggift is lower or where a very long transmission line is required, the losses in a twisted pair may be too great. Under these circumstances either a parallel

wire transmission line consisting of a pair of conductors separated by a thin ribbon of low loss dielectric or a coastal cable in the form of an inner conductor and an outer metallis sheath insulated from each other by low loss separators may be employed. The losses in the two forms of transmission line are about the same, mission line are about the same, rather expensive to install.

The radio receiver used for television is similar to the conventional superheterodyne broadcast receiver. The signal from the transmission line is modulated by or mixed with an oscillation which differs in frequency from the video carrier by 45-75 mc.

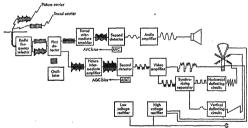


FIG. 15 .- BLOCK DIAGRAM OF RECEIVER, SHOWING WAVE FORM BETWEEN COMPONENTS

As a result of this process, a 45.75-mc. beat, modulated by the video signal, is generated. This is known as the IF or intermediate freenency video signal. The vacuum tube which performs this function is the converter or mixer. Usually a separate local oscillator-supplies the oscillation which is beat with the incoming signal, although circuits can be devised where the converter acts simultaneously as local oscillators.

pass filter (30 to 4,500,000 cycles) following it has an output wave form which exactly duplicates the original video signal which was supplied to the transmitter. The video signal includes, in addition to the information required to reconstruct the picture, pulses which are used to synchronize the horizontal and vertical deflection. These pulses are filtered out from the video signal and used to control the horizontal and vertical relaxation oscillators

of synchronization and deflection have been outlined in preceding sections.

The video signal supplied to the control guid of the viewing tube may be amplified by one or more stages of video amplification after leaving the second detector. This brings the signal level up to the value required, which langes from 20 to 100 v , depending upon the nature of the viewing tube

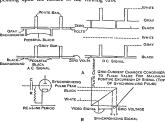


FIG 16 -D C SIGNAL RESTORATION (A) WAVE SHAPES FOR LIGHT AND FOR DARK BACKGROUND (B) RESTORER CIRCUIT

The output of a video amplifier of the type used in television is essentially an A.C wave, that is, the time integral of the amplitude over a complete frame (or several frames) is zero If such a signal were supplied directly to the viewing tube, the background level or average brightness of the reproduction of a dark scene would be about the same as that for a bright scene. This will be clear from a reference to fig 16a. However, the signal contains the information needed to determine the average scene brightness, in that the difference between the height of the synchronizing pulse and the picture signal itself is a measure of this value. Making use of this information, the picture is brought to its true brightness level by the D C restorer. In principle, the restoring circuit consists of a rectifier which charges a condenser to a voltage equal to the peak value of the synchronizing voltage, and adds the resultant D C. voltage to the picture as indicated in fig. 16b. The receiver is normally adjusted so that the synchronizing signal and the shoulder preceding and following it drive the viewing tube to cutoff (darkness) so that, during the return time of the deflection, an unwanted bright streak is not formed on the picture. Since the synchronizing signal is below the cutoff of the viewing tube this is sometimes termed "blacker than black" synchronizing The final signal from the chain of circuits described above, consisting of the picture signal with the D.C. or average brightness level added to it, is then supplied to the grid of the cathode-ray viewing tube. These tubes are described in some detail in the next section.

The receiver is provided with a number of controls which are used by the operator to adjust it to optimum performance. A channel selector switch tunes the set to any one of the several bands in the portion of the radio spectrum within which it is designed to operate. Associated with this is a fine tuning adjustment. This is of particular value in obtaining optimum adjustment of the audio channel. Controls governing the amplitude, distribution and centring of the deflection are generally semipermanent; however, vertical and horizontal synchronizing controls are frequently brought out for the convenience of the operator. The picture quality is governed by two adjustments. One of these controls the gain of the amplifier chain and is commonly (although somewhat incorrectly) called "contrast control." The second adjusts the level relative to the "black" shoulder of the synchronizing signal and is termed "background" or "brightness" control. It should be noted that this external background control does not take the place of the D.C. restorer, but is used in

which are part of the deflection generators. The basic principles conjunction with it. If it is adjusted so that a dark scene is only barely visible, the D C restorer will still cause the reproduction of a scene having a high average light level to be bright the external controls described above the receiver can be adjusted to give pictures having high entertainment and artistic values

#### TELEVISION VIEWING DEVICES

As has already been pointed out, even before World War II the cathode-ray tube had almost completely replaced all other means for reproducing television pictures The television cathoderay viewing tube consists of an electron gun and a fluorescent The gun screen enclosed in a highly evacuated glass envelope produces a narrow electron beam which is focused into a fine spot at the fluorescent screen. An external magnetic deflecting yoke driven by a deflection generator causes the spot to move across the screen in such a way as to sweep out a scanning raster. This laster is synchronized with that of the pickup device at the transmitter by methods which have already been described. The beam current and consequently the instantaneous brightness of the spot on the fluorescent screen is controlled by an aperture grid in the gun. The video signal from the transmitter is applied to this grid causing the spot brightness to vary in such a way that there is reproduced on the face of the viewing tube a duplicate of the picture at the pickup device Fig 17 illustrates the arrangement of elements in a cathode-ray viewing tube

Viewing tubes may be divided into two classes, direct-viewing tubes and projection tubes. These two types are the same in principle but differ in design for functional reasons. The directviewing tube has a large fluorescent screen on which the reproduced picture is observed directly. The projection tube, on the other hand, reproduces a small, very bright image, which can, by means of a suitable optical system, be projected onto a large screen similar to those used for home motion pictures

The guns producing the electron beam which scans the fluorescent screen in both types of viewing tubes are the same in principle as that described in connection with the iconoscope. They consist of a first lens system which includes the cathode, the control grid and the lens which forms the crossover, and a second lens imaging the crossover onto the screen. These guns. however, are required to deliver a much greater beam current than are those in pickup tubes and also to operate at a much higher voltage. This is because the power for the light produced by the screen comes entirely from the beam.

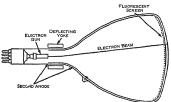


Fig. 17.—SCHEMATIC ARRANGEMENT OF ELEMENTS IN A CATHODE-RAY VIEWING TUBE

Small direct viewing tubes with screens 10 in. to 12 in. in diameter use guns operating at from 7,000 to 10,000 v. delivering a beam current of 100 µamp. or more. Larger tubes, up to 21 ft. in diameter, employ voltages twice as high and may have a screen brightness greatly exceeding that of an ordinary theatre motionpicture screen.

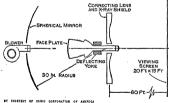
Since the brightness of a projection tube screen must be many times greater than that of a direct-viewing tube, the beam must deliver much more power. To obtain the power, the guns used are operated at a very much higher voltage. This voltage will urn from g to 50 kV, for tubes used in home receivers and may approach 100 kV. in theatre projection receivers. The beam current is also greater than that in even a large directly viewed tube. Just as with the pickup devices, the "spot" size at the screen must be small because overlapping of the scanning lines reduces vertical resolution. The very high beam current needed in viewing tubes make the spot size requirement very difficult to meet although this difficulty is somewhat reduced by the high voltage at which these purs operate.

The control characterastic of the grid in the first lens of the gun is very important. The control grid must be capable of varying the beam current from its maximum value to zero current (cutoff) upon the application of a relatively small range of voltages (e.g. 50 v.). It must present a high impedance to the driving crusts. Finally, it must be designed in such a way that the spot size is independent of beam current.

The fluorescent screen converts the energy in the electron beam into vasible light. Materials which are capable of performing this type of energy conversion at temperatures below in-candescence are known as phosphors. A great many inorganic and organic compounds are phosphors, but only a very few are at the same time sufficiently stable and efficient to be useful for television screen.

Early television screens employed natural willemate for their fluorescent sciens. This is a sinc orthositate which has a bright green luminescence under cathodo-ray hombardment. The screens were prepared by deposting a than layer of finely ground willemite on the inside glass end of the tube. As the study of phosphors progressed, it was found that synthetic will be produced with better colour, higher efficiency and more suitable characteristics. This material, though fairly suitafactory, was later replaced by zinc sulphide activators were even more efficient than synthetic willemite Furthermore, these materials can be synthesized in a variety of colours. By mixing blue and yellow sulphide phosphors in propei proportions, visually white screens can be produced.

Screens of the above-mentioned phosphors are in the form of a thin layer of the powdered material deposited on the glass face of the tube. Where the tube is to be operated at a high voltage  $(\epsilon, \epsilon, to k v, \sigma t move)$  the more surface of the screen may be covered by se extremely thin film of a light metal such as alumnum. This metal film, while dissipating some of the energy of the beam, performs a number of valuable functions. It increases the efficiency of the screen by reflecting toward the observer light is sainly



from the back of the screen which would otherwise be wasted sind also by maintaining full voltage on the screen. It increases contrast by preventing light being scattered by the inner walls of the bulb. It shields the screen from contamination during the proessing of the tube. Finally, it prevents, "burning" of the screen by loss formed along the beam path.

FIG. 18.-THEATRE TELEVISION PROJECTOR

In general, direct-viewing tubes are either mounted with the

fluorescent screen vertical so that the user sees the image on the screen directly or horizontally so that the observer may view the image reflected in a 45° mirror.

The projection tube requires a highly efficient optical system may be a reflecting system may be a conventional refractive system or it may be a reflecting system somewhat similar to the Schmidtpe objective. The latter has the advantage of greater optical efficiency since its effective aperture can be made greater than can that of a refractive system. Fig. 18 illustrates schematically a reflection-type theatte projection system. Heat the projection thus is mounted horizontally, facing a spherical mitror. The mirror images the fluorescent screen of the tube onto the viewing screen. An appear correcting lies is provided in the light path from the reflector to the viewing screen to reduce the image defects of the mirror.

#### TELEVISION BROADCASTING

A complete discussion of television program production and presentation is beyond the scope of this article. However, a few of the fundamental principles involved and the equipment required will be described.

Studio Programs.—The studio used for television programing resembles that used for sound broadcasting but is generally somewhat larger. Like the walls of a sound studio, those of a television studio are carefully treated to control reverberation. If the sound reflection is too small, the sounds picked up by the murcophones will be flat and unitareesting while if the reverbation is too great or has too long a time constant, it is difficult to obtain intelligibility.

The most important single item for the television studio is the provision for lighting. The light levels employed are fairly high, being of the order of 200 to 1,500 foot-candles incident upon the scenes being televised. Two types of lighting are required, diffuse overhead lights to provide even general illumination and spot or modelling lights to give the required dramatic effects by high lights and shadows. The overhead lights usually take the form of a large number of relatively small units right that a few large ones so as to avoid unwanted shadows. These units can be controlled in small banks to permit regulation of the amount and distribution of light in the studio. The spotlights are, in general, such that they can be located around the sets as required.

Where incandescent lights are used, they are a considerable source of heat. It is, therefore, essential to equip the studio with a large-capacity ventilating system and preferably with air conditioning. The high-intensity spotlights are usually provided with heat-shorbing filters to prevent overheating of the set by direct infra-red radiation.

The scenery and stage props used in television productions more nearly resemble those used for motion pictures than those used for the theatre. This is because the direction of viewing is strictly limited in the case of the theatre, while a movie camera or television camera may view the scene from any angle. However, the sets possess a number of properties which are distinctly characteristic of television. In general, they are simpler and bolder in their design, and depend upon over-all composition and atmosphere rather than minute detail to tell their story. The scenery must also be arranged in such a way that it can quickly and silently be changed or taken down without interfering with the view or sound of any other set in use at the time.

It is customary, in presenting a television studio production, to have all of the sets which are to be used located in different parts of one studio. This has been found to be more satisfactory than locating them in different studios, both from the standpoint of direction and of utilization of cameras. The sets must be arranged so that there is no interference between them and so that the cameras can be readily moved into all the positions required counters are used rather than a single unit. By employing more than one camera, it is possible to shift the direction of view rapidly and without interruption of the program. In particular, it permits changing from a distant view of the subject to a close-up without break. Again, when transferring from one studies set to

scene while another is being focused on a new set,

The cameras used in different studios differ in detail of design but in general are similar in principle. The pickup tube is so mounted in the camera that the objective lens images the scene dinectly on the mosaic of the tube. Usually objectives of various focal lengths will be required. For this reason turret lenses are most essential All of the lenses used must be of the same high quality as those employed in good cameras so that the optical system will not cause loss of image quality. The lenses should be fast but not excessively so because most action requires considerable depth of focus. Lens speeds between F/4 and F/7 are commonly employed.

As has already been mentioned, the camera includes such items of electrical equipment required for the operation of the pickup tube as the preamplifier and the deflecting yoke In addition to the electrical equipment associated with the pickup tube, motors are frequently provided for moving and raising the camera. Also, electrical communication means are arranged so that the camera operator is at all times in contact with the control 100m and program director

The camera must be equipped with an accurate view finder. Not only should it permit exact framing of the picture, but also it should indicate the sharpness of focus of the objective over the range of distances for which the camera is to be used. The widely used monitor-type view finder fulfils these requirements.

In order to ensure maximum versatility of the camera, it is mounted on a stlent, smooth-running dollie. Some are motor driven, but many are moved by hand Means for raising and lowering the camera are provided, as well as for tilting and rotating (panning) it about a vertical axis.

The microphones used for television resemble those used for sound motion pictures rather than broadcast microphones Boom microphones are employed which can be located directly over the actors without showing in the picture.

A great many special techniques have been developed for program production These combine modifications of motion-picture and theatre practice with new methods worked out especially for the television art. Like motion pictures, the stage set can be viewed from all directions and distances. Also, transfers can be made from one set to another without appreciable time delay, However, unlike motion-picture production, once the action has started it must continue smoothly and without interruption for the entire program-there can be no "retakes" or breaks in the sequence. Studio plays can frequently be effectively supplemented by scenes from motion-picture films This adds range and scope to the production without detracting from the almost undefinable spontaneity obtained with live talent. Model sets, animated figures and puppets can also be very effectively used

The variety of subject matter suitable for studio programs is very large indeed and includes plays, operas, musicals, variety acts. quiz programs, news and interviews and courses of instruction, to name only a few of the possibilities. It is very necessary to maintain close coordination among the various elements making up the production. For this reason a control room is usually located adjacent to the studio, containing the monitoring equipment and also having a large window overlooking the studio. The program producer and control operators are able to see the studio action directly through the window and at the same time watch the reproduced pictures from the several cameras on viewing screens of the monitors These directors are in communication with key individuals at the cameras and set by means of interphones and are thus in a position to supervise the entire production.

Film Pickup.-Material recorded on motion-picture filmseither special shorts or full-length feature films-is used extensively in television broadcasting. Obviously it is important to be able to use standard motion-picture film for this purpose, rather than special film. Otherwise the expense of recordings would seriously curtail their usefulness. Standard motion-picture film runs at 24 frames per second, and in order to prevent sound and action distortion, it must be used at this speed in television transmission. Therefore the problem exists of designing a projector

another, one camera can transmit the closing portions of one which permits the television transmission of 30 frames per second of a film running at 24 frames per second.

second of a him running at 24 Itames per second.

The most practical solution to this problem is a method which depends upon the storage properties of the teconoscope. A motion-precure projector is arranged to project an image of the film onto the mosaic of the teconoscope. A rotating shutter allows the picture to be flashed onto the mosaic country of the second The flash occurs during the return time of the seaning pattern (note the electron beam and teconoscope is biased to zero current during the relumn timely the return time of the seaning pattern (note the electron beam and teconoscope is biased to zero current during the relumn timely timely the relumn timely to the relumn timely timely the relumn timely timely to the relumn timely timely the relumn timely timely to the relumn timely tim duration is somewhat less than the return interval During this period unation is somewhat less than the return interval. During this period a charge image is accumulated on the mosaic. As the beam scans the mosaic, it converts this charge image into the video signal, the mosaic being in darkness during this time. The intermittent of the motionbeing in darkness during this time. The intermitting of the motion-picture machine is so constructed that every other frame remains in front of the lens 50% longer than the intervening frames Thus, one frame is before the lens a sec and is used for three flashes, and the next 2 sec, and is used for two flashes. It will be seen that the total time for two frames is a sec which equals the normal running time for two frames at 24 frames per second

uer wor trames at 24 trames per second
Unsully more than one projector is repensably arranged so that the
when changing film even the control of the control of the control
when changing film even the control of the control
when changing film even the control
when the control
when the control
when the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the control
the cont

Outside Pickup .-- A great deal of very interesting television material is to be found in events occurring outside of the studio Some of them are scheduled, such as sporting contests, public celebrations and exhibitions Others, however, are spot occurrences which cannot be accurately predicted

The equipment required for this service includes, in addition to one or more cameras, monitoring units and means for relaying the picture to the central control room and main transmitter Suitable sound nicrophones must be provided to supply the sound which accompanies the picture and also a two-way communication system between the camera operator and the central control room

camera operator and the central control room.

The camera used for outside pickup must be capable of much higher sensitivity than those for studio. Therefore portable cameras are presented to the control of the contr lack of light With tubes such as the image orthicon this does not occur because the camera can continue to "see" almost as long as the human eve.

The cameras are of course made as compact and lightweight as possible so that they can be easily moved into position. A cable connects them to the monitor and relay transmitter. These may take the form of a number of small manually portable units which can be carried to almost any location When reduced to such small dimensions some same time made in performance and operating flewibility. However, units of this type are capable of providing high-quality television

DEADLESS the control and monitoring equipment used for such pickup may be very complete to provide for maximum flexibility. One very practical mobile unit which has given excellent service over a number of years may be described as an example. The equipment is housed in power generators, while the other includes the control and monitoring equipment for several (ameras and the cameras themselves. The equipment for several cameras and the cameras themselves. The cameras can be mounted on top of the video truck if desired, or can be located away from the truck and connected to it by cable. In the video truck are racks containing sight and sound monitoring equipment, cor-recting controls, synchronizing equipment, hine amplifiers and provi-sions for the intercommunicating system both to the cameras and to the main control room at the broadcast transmitter.

The transmitter truck contains all the equipment needed for an ultrahigh-frequency relay transmitter, including a highly efficient collapsible antenna. This transmitter is capable of maintaining good serva-

lapsible antenna. This transmitter is capable of maintaining good service over many miles

Television Networks.—As the television art develops, the prob-Television Networks.—As the television art develops, the proportion of chaining a number of stating of relaying programs over large distances will come increasingly into the foreground. Two means are available for forming ledevision networks. One of these is a chain of radio relay links, the other wise-frequency-band coaxial cables are used, each link consists of a receiver and transmitter which there exp the television signal from the preceding station and retransmit it to the one following. These transmitters and receivers are highly directional and operate at a much higher frequency than television becomes the early stages of television chaining, it there is every reason to believe that eventually they will be completely automatic.

Coaxial cables have also been found to be very satisfactory for inter-connecting television stations. The initial cost of installing cables for

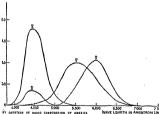
this purpose is high but, once installed, the operating expense and maintenance are low

In the years prior to and following World War II a great deal of in the years prior to and one-lowing world wat it a great dead or experimental work was done on both types of television chains. By the 1950s a network of coaxial cables and microwave links covered virtually all of the United States Television networks had also been established in England and in continental Europe

Colour Television .- An obvious goal of television is the obtainmed 4 a. 1 the commentation of the commentatio ing of a bright, high-definition picture in natural colours. Numerous methods of achieving this result suggested themselves to early workers

blue-sensitive centres.
The presence of on the tree types of sensory centres in the ere nake.
The presence of only three types of sensory centres in the ere nake.
The presence of the content, its green content and its blue content.
These colour components may be separated out, x.e., by passing the light from the object through appropriate red, green and blue filters.
original colour of the object. Strainfly, if the light flux passed through the filters falls on three photocolls, dectrical signals are generated which measure the red, green and blue content of the light.

There signals may be transmitted to another location and be employed there to reconstitute the original colour by controlling the excitation of red, green and blue phosphors in the proper proportion or of



BY COURTESY OF BASIC CORPORATION OF AMERICA FIG. 18,--INTERNATIONAL COMMISSION ON ILLUMINATION TRISTIMULUS SPECIFICATION OF SPECTRUM STIMULI. THE SPECTRAL RESPONSES OF THE SENSORY CENTRES OF THE AVERAGE HUMAN EYE MAY BE REGARDED AS LINEAR COMBINATIONS OF THE THREE CURVES

the same white phosphor, provided that appropriate red, green and blue filters are interposed between the phosphor and the wavevr. In all cases, the light elicited by the three signals is added to form the desired colour. The addition may take place by projection of the three lights in superposition on a screen; by placing the different-coloured brosphore demants as close together that they are not resolved by the

eve (a procedure similar to that employed in three-colour printing); or by presenting the three colour components in such rapid succession to the eye that persistence of vision merges them into a single sense impression

The last method is employed in the field-sequential system with red, green and blue filters rotates in front of the camera tube in synchronism with the field scan, so that picture signals corresponding to synchronism with the held scan, so that pacture signals corresponding to a red, a green and a buc component field are generated in succession a red, a green and a buc component field are generated in succession through a second filter disk or drum, rotated in exact synchronism with the disk at the transmitter. The viewer thus sees a red, a green and a blue component field of the scene televised in such input succession that the fields merge to form a shighe natural-colour preture of

The field-sequential system would require the threefold frequency band width to transmit a picture with the resolution and freedom from fincker characterizing black-and-white television. In order to ac-6-mc channel, the 1950 standards reduced the line number to ac-6-me channel, the 1950 standards reduced the line number to 495, the repetition site of a complete colour picture to 24 pictures per second, ably even more serious than this logs in picture quality was the lack of 'compatibility' of the field-sequential system. Since both is field frequency (144 instead of 60) and its line number (ago instead of 25) visual serious control of the with obsolescence if colour broadcasting would get under way on a large scale

large scale
An early realization of these difficulties led RCA to the development
of its simultaneous, compatible colour system, which uses the signal
amount of its simultaneous, compatible colour system, which uses the signal
arrangement for transmitting and receiving signals under these standards. With this compatible system a colour broadcast is received by
a colour receiver in natural colour and by a standard black-and-white
receiver in the proper half tones, with undaminabled resolution. This is
superposition. The frequency components of the colour signal are all
odd multiples of half the frame frequency. Consequently, they reverse
polarity in successive frames and have no effect on the brightness of
the picture averaged over two successive frames. The viewer of a
proper high highs and half forms in the picture, undisturbed by the
presence of the colour signal. In the colour receiver, on the other hand,
a special colour dector regenerates difference signals between the red,
green and blue component picture signals and the brightness signal,
dations of the brightness signal and the difference signals, family, yields
knescope, reproduce the televised scaes in natural colour on the viewing
screen. An early realization of these difficulties led RCA to the development

Fig. 20 shows the simultaneous generation of the red, green and blue component segnals by three camera tubes, an optical beam splitter serves to project the red, green and blue component pictures of the scene to be televised on their photosmatric surfaces. The three signals scene to be televised on their photosmatric surfaces. The three signals addition as matrix unit derives from them orange-cyan (blue) and addition as matrix unit derives from them orange-cyan (blue) and addition as matrix unit derives from them orange-cyan (blue) and addition as matrix unit derives from them orange-cyan (blue) and addition as matrix unit derives from them orange-cyan (blue) and addition as matrix unit derives from them orange-cyan (blue) and multiple of half the life frequency. Addition of the modulator out-by the life of the company of the modulation of the orange of the company of the orange of the Fig 20 shows the simultaneous generation of the red, green and

usual manner.

In the receiver a band pass filter selects out the colour signal (along with unwanted high-troquency video components, whose effect average signals are recovered by two demodulators an quadrature, synchronused with the subcarrier modulators. A matrix unit derives, finally, the end, green and blue difference signals, which are employed for the rerest, green and blue difference signals, which are employed for the reture on a standard black-and-white frequency channel without apture on a standard black-and-white frequency channel without apture on a standard black-and-white frequency channel without apadaptation of the system to itrea white frequency channel without apadaptation of the system to itrea white frequency channel without apparticular, the resolving power of the eye is much less for colour difference than for brightness differences and, furthermore, less for colour
firement than for brightness differences and, furthermore, less for colour
ange from or nargare to evan. Furthermore, estlandards in britain in an differences in the range between blue-green and magenia than in the range from canage to cyan. Furthermore, oscillations in brightness are less percoptible as filcker at lower frequencies if the emitting areas are small than if they are large. In the system these facts are utilized by limiting exact colour reproduction to 0.5 mc, (about 8 picture elements along a line). More rapid variations in colour are approximated by variations in the colour range between orange and cyan (two-colour radiation), whereas the finise the cital (above 1.7 mc, or finer than 3 picture elements) is reproduced simply as a variation in black and white content. Finally, in coloured "areas, the superposation of the colour

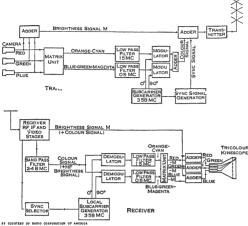


FIG 20 -SCHEMATIC DIAGRAM OF COMPATIBLE COLOUR TELEVISION SYSTEM

signal on the brightness signal signifies that areas of the order of a pic-

signal on the brightness agnal againse that areas of the order of a picture element (dots) are reproduced with a repetition rate of only 15 per second, as compared with a repetition rate of 30 for lines and 65 for The Theorem 15 and 15 for Theorem 15 and 15 for Theorem 15 for



DIG CORPORATION OF AMERICA FIG. 21.-CUTAWAY VIEW OF SHADOW-MASK TRICOLOUR KINESCOPE

in precise superposition and present natural-colour picture

Industrial Television .- Television has been considered chiefly as a means for the distribution of visual entertainment and instruction from a central station. This is only one, though a very important one, of its functions More generally, television finds application whenever the best vantage point for whenever the best vantage point for the observation of a process of an object is not readily accessible. The maccessibility may be the result of remoteness or the inability of one observer to be in two or more places, of cramped quarters or the impossibility of many observers being at the same spot, of danger to life and limb or of discomfort resulting from excessively high or low temperatures, or it may be a matter of economy of time and effort In of economy of time and effort all these instances it becomes advantageous to place a television camera at the best vantage point and to link it to one or several receivers located at the most convenient points for observation. The to cover all such closed-circuit applications, in brief, virtually all forms of television apart from broadcast television

It is of interest to list a few of the es to which industrial television

had been put in the 19505.
In industry the remote observa-In industry the remote observation of furnaces and gauges in power
stations, the control of furnace
castings and the loading of cars at
castings and the loading of cars at
railway sadings in steel mills, the
tevision system
the control of shells in ordnance
depoits and the manupulation of
raducative materials, the observation of rodest engines during test,
salvage operations on sunkes this first

salvage operations on sunken ships

salvage operations on sunken ships
In commerce sales exhibits in department stores, surveillance of
banking activities, plant demonstrations for stockholders' meetings
In education distribution of demonstration factures to several
classes, closs-range viewing of experiments by large groups, demonstraclions with the microscope and micromanspulator, observations of Surgicial
operations, eventually also in colour or in three dimensions, by medical
students and visting physicians, viewing of feld manoeuvies by army

In research: study of biological microspecimens with enhanced contrast and with (e.g., ultra-violet) illumination to which the eye is meanitre, acceleration of routine measurements such as blood counts, observation of combustion processes; handling of radioactive isotopes

The major differences between industrial and broadcast television equipment reside in the camera and camera control. The industrial telesion camera must be compact, mexpensive, rugged and easy to operate.

value assume a must be compact, incremeity-rusgical and easy to convoice the plan plane and plan

located as much as 3,000 ft. from the control unit In combination with a light microscope, the Vidion camera forms a "television microscope," which presents pictures of a microscope, eventually with electronically enhanced contrast, on a large viewing screen. With special ultra-violet-enesitive Vidicous this permits the direct viewing of finest structural detail with ultra-violet illumination of direct viewing of finest structural detail with ultra-violet illumination. A simplified version of an industrial television system, the "TV byc," detailed power and desictions signals for the Vidion camera from a detailed power and desictions signals for the Vidion camera from a standard receiver, greatly reducing the cost of the system.

Several manufacturers produced field-sequential colour television chams with wide transmission channels (to or 18 me for example) to give the required high resolution. These have found use, in particular, in the transmission of surgical operations. Stero techniques have been found useful in the same application as well as in the manipulation of radioactive materials.

lation of radioactive materials
BERLOGARRY—V. K. Zworykin and G. A. Motton, Television—
the Electronics of Image Transmission, and ed. (New York, London,
London, 1924). B. Hubbell, Television. Programming and Production
(New York, 1945; London, 1946). B. TELFORD, THOMAS (1757–1824), British evil enginer
TELFORD, THOMAS (1757–1824), British evil enginer

TELFORD, THOMAS (1757-1844), British cutl engener was born at Westerkirk in Eakchle, Dumfriessher, Aug 9, 1757. At 15 he was apprenticed to a stonemason. He studied in his spare time, and published verses in the local prees In 1750 he want to Edinburgh, where he was employed in the erection of houses. In 1730 he was appointed engineer of the Ellesmer canal, for which he built the Chrk and Pont-y-Cysyllte aqueducts, and this work established his reputation as a canal engeneer.

Telford was commissioned by the British government to report on the improvement of communications in the Highlands of Scolland. He was appointed engineer for the Caledonian canal and for the construction of 20 min. Or roads, a great part through difficult country. He was employed on the improvement of the road between Carlisle and Glasgow, on plans for a system of roads through the more inaccessible parts of Wales, which included the magnificent superson bridge across the Menal straits, and the Conway bridge. The fisheries and industries of Scotland benefited by the improvement in the effected at many of the harbours, and list has been of procleanly work was more than the contract of procleanly work was more than the contract of the contrac

BIRLIOGRAPHY —S. Smiles, The Life of Thomas Telford (London, 1867), T. Telford, Allas to the Life of Thomas Telford, Civil Eng. (London, 1838), Life of Thomas Telford, Written by Himself (London, 1838), Life of Thomas Telford, Written by Himself (London, 1838); A Gibb, The Story of Telford; the Rase of Crvil Engineering

Clandon, 1949).
TELL, WILLIAM. The story of William Tell's skill in shooting at and striking the apple which had been placed on the head of his httle son by order of Gessler, the tyrannical Austrian ballist of Uri, is so closely bound up with the legendary history of the origin of the Swits confederation that they must be considered together. Both appear first in the 19th century, probably as resclie-of the war for the Toggenburg mehrenne (1446-59) class as resclie-of the war for the Toggenburg mehrenne (1446-59) class of China of Zirich, favoured the circulation of stories which assumed that Swis freedom was of immemorial antiquity, while, as the war was largely a struggle between the civic and rural elements in the confederation, the notion that the (tural) Schwyarrs were of Scandinavian descent at once separated then from and trassel them above the German inhabitation of the town.

The Tell story is first found in a ballad, the first nine stanzas of which (containing the story) were certainly written before 1474. It is probably to this that Melchior Russ of Lucerne (who began his Chronicle in 1482) refers when he excuses himself from giving the story. He narrates how Tell then stirred up his friends against the governor, who seized him and took him by boat to his castle on Lake Lucerne. A storm arose and Tell, on account of his great strength, was given the rudder, on his promise to bring the boat to land. He steered it toward a shelf of rock, called in Russ's time Tell's Platte, sprang on shore, shot the bailiff dead with his crossbow and, returning to Uri, stirred up the strife which ended in the battle of Morgarten. In these two accounts, which form the basis of the Uri version of the origin of the confederation, it is Tell who is the leader. We first hear of the cruelties of the Austrian bailiffs in the forest districts in the Bernese Chronicle of Conrad Justinger (1420), who makes no allusion to Tell. The Tell story and the "atrocities" story are first found combined in a manuscript, the White Book of Sarnen. They are contained in a short chronicle written between 1467 and 1476, probably about 1470, and based on oral tradition.

The task of smoothing away inconsistencies and rounding off the tale was accomplished by Giles Tschudi (q.v.), whose re-

cension was closely followed by Johannes von Müller in his History of the Confederation (1780) The final recension of Tschudi's Chronicle (1734-36), which differs in many particulars from the original draft preserved at Zurich, tells how Albert of Austria, in order to deprive the forest lands of their ancient freedom, sent bailiffs (among them Gessler) to Uri and Schwyz Their tyranny resulted in a 11sing, planned at the Ruth, on Nov 8, 1307, and led by Werner von Stauffacher of Schwyz, Walter Furst of Uri. Arnold von Melchthal in Unterwalden, each with ten companions, among whom was William Tell, to expel the oppressors On Nov 18 the Tell incident takes place (described according to the White Book version), and on Jan 1, 1308, the general rising. Tschudi thus finally settled the date, which had before varied from 1260 to 1334 He distorts the historical circumstances In his first draft he speaks of the bailiff as Gryssler -the usual name up to his time, except in the White Book and in Stumpff's Chronicle of 1548-but in his final recension he calls him Gessler, knowing that this was a real name Later writers added a few more particulars Johannes von Muller (1780) described the oath at the Ruth by the three (Tell not being counted in), and threw Tschudi's version into a literary form. Schiller's play (1804) gave the tale of a world-wide renown.

The general result of the researches of various students, J E Kopp, Vischer, Rochholz and others, has been to show that a mythological marksman and an impossible bailiff bearing the name of a real family have been joined with confused and distorted reminiscences of the events of 1245-47, in which the names of many real persons have been inserted and many unauthenticated acts attributed to them. T. von Liebenau has, however, shown (in an article reprinted from the Katholische Schweizerblatter in the Bollettino Storico della Svizzera Italiana for 1800) that in 1283 the Emperor Rudolf of Habsburg gave the right of receiving the tolls for escort over the St. Gotthard pass to his sons, the dukes of Austria The levying of these tolls gave rise to various disputes between the men of Uri and the bailiffs of the dukes of Austria and by 1319 (if not already in 1309) the claim to levy them was given up. These facts show (what could not hitherto be proved) that at the time when legend places the rising of Uri, Tell exploit, etc., the dukes of Austria really had disputes with Uri

The alleged proofs of the existence of a real William Tell in Uri in the 14th century break down hopelessly '(1) The entries in the parish regardst 2,0 at to the Tell chape's (2) That in the "hollow way" near Kussnacht was not known to Melchior Russ and is first mentioned by Tschudi (1572). (b) That on Tell's Platte is first mentioned in 1504 The document which alleges that this chapel was built by order of a Landsgemeinde held in 1388, at which 114 men were present who had been personally acquainted with Tell, was never heard of till 1750. The procession in boats to the place where the chapel stands may be very old, but is not connected with Tell till sout 1582. (c) The chapel at Bürglen is known to have been founded in 1582.

In general see two excellent works by Franz Heinemann, Tell Leonographie, reproductions, with text, of the chief representations of 'fell in art from 150' onward (Luceme, 1502), and Tell Bibbog aphie, (including that of Schiller's play), published in 1508 at Bern. See also W. Vischer, Die Soge von der Befreium 1508 at Bern. See also W. Vischer, Die Soge von der Befreium with a volume of documents 1250-1213 (Heilbronn, 1877); and P. Lang, Die Schweis, Fellipsiel (1524). (W. A B C; X)

TELLICHERRY, a seaport in the Malabar dustict of Madras state, republic of India, on the Southern milway between Cannanore and the French settlement of Mahê. Pop. (1957) do, oc. 0. It is healthful and picturesque town, built upon a group of wooded hills running down to the sea, and is protected by a natural breakwater of rock. It is the seat of the Government Brennan college, connected with Madras university. Ships are able to anchor z mil from the shore. The port has a pier and sea wall and can be used during the monsoon. Tellicherry was at one time defended by a strong mud wall and the old fort still stands north of the town. The East India company established a factory there in 1635 for the pepper and cardamont trade. For two years

(1780-82) the town withstood a siege by Hyder's general, and in the subsequent wars with Mysore, Tellicherry was the base for the ascent of the Ghats.

TELLURIUM, a chemical element and the third member of the sulphur family (symbol Te, atomic number 22, atomic weight 127 foi). It is a complex element, having eight stable isotopes with mass numbers, atranged in order of decreasing abundance, as follows 120, 128, 126, 125, 124, 123, 122 and 120. There are 14 artifically produced unstable isotopes, 4 of which have nuclear isomers. Unstable isomers of two of the stable isotopes have been produced. The United States Atomic Energy commission listed the following sotopes as available for distribution. Tell' 105 days), Tell' (12 days). Tell' (12 days). There are six electrons (52°, 59°) in the outermost man level.

In 1780 F J Muller von Renchesstein, in examining Transylvanuan gold marenls, suspected the presence of a new element in Westgolders and called it metallism problematicum or aurum poradoxum. In 1798 M H Klaproth extracted the element from the crude muneral and established its identity, giving the first differentation between the new element and antimony with which it had been confused. He named the element tellurum. It was not until 1832 that J J Berzelbus made a careful study of the chemistry of

the element

Occurrence.-Although widely distributed, the estimated percentage in the earth's crust is only 10-9. Rarely found as native tellurium, it commonly occurs as tellurides of copper, lead, silver, gold, iron and bismuth Typical minerals are sylvanite, (AuAg)-Te4, calaverite, AuTe2, muthmannite, (AuAg)Te, krennerite, (AuTe2), petzite, (Ag2AuTe2); tetradymite, Bi2Te2S, rickardite, CueTe, melonite, NiTe, and altaite, PbTe. Less common are the tellurites, telluric ochre, TeO2, durdenite, Fe2(TeO2)2 4H2O, and tellurates as montanite, Bi(OH), TeO, and ferrotellurate, FeTeO4. The tellurides occur with the sulphides of copper, silver, gold and nickel. Red tellurium sulphur of Japan contains 99 76% S, o 17% Te, o o6% Se and o or % As. Tellurium minerals are found in the United States, Canada, Mexico, South America, Sweden, central Europe, Northern Rhodesia, the U.S.S.R and Japan. The chief sources of tellurium are the slimes from copper and lead refineries and flue dusts from processing of telluride gold ores

Methods of Production .- The crude copper anodes used in the electrolytic refining of copper contain a high percentage of selenium and tellurium which was present in the ore. Upon electrolysis of the copper, the selenium and tellurium and other valuable elements (gold and silver) settle in the electrolyte as anode mud. Although procedures for the recovery of tellurium are not identical in this and other types of residues, the general principles include fusion with sodium carbonate and nitrate or extraction with sodium hydroxide, neutralization of the water solution of sodium tellurite to form precipitated tellurium dioxide and, finally, dry reduction of the tellurium dioxide by means of a mixture of flour and borax to form molten tellurium. An alternative method includes solution of the dioxide in hydrochloric acid and reduction with sulphur dioxide to form precipitated tellurium Tellurium appears on the market in the form of bars, as ground crystalline tellurium or as dry precipitated powder. Some tellurium has been redissolved in nitric acid (specific gravity 1.2) and crystallized as basic nitrate

Physical Properties .- Tellurium is a brittle, silvery white, metallic substance with density 6 24; it melts at 449.8° C and boils at 1,390° C.; its hardness is 2.3 (Mohs). It crystallizes in hexagonalrhombohedral prisms and is isomorphous with the stable gray modification of selenium Its allotropy is less well defined than that of either selenium or sulphur. It was presumed that amorphous and crystalline modifications of tellurium existed X-ray defraction has shown that precipitated tellurium is not amorphous but crystalline (hexagonal). Colloidal preparations are easily made by reducing dilute solutions of telluric acid with hydrazine or sulphurous acid, with or without protective colloids. Alpha particle bombardment of tellurium produces Xe132. The vapour of tellurium at the boiling point is diatomic Te2. Tellurium vapour lamps containing also mercury provide almost a continuous spectrum which approaches the characteristics of daylight. Transmission is in the red (7,200-5,950 A) 14.5%, yellow (5,950-5,650 A) 21-KK

22 5%, green (5,650–4,950A) 56% and blue (4,950–3.500 A) 7%.
Chemical Properties.—Tellurum occurs in Group VI of the
periodic system with oxygen, subphur and selenium. In the second
long series of 18 elements, it hes between antimony and iodine. Although strongly electronegative, tellurum is less so than selenium,
sulphur or oxygen. Tellurum exhibit valence states of −2, +2,
4 and +6 These are illustrated by (−2) hydrogen telluride
and the tellurides, (+2) tellurum monoxide and tellurum dichloride, (+4) tellurum dioxide, telluride and the tetra haldes, (+6) tellurites and the
tetra haldes, (+6) tellurium trioxide, telluric acid, the tellurites
and the hexafluoronde.

Compounds,-Hydrogen telluride (H2Te) is prepared by the action of hydrochloric acid on aluminum or magnesium telluride or by action of water on aluminum telluride (Al<sub>2</sub>Te<sub>3</sub>) Pure H<sub>2</sub>Te is reasonably stable but dry or moist reacts readily with oxygen to form elemental tellurium and water. Both melting and boiling points of H2Te are lower than those of water and H2Te is less polar Its solubility in water is at least o on moles per litre at 760 mm pressure. Hydrogen telluride is both a stronger reducing agent and a stronger acid than either hydrogen sulphide or hydrogen selenide The respective constants for the primary ionization of H2S, H2Se and H2Te are 1 15×10-7, 1 88×10-4 and 2 27×10-3 Like H2S and H2Se, H2Te has a very disagreeable odour and is very toxic. Sodium telluride (Na2Te) is prepared by a direct combination of sodium and tellurium in liquid ammonia; an appropriate excess of tellurium dissolves the precipitated Na2Te and yields a polytelluride (viz , Na2Te1-Na2Teb) Hydrogen telluride may be added to aqueous solutions of sodium hydroxide to form NaHTe or Na2Te Air or oxygen must be excluded since oxidation will cause complete precipitation of tellurium. The +2 valence is illustrated by tellurium monoxide (TeO) and tellurium dichloride (TeCla). The former is prepared by heating tellurium sulphite in vacuum at 200° C, the products being tellurium monoxide, TeO, and sulphur dioxide, SO2 Tellurium dichloride is prepared by the direct union of chlorine and tellurium, an excess of chlorine yielding the tetrachloride,  $TeCl_4(+4 \text{ valence})$ . Similar iodides and bromides have been prepared. All are solids at 25° C. The tetrachloride and the tetrabromide melt at 214° and 380° and boil at 414° and 421° C respectively The chlorides or bromides react rapidly with water according to the following type reaction, 2 TeCl2+2H2O=TeO2+ 4H++4Cl- Although only slightly soluble in water, tellurous acid, H2TeO3, and its salts are known. Ionization constants have been reported for tellurous acid;  $K_1 = 2 \times 10^{-3}$  and  $K_2 = 20^{-8}$ . Dissolved in strong acids,  $TeO_2$  forms the positive ion (TeOOH)+. The alkali tellurites are subject to air oxidation at elevated temperatures

Tellurium dioxide can be prepared by heating the trioxide above its melting point but is most commonly prepared by the ignition or neutralization of tellurium basic nitrate, 2TeO2.HNO3. The hexafluoride, telluric acid and the tellurates illustrate the +6 valence for tellurium. Contrasted with the other halides, the hexafluoride has a much lower melting and boiling point, -37 8° and -38 9° C respectively, and a much higher heat of formation, 315,-000 cal Othotelluric acid (HaTeOs) is easily prepared by the chromic acid oxidation of tellurium basic nitrate or the hydrogen peroxide oxidation of an acid solution of tellurium dioxide. A solubility curve for telluric and shows H:TeO4.6H2O the stable form below 10° C. and H2TeO4 2H2O the form crystallized above 10° C. Salts of the hypothetical acids pyrotelluric, H2Te2O7, and tetratelluric, H2Te4Om, are known Orthotelluric acid loses water upon heating. Conversion to tellurium trioxide, TeO3, is complete at 300° to 360° C. The conversion to metatelluric acid, HaTeO4, is considered doubtful. If orthotelluric acid is heated in a closed tube at 140° C., a viscous liquid, allotelluric acid,  $(H_2TeO_4)_{\eta,\eta}=c.$  2.9, is formed. Presumably the transition point between orthotelluric and allotelluric acid is 131° C. Allotelluric acid is a relatively strong acid and exhibits properties quite different from those of the ortho acid. It is soluble in alcohol and separates sulphur from sodium thiosulphate. Upon standing, aqueous solutions hydrolyze and form orthotelluric acid, HaTeOs. Two new acids have been reported, HeTeCle.2H2O, citron yellow, and HeTe-Bre, red. Both tellurites and tellurates form co-ordination compounds such as ammonium ditelluratohexamolybdate, potassium chromotellurate and ammonium triarsenatotellurate

Organic compounds vary in complexity from the relatively simple alkyl tellurides to the more complex cyclic compounds which contain tellurium in the ring There are simple aliphatic com-pounds of the types, R<sub>4</sub>TeX<sub>2</sub>, R<sub>4</sub>TeX and RTeX<sub>3</sub> Among the aromatic derivatives there are types R2Te, R2Te2, RTeR' J A. N Friend gave an excellent review of organic compounds of tellurium and their preparation

Uses .- Although comparatively large supplies of tellurium are available no single use has been developed which creates large demand for this element Early attempts to use tellurium in metallurgical products seemed to indicate that the addition of tellurium to the alloys of aluminum, tin, certain steels and cast iron gave undesirable properties. Apparently too much was added, for it has been reported that small concentrations of tellurium in aluminum alloys increases ductility, in tin alloys increases the hardness and tensile strength and in stainless steels increases the machinability. Appreciable increase in the depth of chill in iron can be obtained by addition of minute amounts of tellurium. The addition of 0.05% Te to lead increases its resistance to corrosion. In manganese-magnesium alloys tellurium increases resistance to corrosion. Tellurium has been used as a brightener in certain plating baths. A beryllium-copper-tellurium alloy has been reported. Selenium-copper and tellurium-copper alloys used to make arc tips for electric contacts possess antiwelding properties. Selenium and tellurium in copper or copper-rich alloys improve machinability without producing "hot shortness" Both are used in preference to sulphur. In tin-rich alloys like Babbitt metal the addition of tellurium refines the grain structure, aids casting and improves physical properties at high temperatures. Tellurium in hydrogenation and cracking catalysts, used for conversion of heavy oils to motor fuels, reduces carbon formation. The addition of o 1% to 2%. tellurium in rubber compounding improves resistance to heat, oxidation and abrasion and increases resiliency. Some organic tellurium compounds have germicidal properties and diethyl telluride possesses antiknock characteristics. This latter use has not been important since it is accompanied by a disagreeable odour Zinc tellurite has been patented as an antifouling paint. Tellurium has been used to a limited extent in colouring glass or porcelain, large colloidal particles giving a blue colour, small particles a brown colour and telluride a red to red-violet colour. Acid solutions of dioxide have been used as a dip for silver ornaments, giving a "platinum finish" to the metal. Soluble tellurium compounds are used in toning baths in photography. There are no common therapeutic uses for tellurium or its compounds at present. As little as 1 mm(micromole) of tellurium taken into the human system gives the breath a penetrating garliclike odour, which may appear in less than half an hour after the ingestion of the tellurium Although not well documented, 2 g. of tellurium as sodium tellurite may be a lethal dose. The use of colloidal tellurium as a fungicide and insecticide in wood preservation has been reported. This had not become common practice by mid-century.

In the 1940s and 1950s a variety of articles were published in technical journals on such topics as effect of tellurites on pyruvic dehydrogenase, catalyst in Kjeldahl digestion, effect on electrodes for the electrolysis of sodium chloride, grain growth of chromium steel, effect on hydrogen absorption by steel, effect on iron car-" bonyl, tellurites as poisons for enzymes, solution of tellurium mirrors by free radicals and the catalytic hydrogenation of shale oils. However, no new use was reported which would contribute to large-scale consumption of tellurium or its compounds.

Analytical.-Like selenium, tellurium is easily precipitated from dilute hydrochloric acid solutions by reducing agents such as sulphur dioxide or hydrazine hydrochloride. Two common reactions are used for the separation of tellurium from selenium; red selenium is precipitated from strong hydrochloric acid solutions, by sulphur dioxide, tellurium is not. Upon separation of the selenium by filtration, the solution is diluted and the tellurium precipitated by further addition of sulphur dioxide. The fusion of selenium and tellurium with potassium cyanide forms potassium selenocyanate. -KCNSe, and potassium telluride, KaTe, Bubbling air through a water solution of this mixture precipitates elemental tellurium. The addition of potassium iodide to a dilute acid solution of tellunum precipitates tellurium tetraiodide, TeI4, which is soluble in an excess of potassium iodide, forming K2TeIs Tellurium is commonly weighed as the element

Tellurous acid may be oxidized to tellurate by potassium permanganate. Tellurates are reduced quantitatively by titanous chlorade

chloride Binizionapity — R. Abegg, F. Auerbach and I. Koppel, Handburk der Anorquaischen Chemie, vol vi, with a chapter on the colloid chemistry of tellurum (Leppilg, 1927), B. S. Tigophian, Chapters in the Victor Lenher, Miscellancous Papers, U.S. Atomue Energy Commesson, astope Division, no 4 (Golk Ridge, Tenn., 1957), Joseph William Melor, Comprehensive Treatine on Integrate and Theoriest Chemistry, 4th of two, et al. (1988), p. 1988, p. 1989, p. yearly supplements); Don M. Yost and Horace Russell, Systematic In-organic Chemistry of the Fifth-and-Sixth-Group Nonmetallic Elements (New York, 1944, London, 1946) John Albert Newton Friend, Test-book of Inorganic Chemistry, vol xi, part iv (Philadelphia, London, 1937); Charles Palache, Harry Berman and Chiford Frondel, System of Mineralogy of James Dwight Dana and Edward Salisbury Dana (New York, 1944; London, 1945) (V W M) York, 1944; London, 1945)

TELPHERS: see MONORAILS AND TELPHERS

TELUGU, one of the five great Dravidian languages. The Telugu-speaking peoples occupy an area beginning north of Madras city and extending northwest to Bellary, where Telugu meets Kanarese, and northeast to near Orissa In many respects it occupies an independent position and can be characterized as the only descendant of the Andhra dialect of Old Dravidian.

See Bishop Caldwell, Comparative Grammar of the Dravidian Lan-uages, and Linguistic Survey of India, vol iv (1906). TEM, a people in northwest Dahomey speaking a language related to Kokomba. They live in extended family groups in com-

pounds in villages surrounded by a defensive wall. TEMBU (Ama-Tembu), a powerful Kaffir tribe, which has given its name to Tembuland, a division of Cape Colony southwest of Griqualand East. They are traditionally descended from Tembu, elder brother of Xosa, from whom most "Kaffirs" claim

TEMENOS, the Greek term in archaeology given to the enclosed sacred area around a temple or sanctuary

TEMPE, VALE OF, the ancient name of the gorge, through which the Peneus river (mod Salambria) reaches the sea from the plain of Lower Thessaly. Greek legend attributed this chasm to Poseidon; before it was riven, between Olympus and Ossa, Thessaly was a lake. It is about 41 mi. long, and toward the middle of the pass, where the rocks are highest, the precipices in the direction of Olympus fall steeply to the stream, but those which descend from Ossa are the loftiest, for they rise in many places not less than 1,500 ft. from the valley. It was a position easily defended, but has often offered a practicable entrance to Thessaly from the north; a number of castles (of which the ruins still exist) were built at different times at the strongest points. The mediaeval road follows sometimes one bank, sometimes the other; the railway is wholly north of the stream. Being still forested, with numerous lateral valleys, the gorge is unusually picturesque for Greece its beauty was famous in antiquity. Tempe was sacred to Apollo, to whom a temple was erected on the right bank. Every ninth year a sacred mission visited the valley to pluck laurel for the chaplets for the Pythian games.

TEMPERA, the name given to the painting processes in which the medium employed is an albuminous, gelatinous or colloidal material. Practically, this is equivalent to saying that any painting process in which a vehicle or binding material other

than oil is employed is tempera.

Alter a could be the first and the st

History.-The earliest known painting was undoubtedly of this nature. The wall paintings of ancient Egypt and Babylon and those of Mycenean Greece, as well as the mummy cases and papyrus rolls in the first named country, were executed in some form of tempera. The same is probably true of the wall paintings in Italian tombs. Yolk of egg, either alone or with the addition of a little vinegar, was the vehicle most generally used, but Temperance and Prohibition Organizations—In 1888 a temperance society was founded at Saratoga, NY, and nn 1813 the Massachusetts Society for the Suppression of Interperance and et as appearance. These seem to have been the entimerance and the sage and the superance and the sage and the same and the sage and the device of a pledge of abstunence had been introduced in 1800. The movement made rapid progress, manely under the influence of the churches In 1806 the American Society for the Promotion of Temperance was founded in Boston, and by sight there were 6,000 local societies in several states with more than 1,000,000 members. The campaign was, for the most part, directed against the use of distilled spirits only, and the proposal to include all alcoholic dranks in the pledge of total abstunence, though adopted by a few societies, was rejected in 1833 by the American society, but accepted in 1836 and retained thereafter

In Europe the earliest organizations were formed in Ireland A temperance club is said to have been started at Skibbereen in 1818. and others followed, but it was in 1820 that the organized movement began to make effective progress with the formation of the Ulster Temperance society By the end of that year there were 25 societies in Ireland and two or three in Scotland In 1830 the movement spread to Yorkshire and Lancashire, and supported a newspaper called the Temperance Societies' Record, according to which there were then 127 societies with 23,000 paying members and 60,000 associated abstainers. In 1831 the British and Foreign Temperance society was founded in London with the bishop of London (Charles Blomfield) for president and Archbishop John Sumner for one of the vice-presidents This important society, of which Queen Victoria became patron on her accession in 1837, came to an end in 1850, when the whole cause was under an eclipse The most remarkable episode in the temperance campaign at this period was the mission of the Rev. Theobald Mathew of Cork, commonly known as Father Mathew, greatest of all temperance missionaries He travelled through Ireland in the years 1838-42 and everywhere excited intense enthusiasm People flocked to hear him and took the pledge in crowds In 1841 the number of abstainers in Ireland was estimated to be 4,647,000, in three years the consumption of spirits fell from 10,815,000 to 5,290,000 gal. This was not all due to Father Mathew, because great depression and distress prevailed at the same time, but he exercised an extraordinary influence. In 1843 he went to England, where he had less (though still great) success, and in 1850 to America. He died in 1856, by which time the cause had fallen into a depressed state in both countries. In the United States a flash of enthusiasm of a similar but smaller character, known as the Washingtonian movement, had appeared. In 1845 a law prohibiting the public sale of liquor was passed in New York state but repealed in 1847; in 1851 Maine adopted prohibition.

The Church of England Temperance society, much the largest at miles of the church was founded in 1864 and reconstituted in 1873. It was incorporated in 1907, reconstituted again in 1911 and 1917, and recognized by the church assembly in 1923 It carries on an extensive publication department and educational course, spolice court and prison gate missions to seamen, travelling vans and ine-briate homes.

The United Kingdom alliance, founded in 1853, became the chief political organization. Its object was prohibition of the think trade, but it audopted the polity of local prohibition of the think trade, but it audopted the polity of local prohibition by means of local option. It began publication of the "national drink bill," a calculation of the national expenditure on alcohole liquors. Other legislative organizations in Britain are the National Temperance league, the British Temperance league, the National United Temperance Legislation league and others in Scotland, Ireland and Royal Naval Temperance society. International societies emurated are the World League Against Alcoholism, the World Prohibitive federation, the International Orders of Good Templars and the World's Woman's Christian Temperance union.

Thus temperance and total abstinence became the objects of the united efforts of education and legislation in many regions. This union was probably promoted in part by the fact that once a person has become an alcohol addict recovery usually requires total ab-

stinence. In later years the organized movement in many countries embraced both voluntary and compulsory abstinence and combined the inculcation of individual abstinence with the promotion of legislation for the reduction or suppression of the alcoholic liquor traffic. On the whole the latter predominated, particularly in the United States, where organized agitation made temperance or prohibition partly a political question and produced various experiments in legislation (See Promistrion) Besides combining the moral and the political elements the modern movements were characterized by the following features () international organization; (3) organized cooperation of women; (3) juvenile temperance; (4) teaching of temperance in schools and elsewhere, (5) scientific study of alcohol and incibriety.

International organization appears to have been started by the Order of Good Templars, a society of abstainers, formed in 1851 at Utica, N.Y It spread over the United States and Canada, and in 1868 was introduced into Great Britain Several years later it was extended to Scandinavia, where it became very strong Temperance societies had previously existed in Norway from 1836 and in Sweden from 1837, these seem to be the earliest examples on the continent of Europe The Good Templars organization also spread to several other European countries, to Australasia, India, South and West Africa and South America Several other international societies were founded, and international congresses were held, the first in 1885 at Antwerp, Belg. A World's Prohibition conference was held in London in 1909, attended by about 300 delegates from temperance societies in nearly all parts of the world. This conference resulted in the foundation of an International Prohibition federation, embracing every country in Europe with three or four minor exceptions, the United States, Mexico, Argentina, much of the British Commonwealth, China, Japan, Palestine, Tunisia and Hawaii.

Alcoholics Anonymous is an organization of former alcohol addicts who have recovered from this affliction and have become dual abstances. It is a national organization, started in the United States but gradually extended to other countries. The primary object of this organization is to aid, by education and personal service, other alcohol addicts to recover from their addiction.

Women's Organizations.—The organization of women, which has become international, dates from 1874, when the National Woman's Christian Temperance union was founded at Clevelard, O. It employs educational and social as well as political means in promoting legislation About 1883 Frances Willard, who had been the moving spirit of the union, carried this organization of women into other lands and formed the World's Woman's Christian Temperance union, which by the 1950s had branches in about 50 countries.

Javanile Groups.—The inclusion of children in temperance organization goes back to faq, when a society of inventile obstainers who had taken the piedge was formed at Leeds; it took the name of Band of Hope. The practice spread, and in 1874 n Band of Hope union was formed. Within the next century a number of such unions were established, in Sociand, Ireland and separate counties in England; the Bands of Hope were said to number 13,000 in

School Programs:—The teaching of temperance in schools, a feature of social education and moral programda, was began by private effort in 1852 when John Hope insuguated a regular weekly " visitation of day school is Edinburgh. In 1875, at the mvitation of the National Temperance league, Sir Benjamin Richardson wrote his Temperance Leation Book, which was adopted by many schools as a primer. In 1889 school teaching by travelling lecturers was taken up by the U.K. Band of Hope union, and the example was followed by many other societies which spent large sums on itherant lecturers. The Church of England Temperance society carried on similar work. In 1906 the board of education in Ireland made hygiene and temperance a compulsory subject in the public schools; in 1909 the English board issued a syllabus of temperance teaching; in Sootland courses in hygiene and temperance public schools; in 1909 the English board issued a syllabus of temperance teaching; in Sootland courses in hygiene and temperance were adopted by many local educational authorities. In the United States compulsory teaching of temperance is of much longer standing and more advanced. The question was first taken up by the

liquid obtained by boiling parchment or the skins of animals in water, which is practically the same thing as using glue Pliny mentions the use of milk as a medium

In more modern times it was the medium of the Italian primitives. Cimabue learned it from the Greeks, or so says Vasari. and Giotto, Filippo Lippi, Ghiilandajo, Botticelli and many others used it for their inspired works Raphael, Titian and Tintoretto probably used it, at least for underpainting. In northern Europe tempera was earlier supplanted by oil than in Italy, but many of the Flemish and German primitives employed it

Process.-The ground used by Cimabue, Giotto and their compatriots was usually gesso (plaster of Paris). Cennini gives very full instructions for the making of gesso panels a complicated process involving, first, the preparation of the panel of poplar, lime tree or willow wood, of which all the interstices were to be filled with a mixture of size and sawdust. The panel was then covered with old linen cloth held in position by more size On this surface the gesso grasso, or heavy plaster of Paris, ground in size, was spread with a spatula The gesso sottile or final ground, composed of thoroughly slaked plaster of Paris mixed with size, was then applied with a brush

Devotees of tempera painting as practised by the Italians are convinced, not only of its great permanency, but of its peculiar charm. To quote Miss Herringham, the translator of Cennini: "There is no doubt that while fresco and tempera produce a decorated space in itself pleasant and figures and other objects can be suggested in slight chiarosculo (q v.) without appearing unfinished or crude, this is not the case in oil painting, which seems incapable of giving that pleasantness to the surface of a wall and re-quires a completeness in values, tones and tactile qualities which makes the spectator look into the picture and forget the surface. Therefore the one art is monumental, where the surface must not be forgotten or obliterated and the other on the whole appears opposed to monumental painting."

Roger E. Fry, writing in the Burlington Magasine of the charm of classic tempera, says. "One may sum up the whole question of tempera as a medium by saying that, while it is more difficult than in oil painting to produce any effect at all, it is yet more difficult, almost impossible indeed, to produce with tempera those thoroughly ugly and uninviting surfaces which it requires profound science to avoid in the clayey mixtures of oil paint. Nothing would be likely to have a more restraining and sobering influence on our art than the substitution of tempera for oils as the ordinary

medium of artistic expression,' Modern Uses .- Egg tempera, the medium to which both of these laudatory comments apply, is doubtless a most charming medium and an exceedingly permanent one, as demonstrated by the apparently magnificent preservation of many specimens of very great antiquity. It does, however, as Fry points out, present many technical difficulties, principally because of its exceedingly rapid drying. "Transitions of colour" says Fry, "must be made by hatched strokes or else by continual laying one thin coat over another until the transition is produced." This was the practice of the early Italians. In these days of ready mixed colours. procurable anywhere, there is not much occasion for the keeping alive of the ancient practices. Occasionally, however, an artist uses them successfully for current work. In different fields, certain workers do find it desirable today to combine dry colours with a tempera medium. For example, commercial illustrators have discovered that it is possible, by the admixture of dry pigment with a gum arabic-glycerine compound, to obtain colour of much stronger intensity-saturation-than can be had in commercial water colour. This method of working has the advantage that the strength of the prepared colour is within the artist's control It is also claimed that it is possible to obtain a very even and flat tone and one that, because of the absence of reflections, is particularly adapted to photographic reproduction.

Doubtless there are many other forms of artistic endeavour in which use is made of tempera mediums with dry colour, as in some forms of modern fresco, for example, but tempera in its modern application is, like oil painting, almost entirely a matter

many other substances were also employed. Among them were the of the use of prepared colours. These are ground by the manufacturers in various colloidal, gelatinous or albuminous vehicles and sold put up in tubes, pans or pots, but, unlike oil, the products of different manufacturers differ so greatly in character as to necessitate completely different techniques The product of some colourmen is to be used with the addition only of water, while in other varieties the use of prepared "tempera mediums" is necessary These are, naturally, compounds similar to the vehicles in which the particular colours are ground. It may be noted that ordinary water colour, show-card colour and the like are, of course, strictly tempera, being ground in gum arabic and glycerine, although water colour is only characteristic of the tempera medium when used as gouache or body colour

As noted above, the products of different colourmen vary so radically that it is difficult to give any idea of present-day tempera technique. In common they all present the quality of opacity; they may be used upon a great variety of surfaces and, in most cases, the permanency of the results depends only upon that of the ground Because of their opacity they may be used to very great advantage on dark grounds-a method of painting which has much to commend it. Most of the temperas in the market, however, are subject to the rather serious objection that the colours become lighter in drying.

Except as used for underpainting, tempera painting of today is a direct process. Unlike oil the colour usually dries very quickly upon the ground and any alteration of a tone by "painting into" it is difficult to achieve successfully. This directness, this premier coup quality, is one of the charms of the medium and also makes it desirable for quick sketching

Most users of tempera today are in the habit of employing it very flatly, frequently in the form of spots or "lozenges, to speak, of clean colour applied to grounds which vary from gray or brown to black. This technique is highly characteristic of tempera painting as it is found in the water-colour shows of the United States But some forms of commercial tempera may be used in a manner which approaches oil in appearance and in which the broken quality of a partially mixed tone may be preserved For this type of painting very little or no medium is used; heavy water-colour paper is employed as a ground and this may be obtained in a variety of tints from white to black. A number of prominent artists still use tempera as the medium with which to commence paintings which are completed in oil.

Emil Carlsen, one of the most noted of those who employed this technique, used an absorbent canvas, certain commercial colours and a commercial egg medium. For the first painting he recommended the using of the colour thinly, with water as a medium. This completed, the canvas is allowed to dry for a day or two, is then given one or two coats of tempera varnish A, and again let dry for a few hours. The picture is now given a light wash of the egg tempera medium and the painting is continued, using egg tempera as the medium instead of water. The colours can now be used solidly but it is necessary to lay layer over layer and let them dry between times or the colour will crack "The result," said Carlsen, "is an extremely hard and light underpainting, that, if vamished with a good coat of tempera varnish, well dried, will hold up a piece of painting wonderfully and give it more luminosity in the picture's future than any other process.

It will be evident that the art of tempera painting is even more difficult to limit and define than is painting in oil. It is an art the technique of which varied greatly, as did the vehicles em-ployed, even in its classic period, and this is equally true as to the more or less sporadic revivals of the old processes which are employed today, while, as to the commercial tempera of the shops, the colours supplied by one manufacturer may possess radically different qualities and call for a totally different technique from those of another manufacturer, and still be equally desirable. But in this very lack of uniformity is an incentive to the artist who is seeking for an individual, a personal technique. Whether he seeks for this in the use of prepared products or in the study and application of the ancient methods he will find in tempera a number of subtle and illusive charms which will well reTECHNIQUE OF, PAINTS, CHEMISTRY OF )

TREINIQUE OF, PAINTS, CHEMISTRY OF)

BRILDGRAFFY—Connino Chamin, II libro dell' Arte (c. 4312),
trans by C. J. Herringham with "Notes on Mediaceval & Herringham with "Notes on Mediaceval & Herringham with "Notes on Mediaceval & Herringham with "Notes on Mediaceval & Herringham with "Notes on Herringham with "Notes of the Chamilton of the Old Marier (London, 1911), A. P. Laurie, The Piements and Medium's of the Old Marier (London, 1911), A. P. Laurie, The Premental & Mediad and Marier (London, 1911), A. P. Laurie, The Premental & Mediad and Marier (London, 1911), A. P. Laurie, The Premental & Mediad and Marier (London, 1911), A. P. Laurie, The Premental & Mediad and Marier (London, 1911), A. P. Laurie, The Premental & Mediad and Marier (London, 1911), A. P. Laurie, The Marier (London, 1911), A. P. Laurie, The Marier (London, 1911), A. P. Laurie, T. nd Papers of the Society of Mural Decorators and Painters in Tempera (Brighton, 1007-24)

TEMPERAMENT, in psychology, means a kind of lasting emotional mood or temper. Some people are habitually cheerful, others are as habitually melancholy, and so on The oldest known classification of temperaments is considerably more than 2,000 years old, and the names associated with that classification are still in daily use It originated with a Greek medical school known as the Hippocratic school (see Hippocrates and the Hip-POCRATIC COLLECTION), and was based upon a theory about the varying proportions of four junces (or "humours") in bodies (Latin temperare means "to measure") The four liquids in the body were alleged to be blood, phlegm, black bile and yellow bile And according as one or other of these four preponderates in the body of a person, there results the sanguine temperament (Latin sangus, blood), the phlegmatic temperament, the melancholic temperament (Gr. μελαγχολικός, with black bile) or the choleric temperament. The sanguine temperament is quick, predisposed to pleasant emotions, but weak and inclined to change quickly from one interest to another The phlegmatic temperament is slow, lacking in vivacity, but calm and strong. The melancholic temperament is predisposed to sad emotions, slow and weak The choleric temperament is predisposed to anger and emotionally quick and strong. (See Personality)

In Music.-Temperament is the manner in which the limited number of notes of a keyboard instrument are tuned or tempered, various methods being possible; e g., unequal temperament, meantone intonation and equal temperament. In the case of an instrument tuned in unequal temperament a few keys will be as near as possible to the mathematical ideal of just intonation, but all the other keys will be more or less seriously out of tune.

Thus supposing the key of C to be tuned in just intonation, with G tuned in consequence as a really exact fifth, this same G will not be in tune when it is required to serve, not as the fifth to C, but as, say, the third to E flat or the fourth to D. Hence therefore the adoption as a compromise of the system known as equal temperament, whereby these inaccuracies of intonation are equally distributed over all the keys, with the result that no one key is better than another but all are sufficiently in tune for practical purposes and can be used with equal freedom,

The mean-tone system was an unequal temperament that split the difference between the major tone (8. 9) and the minor tone (9: 10). It long had its warm advocates, but finally had to yield to the superior practical advantages of equal temperament.

(See HARMONY; MUSICAL NOTATION.)

TEMPERANCE. The word temperance, which strictly means moderation, acquired a particular meaning in connection with intoxicating liquor and is here used in that sense.

History.-Ever since man in some distant age first discovered the process of fermentation by which sugar is converted into alcohol and carbonic acid, and experienced the intoxicating effects of the liquor so produced, there has been a temperance problem. The records of the ancient oriental civilization contain many references to it, and from very remote times efforts were made by priests. sages and lawgivers in India, Persia, China, Palestine, Egypt, Greece and Carthage to combat the injury of drunkenness to the individual and society. But the evil appears never to have been so great or the object of so much attention in the ancient world as in western countries, especially in modern times. Two circumstances differentiate the modern problem: the greater use of distilled spirits as a beverage and the climatic conditions prevailing in the more

pay him for the search (See also Painting, Oil Painting, northern latitudes which are the home of western civilization There is reliable evidence that the excess consumption of alcoholic beverages is greater among the people in northern Europe and North America than among the people in southern Europe and other people living in warmer climates But it is not certain that the colder climate is an essential factor in this difference Northern peoples moving to warmer climates do not seem to decrease their alcohol consumption Also, the Jewish people have a very small percentage of excessive drinkers and alcohol addicts irrespective of the chmate in which they live

The intoxicating drinks used by the ancients were wines obtained from grapes or other fruits and beers from various kinds of grain. These products were not confined to the east, but were also known to the ancient civilizations of Mexico and Peru and even to primitive peoples who used the sugar-containing juices and other substances indigenous to their countries In the time of the Romans the barbarians of northern Europe used fermented liquors made from honey (mead), barley (beer) and apples (cider) in place of grape wine. All such drinks produce intoxication if taken in sufficient quantity, but their action is much slower and less violent than that of distilled spirits. This difference is the result of the greater concentration of the alcohol in the distilled spirits which leads to a more rapid absorption of the alcohol into the blood stream and to a higher concentration of alcohol in the blood The concentration of the alcohol in the blood determines the degree of intoxication of the individual

Potable distilled spirits were apparently not known until the 13th century. The distilled essence of wine or aqua vitae (brandy) is mentioned then as a new discovery by Arnaldus de Villa Nova. a chemist and physician, who regarded it, from the chemical or medical point of view, as a divine product It probably came into use gradually, but once the art of distillation had been mastered it extended to other alcoholic products in countries where wine was not produced Malt, from which beer has been made from time immemorial, was naturally used for this purpose Then came corn brandy in the north and east of Europe, rum from sugar canes in the Indies, potato spirit and, eventually, as the distillation process was perfected, rectified ethyl alcohol from almost anything containing fermented sugar or starch

The concentrated form of alcohol thus evolved long carried with it the prestige of a divine essence given to it in the middle ages when chemistry was allied to all sorts of superstitions. It had potent properties and was held to possess great virtue This view was embodied in the name "water of life," and was at one time almost universally held. Ardent spirit seemed particularly desirable to the people of the cold and damp regions of northern Europe, where people took to it with avidity and imbibed it without restraint when it became cheap and accessible That happened in England in the early part of the 18th century (see LICENSED VICTUALLER); and out of the bad results which followed there eventually arose the modern temperance movement. The legislature had been busy with the liquor traffic for more than two centuries previously, but its task had been the repression of disorder. drunkenness was a nuisance and had to be checked in the interests of public order. It is significant that though drunkenness had been prevalent from the earliest times, the disorder which brought about attempts at legislative control did not make its appearance until after the introduction of distilled spirits.

Intemperance was one of many problems which arose during the latter half of the 18th century to become the subject matter of social reform in the 19th. It was a question of individual health and social welfare. A breach had been made in the unthinking traditional belief in the virtue of alcoholic liquor by the experiences referred to; and medical thought, as soon as it began to be con-cerned with health as distinguished from the treatment of disease. took up the matter. In 1804 Thomas Trotter of Edinburgh, Scot , published a book on the subject which was an expansion of his academic thesis written in 1788. Benjamin Rush of Philadelphia, distinguished U.S. physician and politician who had studied in Edinburgh and London, wrote a striking paper on the subject in the same year, and soon after this the organized temperance movement was set on foot in the United States.

Temperance and Prohibition Organizations—In 1868 a temperance society was founded at Saratoga, NY, and in 1813 the Massachusetts Society for the Suppression of Intemperance and its appearance. These seem to have been the earliest organizations, though the device of a pledge of abstinence had been introduced in 1800. The movement made rapid progress, mainly under the influence of the churches. In 1816 the American Society for the Promotion of Temperance was founded in 1800 and the promotion of Temperance was founded in Booton, and by right proposed in 1900 and the proposition of the promotion of the promotion of the most part, directed against the use of distilled spirits only, and the proposal to include all alcoholic drinks in the pledge of total abstancer, chooling adopted by a few societies, was rejected in 1830 and retained thereafter.

In Europe the earliest organizations were formed in Ireland A temperance club is said to have been started at Skibbereen in 1818. and others followed, but it was in 1829 that the organized movement began to make effective progress with the formation of the Ulster Temperance society. By the end of that year there were 25 societies in Ireland and two or three in Scotland In 1830 the movement spread to Yorkshire and Lancashire, and supported a newspaper called the Temperance Societies' Record, according to which there were then 127 societies with 23,000 paying members and 60,000 associated abstainers. In 1831 the British and Foreign Temperance society was founded in London with the bishop of London (Charles Blomfield) for president and Archbishop John Sumner for one of the vice-presidents This important society, of which Queen Victoria became patron on her accession in 1837, came to an end in 1850, when the whole cause was under an eclipse. The most remarkable episode in the temperance campaign at this period was the mission of the Rev Theobald Mathew of Cork, commonly known as Father Mathew, greatest of all temperance missionaries He travelled through Ireland in the years 1838-42 and everywhere excited intense enthusiasm. People flocked to hear him and took the pledge in crowds. In 1841 the number of abstainers in Ireland was estimated to be 4,647,000, in three years the consumption of spirits fell from 10,815,000 to 5,290,000 gal This was not all due to Father Mathew, because great depression and distress prevailed at the same time, but he exercised an extraordinary influence. In 1843 he went to England, where he had less (though still great) success, and in 1850 to America He died in 1856, by which time the cause had fallen into a depressed state in both countries In the United States a flash of enthusiasm of a similar but smaller character, known as the Washingtonian movement, had appeared In 1845 a law prohibiting the public sale of liquor was passed in New York state but repealed in 1847; in 1851 Maine adopted prohibition

The Church of England Temperance society, much the largest at mid-soft nentury, was founded in 1862 and reconstituted in 1873. It was incorporated in 1907, reconstituted again in 1911 and 1921, and recognized by the church assembly in 1923 It carries on an extensive publication department and educational courses, police court and prison gate missions to seamen, travelling vans and in-chrate homes.

The United Kingdom alliance, founded in 1853, became the chife political organization. Its object was probibition of the drink trade, but it adopted the policy of local prohibition by means of local opton. It began publication of the "attional drink bill," a calculation of the national expenditure on alcoholic liquors. Other legislative organizations in Britain are the National Temperance league, the British Temperance league, the National United Temperance council, the National Temperance deceration, the Temperance Legislation league and others in Scotland, Ireland and Wales. There is also a Royal Army Temperance association and a Royal Naval Temperance society. International societies enumerated are the World League Aganst Alcoholism, the World Prohibitive federation, the International Orders of Good Templars and the World's Woman's Christian Temperance union.

Thus temperance and total abstinence became the objects of the united efforts of education and legislation in many regions. This union was probably promoted in part by the fact that once a person has become an alcohol addict recovery usually requires total ab-

stinence. In later years the organized movement in many countries embraced both voluntary and compulsory abstinence and combined the inculcation of individual abstinence with the promotion of legislation for the reduction or suppression of the alcoholic liquor traffic. On the whole the latter predominated, particularly in the United States, where organized agitation made temperance or primeter in legislation. (See Promistrion ) Besides emperance or primeries in legislation. (See Promistrion ) Besides combining the moral and the political elements the modern movements were characterized by the following features: (c) international organization; (c) organized co-operation of women, (d) juvenile temperance; (4) teaching of temperance in schools and elsewhere; (s) scientific study of alcohol and indirectly.

International organization appears to have been staited by the Order of Good Templars, a society of abstainers, formed in 1851 at Utica, N.Y It spread over the United States and Canada, and in 1868 was introduced into Great Britain Several years later it was extended to Scandinavia, where it became very strong. Temperance societies had previously existed in Norway from 1836 and in Sweden from 1837, these seem to be the earliest examples on the continent of Europe The Good Templars organization also spread to several other European countries, to Australasia, India, South and West Africa and South America Several other international societies were founded, and international congresses were held, the first in 1885 at Antwerp, Belg. A World's Prohibition conference was held in London in 1909, attended by about 300 delegates from temperance societies in nearly all parts of the world This conference resulted in the foundation of an International Prohibition federation, embracing every country in Europe with three or four minor exceptions, the United States, Mexico, Argentina, much of the British Commonwealth, China, Japan, Palestine, Tunisia and Haurari

Alcoholac Anonymous is an organization of former alcohol additts who have recovered from this affliction and have become dual abstainers. It is a national organization, started in the United States but gradually extended to other countries. The primary object of this organization is to aid, by education and personal service, other alcohol addites to recover from their addiction

Women's Organizations:—The organization of women, which has become international, dates from 1874, when the National Woman's Christian Temperance union was founded at Cleveland, O It employs educational and social as well as pellitical means in promoting legislation About 1885, Frances Willard, who had been the moving spirit of the union, carried this organization of women into their lands and formed the World's Woman's Christian Temperance union, which by the 1950s had branches in about 50 countries.

Juseuile Groups:—The inclusion of children in temperance organization goes back to 1847, when a society of juvenile abstainers who had taken the pledge was formed at Leeds; it took the name fopand of Eope. The practice spread, and in 1874 B B and of Hope, union was formed Within the next century a nulmber of such unions were established, in Scotland, Ireland and separate counties in England; the Bands of Hope were said to number 15,000 in

School Progrants—The teaching of temperance in schools, a feature of social education and moral propaganda, was begun by private effort in 1852 when John Hope haugurated a regular weekly visitation of day schools in Edinburgh. In 1875, at the invitation of the National Temperance league, Sir Benjamin Richardson wrote his Temperance Leason Book, which was adopted by many which was adopted by many other schools as a primer. In 1889 school teaching by travelling lecturers was taken up by the U.K. Band of Hope umon, and the expansive was followed by many other societies which spent large sums on litherant lecturers. The Church of England Temperance society carried on similar work. In 1906 the board of education in Ireland made hygiene and temperance compulsory subject in the public schools; in 1909 the English board issued a syllabus of temperance teaching; in Sootland courses in hygiene and temperance was adopted by many local educational authorities. In the United States compulsory teaching of temperance is of much longer standing and more advanced. The question was first taken up by the

that by teaching the physiological effects of alcohol to all children the problem of intemperance would be effectually solved, and a systematic political campaign was planned and carried out for the purpose of obtaining compulsory legislation to give effect to this The campaign was successful in New York in 1884, in Pennsylvania in 1885 and subsequently in other states Laws were passed in every state and territory making antialcohol teaching part of the curriculum in the public schools Teaching of temperance became compulsory in Canada except in Quebec and Prince Edward Island; in France in 1902, in Sweden in 1892, and in Ireland It became optional in Australia, South Africa, some parts of India, Belgium, Finland, Denmark, Norway, Germany and Switzer-

Scientific Study -- The physiology and pathology of alcohol consumption is a very large subject movement were medical men, and though the churches soon became the chief moving force, doctors continued to exercise an influence. Medical abstinence societies were formed in England, Germany, Belgium, the Netherlands, Norway, Sweden and Denmark (See also Prohibition, Local Option, Licensed Vict-UALLER, DISINTERESTED MANAGEMENT, LIQUOR LAWS AND LIQUOR CONTROL ) (A St, A J. Cn)

TEMPERATURE, INVERSION OF: see Inversion of TEMPERATURE

## TEMPERATURE OF BODY: SEE ANIMAL HEAT.

TEMPERING is the imparting of a certain degree of hardness to a tool or spring. The older practice was that of first hardening a tool to the limit, and then "letting it down," eg, allowing access of heat until a certain colour was shown on a part polished bright for observation, and then quenching in water or oil This method is still practised on a large scale, but with the use of furnaces and pyrometers the tempering heat can be raised accurately without going through the hardening process first. Tempering colours range from the bright vellow down to grey covering such tints as pure yellow, dark yellow, brown yellow, red brown, purple red, violet, cornflower blue, pale blue The bright yellow gives the hardest temper suitable for steel engraving tools and certain metal cutting tools, while at the other end of the range lie saws for wood and most springs. See also Annealing and HARDINING

TEMPLARS. The Knights Templars, or Poor Knights of Christ and of the Temple of Solomon (pauperes commulitones Christi templique Salomonici), formed one of the three great military orders, founded in the 12th century. Unlike the Hospitallers and the Teutonic Knights it was a military order from its very origin. Its founders were a Burgundian knight named Hugues de Payns and Godeffroi de St Omer, a knight from northern France, who in 1119 undertook the pious task of protecting the pilgrims who, after the first crusade, flocked to Jerusalem and the other sacred spots in the Holy Land They were quickly joined by six other knights and soon afterwards organized themselves as a religious community, taking an oath to the patriarch of Jerusalem to guard the public roads, to forsake worldly chivalry, "of which human favour and not Jesus Christ was the cause, living in chastity, obedience and poverty, according to the rule of St. Benedict, "to fight with a pure mind for the supreme and - true King."

To this nascent order of warrior monks Baldwin II., king of Jerusalem, handed over a part of his royal palace lying next to the former mosque of al-Aksa, the so-called "Temple of Solomon," whence they took their name. They had at first no distinctive habit, wearing any old clothes that might be given to them. Nor was their community exclusive. Their primitive rule seems to have enjoined them especially to seek out excommunicated knights, and to admit them, after absolution by the bishop, to their order, and they thus served a useful purpose in at once disciplining and converting the unruly rabble of "rogues and impious men, robbers and committers of sacrilege, murderers, perjurers and adulterers" who streamed to the Holy Land in hope of

Patrol lat 182, p 928).

Bernard of Clairvaux, De laude novae militue, cap. v (in Migne,

Woman's Christian Temperance umon in 1879, it was believed plunder and salvation. It was this rule which led later to the most important privilege of the order, the immunity from sentences of excommunication pronounced by bishops and parish priests

This practice might have brought them at once under the suspicton of the Church, and it soon became expedient to obtain the highest sanction for the new order and its rules. In the autumn of 1127 accordingly Hugues de Payns, with certain companions, appeared in Europe, where he was fortunate enough to secure the enthusiastic support of the all-powerful abbot of Clairvaux Grateful pilgrims had already begun to enrich the order, the De laude novae militiae, a glowing panegyric of this new and holy conception of knighthood, addressed by Bernard to Hugues de Payns by name, insured the success of his mission. In 1128 the council of Troves discussed and sanctioned the rule of the order

Rule of the Temple .- No ms of the original French Rule of the Temple (Règle du Temple) exists, but in essentials the later copies preserve the matter and spirit of the primitive Rule, and they prove that to the end the order was, in principle at least, submitted to the same strict discipline as at the beginning. Of a secret Rule, in spite of the most diligent research, no trace has ever been found It is now generally held that none ever existed The legend of its existence, so fatal to the order, is probably traceable to the fact that the complete Rule was jealously guarded by the chief office-bearers of the order

The Rècle du Temble in its final form as we now possess it contains the rules for the constitution and administration of the order; the duties and privileges of the various classes of its personnel, the monastic rules, regulations as to costume and as to religious services; rules for the holding of chapters, and a summary of offences and their punishment, the procedure at the election of a grand master and at receptions into the order, a definition of the relations of the order to the pope, and to other religious orders

At the head of the order was the master of the Temple at Terusalem (in Cyprus after the fall of the Latin Kingdom), known as the grand master. His authority was very great-except in certain reserved cases his word was law-but he was not absolute Thus in matters of special importance-alienation of the estates of the order, attack on a fortress, declaration of war, conclusion of an armistice, reception of a new brother-he had to consult the chapter, and was bound by the vote of the majority, nor could he modify or abrogate a decree of the council of the order without their consent. He had to obtain the consent of the chapter also to the nomination of the grand commanders of the provinces of the order; the lesser offices were absolutely in his gift. He was elected by a complicated process, a chapter summoned ad hoc electing a "commander of the election" and one other brother who, after vigil and prayer, co-opted two more, these four choosing another two, and so on till the number of the twelve apostles had been reached. A chaplain, representing Jesus Christ, was then added to complete the electoral college (See Curzon, Règle du Temple, p. xxxv.).

Of peculiar importance were the chaplains (fratres capellani), These did not originally form part of the order, which was served by priests from outside The bull Omne datum optimum of 1163 imposed on clerics attaching themselves to the order an oath of life-long obedience to the grand master; by the middle of the 13th century the chaplains took the same oath as the other brothers and were distinguished from them only by their orders and the privileges these implied (e.g., they were spared the more humiliating punishments, shaved the face, and had a separate cup to drink out of). The order thus had its own clergy, exempt from the jurisdiction of diocesan bishops and parish priests, owing obedience to the grand master and the pope alone,

It remains to be said that the brethren were admitted either for

life or for a term of years. Married men were also received, but on condition of bequeathing one half of their property to the order. History—Long before St. Bernard's death (1153) the new order was established in almost every kingdom of Latin Christendom, and every establishment was the recipient of rich endow-ments. Henry I., for example, granted them lands in Normandy; and Louis VII. in the latter years of his reign gave them a piece of land outside Paris, which in later times became known as the Temple, and was the headquarters of the order in Europe, and Stephen of England granted them the manors of Cressing and Witham in Essex, and his wife Matilda that of Cowley, near Oxford Spiritual privileges were granted to them by the popes as lavishly as temporal possessions by the princes and people Pope Adrian IV allowed them to have their own churches, Eugenius III added to these the right to have churchvards They were, moreover, as defenders of the Church exempted from the payment of tithes. Finally, they were exempted from the action even of general censures and decrees of the popes, unless mentioned in them by name Very soon the order refused to submit in any way to the ordinary jurisdiction of the diocesan bishops and formed in effect a separate ecclestastical organization under the pope as supreme bishop. The result was that, scarce twenty-five years after its foundation, the order was at open feud with bishops and parish pirests, and the popes found it necessary to issue decree after decree to protect it from violence and spoliation.

So long, however, as the attention of the papacy and of Christendom was fixed on the problem of recovering and safeguarding the Holy Land, the postuon of the Templars was unassailable and all efforts to curb the growth of their power vain The later history of the Templars is therefore the history of the CRUSADES (or P.).

Fall of Latin Kingdom .- There is something Homeric in the story of the fall of the Latin kingdom as related by the historians of the next century A French knight, Gerard de Riderfort, coming to the East in quest of fortune, attached himself to the service of the ambitious Raymond, count of Tripoli; looking for the hand of some wealthy widow in reward. Failing ignominiously in this, Gerard enrolled himself among the Templars, biding his time for revenge, and was elected grand master in 1184 Baldwin IV., king of Jerusalem, died in 1185, leaving the throne to his young nephew Baldwin V. the son of his sister Sibylla, under the guardianship of Raymond, whose term of office was brief, as the little king died in September 1186 This was Gerard's opportunity The Templars carried the body of their dead sovereign to Jerusalem for burial; and then, unknown to the barons of the realm, Gerard and the patriarch crowned Sibylla and her husband Guy de Lusignan, Raymond's rival This was the overthrow of Raymond's ambition; and both Latin and Arabic writers are agreed that the Christian count and the Mohammedan sultan now entered into an alliance. To break this friendship and so save the kingdom, Gerard and the grand master of the Hospitallers were sent north to make terms with Raymond. But the rash valour of the Templars provoked a hopeless contest with 7,000 Saracens. The grand master of the Hospitallers was slain, but Gerard made his escape with three knights to Nazareth (1st May 1187). In this emergency Raymond became reconciled with Guy; and Gerard placed the Temple treasures of Henry II, at his king's disposal. Once more it was the Templars' rashness that led to the disastrous battle of Hittin (4th July). Gerard and the king fell into the hands of Saladin, but were released about a year later; Raymond of Tripoli made his escape through treachery or fortune; and 230 Templars fell in or after the battle, for the fight was scarcely over before Saladin ordered all the Templars and Hospitallers to be murdered in cold blood. One after another the Christian fortresses of Palestine fell into the hands of Saladin Jerusalem surrendered on and-ard October 1187, and the treasures of the Temple coffers were used to purchase the redemption of the poorer Christians, part of whom the Templar warriors guarded on their sad march from the Holy City to Tripoh. Part of their wealth was expended by Conrad of Montferrat in the defence of Tyre; but, when this prince refused to admit Guy to his city, both the Templars and the Hospitallers from the neighbouring parts flocked to the banner of their released king and accompanied him to the siege of Acre (22nd August 1189). In his company they bore their part in the two years' siege and the terrible famine of 1190-91; and their grand master died in the great battle of 4th October 1189, refusing to survive the slaughter of his brethren.

On the capture of Acre Philip Augustus established himself in the palace of the Templars, who are, however, stated to have sympathized with Richard. The English king sold them the island of Cyprus to 100,000 besants, but, unable to pay the purchase money, they transferred the debt and the principality to Guy of Lusignan Richard consulted them before deciding on any great military movement, and in June 1192 they advocated the bold plan of an advance on Egypt rather than on Jerusalem It was in the disguise of a Templar and in a Templar galley that Richard left the Holy Land, after the failure of his own military schemes When Acre was recovered, the Templars, like the Hospitallers, received their own quarters in the town, which from this time became the centre of the order. On the death of Henry of Champagne (1197) they vetoed the election of Raoul de Tabarie, after the death of his successor Amalric they refused to renew the truce with Saladin's brother, Saif al-Din, and led an expedition against the Saracens before the arrival of the new king, John de Brienne, at whose coronation in 1210 William de Chartres, the giand master, was present. Seven years later, with the aid of Walter de Avennis and of the Teutonic Knights, they commenced the building of their fortress of Castle Pilgrim, near Acre, on a rocky promontory washed by the Mediterianean on every side except the east.

It was from this castle that in May 1218 the fifth cruside started for the expedition against Egypt. The Templars were the heroes of the sege of Damietta, at which William de Chaitres was slain, "First to attack and last to retreat," they saved the Christian army from annuhilation on 19th August 1219, and when the city surrendered (5th November) the only one of its twentyeight towers that had begun to gue way had been shaken by their engines. On the other hand, if was largely owing to their objections that John de Brienne refused the sultan's offer to restore Jerusalem and Palestine

From the very first the Templais seem to have been opposed to Frederick II , and when he landed at Acre (7th September 1228) they refused to march under the banners of an excommunicated man, and would only accompany his host from Acre to Joppa in a separate body. They were accused of notitying Frederick's intended pilgrimage to the Jordan to the sultan, and they were certainly opposed to Frederick's ten years' peace with Al-Kāmil, the sultan of Egypt, and refused to be present at his coronation m Jerusalem. On neither side was the treaty fully observed, and preparations were made in Europe for a fresh crusade. In the meantime open dissension broke out between the Templars and the Hospitallers, the former advocating negotiations with the sultans of Damascus and Kerak, the latter with the sultan of Egypt; and when Richard of Cornwall arrived (11th October) he had to decide between the two rival orders and their opposing policies. After some hesitation he concluded a treaty with the sultan of Egypt, much to the annoyance of the Templars, who openly mocked his efforts. On his departure, the three orders came to open discord. the Templars laid siege to the Hospitallers in Acre and drove out the Teutonic Knights "in contumellam imperatoris." They were successful on all sides. The negotiations with Damascus and Kerak were reopened, and in 1244 Hermann of Pengord wrote to the princes of Europe that after a "silence of fifty-six years the divine mysteries would once more be celebrated in the Holy City."

It was in this moment of danger that the sultan of Babylon called in the bathrones Kharizmians, whom the Mongol invasions had driven from their native lands. These savages, entering from the north, flowed like a tide past the newly built and impregnable Templar fortress of Safed, swept down on Jerusalem, and atnihilated the Chistian army near Gasa on October 18th, 1244. From this blow the Latin kingdom of the East never recovered; 600 mights took part in the battle; the whole force of the Templars, 300 in number, was present, but only 13 survived, and of 200 Hospitalizers only 16. The masters of both orders were slain or take prisoners, and Jerusalem was lost to Christendom once more. The havoc caused by the Kharizmians was alleged by pope in nocent IV. as the reason for again summoning Christendom to the rescue of the Holy Land. Recognizing the fact that the true

way to Jerusalem lay through Egypt, Louis IX, led his host to the banks of the Nile, being accompanied by the Templars Their master, William de Sonnac, attempted in vain to restrain the rash advance of the count of Artois at the battle of Mansura (8th February 1250), which only three Templars survived St Louis, when captured a few weeks later, owed his speedy release to the generosity with which the order advanced his ransom-

A new enemy was now threatening Mohammedan and Christian alike For a time the Mongol advance may have been welcomed by the Christian cities, as one after another the Mohammedan principalities of the north fell before the new invaders. But this new danger stimulated the energies of Egypt, which under the Mameluke Bibars encroached year after year on the scanty remains of the Latin kingdom. The great Frankish lords, fearing that all was lost, made haste to sell their lands to the Templars and Hospitallers before quitting Palestine for ever But they lost their power of resistance, and became so enfeebled as to welcome the treaty which secured them the plain of Acre and a free road to Nazareth as the result of the English crusade of 1272 While thus weak against external foes, the Templars were strong enough for internal warfare. In 1277 they espoused the quarrel of the bishop of Tripoli, formerly a member of the order, against his nephew Bohemond, prince of Antioch and Tripoli, and began a war which lasted three years In 1276 their conduct drove Hugh III . king of Cyprus and Jerusalem, from Acre to Tyre In the ensuing year, when Mary of Antioch had sold her claim to the crown to Charles of Anjou, they welcomed this prince's lieutenant to Acre and succeeded for the moment in forcing the knights of that city to do homage to the new king. Thirteen years later (26th April 1290) Tripoli fell, and next year Acre, after a siege of six weeks, at the close of which (16th May) William de Beaujeu, the grand master, was slain. The few surviving Templars elected a new master, and sailed for Cyprus, which now became the headquarters of the order

Power and Influence of the Order.-For more than a hundred years the Templars had been one of the wealthiest and most influential factors in European politics. If we confine our attention to the East, we realize but a small part of their enormous power. Two Templars were appointed guardians of the disputed castles on the betrothal of Prince Henry of England and the French princess in 1161 Other Templars were almoners of Henry III, of England and of Philip IV of France. One grand master was godfather to a daughter of Louis IX.; another, despite the prohibition of the order, is said to have been godfather to a child of Philip IV. They were summoned to the great councils of the Church, such as the Lateran of 1215 and the Lyons council of 1274. Frederick II.'s persecution of their order was one of the main causes of his excommunication in 1239, and his last will enjoined the restoration of their estates. Their property was scattered over every country of Christendom, from Denmark to Spain, from Ireland to Cyprus But the wealth of the Templars was due not so much to their territorial possessions as to the fact that they were the great international financiers and bankers of the age. The Paris Temple was the centre of the world's money market. In it popes and kings deposited their revenues, and these vast sums were not hoarded but issued as loans on adequate security. Above all, it was the Templars who made . the exchange of money with the East possible. It is easy, indeed, to see how they were the ideal bankers of the age; their strongholds were scattered from Armenia to Ireland, their military power and strict discipline ensured the safe transmission of treasure. while their reputation as monks guaranteed their integrity Thus they became the predecessors, and later the rivals, of the great Italian banking companies. To take interest (usury) was of course unlawful. The method of circumventing this seems to have been that the mortgagees paid to the mortgagors a nominal rent which was used towards the reduction of the debt. The difference between this and the real rent represented the interest. A document throwing a vivid light on the banking methods of the Templays and Hospitallers is a charter of Margaret, queen of the the order, and though promising an inquiry, doing his best to gastish, a.p. 1186, from the abbey of Fontevrault, printed in procrastinate. Philip determined to force his hand. All France

Calendar of Documents, France (1899), vol i, ed. J. H Round, No 1084

Suppression of the Order .- Never had the order of the Temple been to all appearance more powerful than immediately before its ruin Sovereign power, in the sense of that of the Teutonic Knights in Prussia or the Knights of St. John in Rhodes and later in Malta, it had never possessed, but its privileges and immunities constituted it a church within the church and-in France at least-a state within the state Philip IV, indeed, in pursuance of his policy of centralizing power in the crown, had from 1287 onwards made tentative efforts to curtail the power and wealth of the order, but soon his necessities forced him to a temporary change of policy In January 1293 the privileges of the order in and about Paris were confirmed and extended, and in 1207 Philip borrowed 5,200 livres tournoises from the Paris Temple. Then came the great quarrel with Pope Boniface VIII, and on the 10th of August 1303 the king signed with Hugues de Peraud, the general visitor of the French Templars, a formal treaty of alliance against the pope On the 6th of February 1304 Boniface's successor, Benedict XI., once more confirmed all the Templars' privileges, while Philip, for his part, appointed Hugues de Peraud receiver of the royal revenues and, under pressure of the disastrous campaign in Flanders, in June granted a charter exempting the order from all hindrances to the acquisition of property Two years later the king took refuge in the Temple from the violence of the Paris mob, and so late as the spring of 1307 was present at the reception of a new Templar

Yet for some two years past the king had been plotting a treacherous attack on the order. His motives are clear, he had used every expedient to raise money, had robbed and expelled the Jews and the Lombard bankers, had debased the coinage, the suppression of the Templars would at once rescue him from their unwelcome tutelage and replenish his coffers. He cherished also another ambition. The question of an amalgamation of the great military orders had often been mooted, the project had been approved by successive popes in the interests of the Holy Land; it had been formally proposed at the Lyons council of 1274, only to be rejected by the opposition of the Templars and Hospitallers themselves To Philip this scheme commended itself as an opportunity for bringing the orders under the control of the French crown; there was to be but one order, that of the "Knights of Jerusalem," of which the grand master was always to be a prince of the toyal house of France. Clearly, it only needed an excuse and a favourable opportunity to make him attack the Templars; and, once having attacked them, nothing short of their entire destruction would have been consistent with his safety. The excuse was found in the denunciation of the order for heresy and unspeakable immoralities by a venal informer; the opportunity was the election of a pope, Clement V., wholly devoted to the interests of the king of France.

For perhaps half a century there had been strange stories circulating as to the secret rites practised by the order at its midnight meetings, stories which probably had their origin in the extreme precautions taken by the Templars, originally perhaps for military reasons, to secure the secrecy of their proceedings, which excited popular curiosity and suspicion.

In the spring of 1304 or 1305 a certain Esquiu de Floyran of Béziers pretended to betray the "secret of the Templars" to James II. of Aragon The pious king, who had every reason to think well of the order, did not affect to be convinced, but the prospect of spoils was alluring, and he seems to have promised the informer a share of the booty if he could make good his charges. Esquiu now turned to Philip of France, with more immediate success. For the purpose of collecting additional evidence the king caused twelve spies to find admission to the order, and in the meantime sought to win over the pope to his views. Clement V. owed the tiara to the diplomacy of Philip's agents, perhaps to their gold; but though a weak man, and moreover a martyr to ill health, he was not so immediately accommodating as the king might have wished, expressing his disbelief in the charges against

was at this time under the jurisdiction of the Inquisition, and the Inquisition could act without consulting the pope The grand mousitor of France, William of Paris, was Philip's confessor and creature The way was thus open for the king to carry out his plan by a perfectly legal method. His informers denounced the Templars to the Inquisition, and the grand inquisitor-as was the customary procedure in the case of persons accused of heresy-demanded their arrest by the civil power. On the 1.4th of September 1307, accordingly, Philip issued writs to his bailis and seneschals throughout the kingdom, directing them to make preparations to arrest the members of the order

The Templars had for some time past been aware of the charges against them On the 6th of June 1306 Pope Clement had summoned Jacques de Molay, the grand master, from Cyprus to France, in order to consult him on the projected crusade. He had obeved the call, and, in an interview with the pope, had taken the opportunity to demand a full inquiry. They had, however, taken no measures to defend themselves, the sudden action of the king took them wholly by surprise; and on the night of Friday, the 13th of October 1307, their arrest was effected without difficulty. Jacques de Molay himself with sixty of his brethren being seized

in Paris

The Templars were caught in toils from which there was no escape To force them to confess, they were first tortured by the royal officials, before being handed over to the inquisitors to be, if need were, tortured again. In Paris alone thirty-six died under the process The result was, at the outset, all that the king could desire Of 138 Templars examined in Paris between the 19th of October and 24th of November, some of them old men who had been in the order the greater part of their lives, 123 confessed to spitting on (or "near") the crucifix at their reception Many of the prisoners confessed to all the charges, however grotesque But the most damning confession was that of the grand master himself, publicly made with tears and protestations of contrition and embodied in a letter (October 25) sent to all the Templars in France He had been guilty, he said, of denying Christ and spitting on the cross

To the pope, meanwhile, the proceedings in France were to the highest degree unwelcome. He had, indeed, become convinced, if not of the general guilt of the order, at least of the guilt of some of its members But the aftair was one which he desired to reserve for his own judgment, Philip's action he interpreted, rightly, as an encroachment of the civil power on the privileges and property of the Church, and his fears were increased when the French king, without consulting him, sent letters to King James of Aragon, Edward II. of England, the German king Albert and other princes, calling upon them to imitate his example On the 27th of October Clement issued letters suspending the powers of the Inquisition in France What followed is not clear, for the documentary evidence for these months is very defective; but on the 22nd of November the pope issued a bull calling on all kings and princes to arrest the Templars everywhere, his motive probably being to forestall the probable action of the secular powers and keep the affair in his own hands. All scruples and hesitations now vanished In England the Templars were arrested on the 10th of January 1308, in Sicily on the 24th of the same month, in Cyprus on the 27th of May; in Aragon and Castile the process was less easy, for the

Meanwhile, on the 26th of May, Philip had made his solemn entry into Poitiers, where the pope and cardinals had already assembled for the purpose of conferring with the king on the matter. After stormy debate, an arrangement was made. The king agreed to hand over to the papal commissioners the property and persons of the Templars; Clement, for his part, withdrew the sentence of suspension against the grand inquisitor of France and ordered an inquisition into the charges against individual Templars by the diocesan bishops with assessors nominated by himself. The examination of the grand master, of the grand visitor of

knights, forewarned, had put their fortresses into a state of

defence, notably their strong castle of Monzon, which was only taken after a long siege on the 17th of May, while the last of the

Templars' strongholds, Castellat, did not fall until Nov. 2nd.

France, and of the grand preceptors of Cyprus, Normandy and Aquitaine he reserved to himself Inquisition was to be made into the conduct of the order in each country by special papal commissions, and the fate of the order as a whole was to be decided by a general council, summoned at Vienne for the 1st of October 1311, when the question of the guilt of the order might be considered Meanwhile the pope and cardinals had elaborated the organization of the new inquisition. There was much confusion and delay, however, and the actual public trial did not begin till the 11th of April, 1310 Many Templars, trusting m the assurance implied in their citation, had volunteered to defend the order and withdrew their pievious confessions They were soon undeceived, the commission was packed with creatures of the crown The evidence given in Paris for or against the order was, it was soon found, used against the individual Templars on their return to the provinces; the retractation of a confession, under the rules set up for the diocesan inquisition, was punished with death by fire Sixty-seven Templars perished in this way during May 1310 Meanwhile Clement and Philip had come The pope condemned the Templars The council of Vienne met in October 1311 A discussion arose as to whether the Templars should be heard in their own defence Clement, it is said, broke up the session to avoid compliance; and when seven Templars offered themselves as deputies for the defence he had them cast into prison Towards the beginning of March Philip came to Vienne, and he was seated at the pope's right hand when that pontiff delivered his sermon against the Templars (3rd April 1312), whose order had just been abolished, not at the general council, but in private consistory (22nd March) On 2nd May 1312 he published the bull Ad Providam, transferring the goods of the society, except for the kingdoms of Castile, Aragon, Portugal and Majorca, to the Knights of St. John.

The final act of the stupendous tragedy came early in 1314. Jacques de Molay, the grand master, had not hitherto risen to the height of his great position; the fear of torture alone had been enough to make him confess, and this confession had been used to extract avowals from his brethren, subject as they were to unspeakable sufferings and accustomed to yield to the military chief Humiliation on humiliation had been heaped on the wretched man, public recantations, resterated confessions Before the papal commission he had flamed into anger, protested, equivocated-only in the end to repeat his confession once more .The same had happened before the commission of cardinals at Chinon; the audience with the pope, which he demanded, he had never obtained. On the 6th of May 1312 Pope Clement issued his final decision as to the fate of the Templars in general, that of the five great offices of the order he reserved in his own hand. With this a silence falls over the history of the Templars, the fate of the order had been decided, that of the individuals still under trial was of little interest to contemporary chroniclers. Then the veil is suddenly lifted. Jacques de Molay has found his wonted courage at last, and with him Gaufrid de Charney, the preceptor of Normandy, on the 14th of Maich 1314 they were brought out on to a scaffold erected in front of Notre Dame, there in the presence of the papal legates and of the people to repeat their confessions and to receive their sentence of perpetual imprisonment. Instead, they seized the opportunity to withdraw their confessions and to protest to the assembled thousands the innocence of the order. King Philip the Fair did not wait to consult the Church as to what he should do; he had them burnt.

A word must be added as to the significance of the work of the Templars and of the manner of their fall in the history of the world Two great things the order had done for European civilization: in the East and in Spain it had successfully checked the advance of Islam; it had deepened and given a religious sanction to the idea of the chivalrous man, the homo legalis, and so opened up, to a class of people who for centuries to come were to exercise enormous influence, spheres of activity the beneficent effects of which are still recognizable in the world. On the other hand, the destruction of the Templars had three consequences fateful for Christian civilization. (1) It facilitated the conquests of the Turks by preventing the Templars from playing in Cyprus he part which the Knights of St John played in Malta (2) It sartly set a piecedent for, partly confirmed, the ciuel criminal recedure of France, which lasted to the Revolution (3) It set he seal of the highest authority on the popular belief in witchraft and personal intercourse with the devil, sanctioned the exsedient of wringing confessions of such intercourse from the ccused by unspeakable tortures, and so made possible the hideous vitch-persecutions which darkened the later middle ages and, ven in Protestant countries, long survived the period of Refor-

On the question of the guilt or innocence of the Templars in espect of the specific charges on which the order was condensing pinnon has long been divided Their mnocence was maintained by the greatest of all their contemporaises, Dante (Pung xx 92), and by the historian Villain and others I minor erent times a certain heat was introduced into the discussion of the question owing to its having pen for centuries brought into the airna of party controversy, be-ween Protestants and Catholics, Gallicans and Ultramontanes. Freerement be the control to the control bullant defence of the older The challenge was taken up, among others, by the ornelizate F our lammer-Purgsaid who, in a paper shorts, by the ornelizate F our lammer-Purgsaid who, in a paper described to the control of the control uzued for the evistence of a secret doctrine based not on Grossteism use on the monotoness of ablant, of which Baybornet (Mahamet) use on the monotone (Mahamet) of the desired of the desired of the desired of the desired of the desired of the monotone of the order. The view was also taken by a succession of German scholars; in England, by C. G. Addison, and in France of German scholars; in England, by C. G. Addison, and in France in the contraction of the desired of Unitergoing des L'empeuirremorateurs (1988), maintainet mat the custom of denying Cainst and spitting on the cross was often, and im some provinces universally, practised at the reception of the brethien, "as coarse test of obedience, of which the original sense had parity been logotten, partly heretically interpreted under the influence of later hereases." Pertiz points out that the failure of the Crusades had weak-hereases." Partiz points out that the failure of the Crusades had weak-hereases."

tongotten, partly heretically interpreted under the militoneo of later hereases. Furt points out that the failure of the Crusades had weak-under merb absolute beded in Chrusharily, at least as represented by the property of the property of the conclusion of the property of the conclusion that the Templan were mucent. Leading superated the facination (2888, vol. 18), had liready come independently to the conclusion that the Templan were mucent. Leading superated the facination (2888, vol. 18), and already come independently to the conclusion that the Templan were mucent. Leading superated the facination of the facility interesting and partly on a mass of new material drawn from the Angeonies archives, had for at object to establish the monence of the order on an incontrovertible basis (Papishimu und Distengung dar Templemordens, 2007), vol. 186, and the superated of the transport of the superated of the transport of the superated of the transport of the transpor

TEMPLE, FREDERICK (1821-1902), English divine, archbishop of Canterbury, was born in Santa Maura, one of the Ionian Islands the son of Major Octavius Temple. He was educated at Blundell's School, Tiverton, and at Balliol College, Oxford The "Tractarian Movement" had set in five years before he went up to Oxford, but the memorable tract, No go, had not vet been written. After much discussion and reflection he drew closer to the camp of "the Oxford Liberal Movement." In 1842 he took a "double-first" and was elected fellow of Balhol, and lecturer in mathematics and logic. Four years later he took orders, and with the aim of helping forward the education of the very poor, he accepted the headship of Kneller Hall, which served at that time for the training of masters of workhouse and penal schools. But the experiment was not altogether successful, and Temple himself advised its abandonment in 1855. He then accepted a school-inspectorship, which he held until he became headmaster of Rugby in 1858. In the meantime he had attracted the admiration of the prince consort. and in 1856 he was appointed chaplain-in-ordinary to the queen In 1857 he was select preacher at his university

At Rugby Temple showed great energy and bold initiative, Whilst making the school a strong one on the classical side, he instituted scholarships in natural science, built a laboratory, and gave importance to that side of the school work. He had the courage also to reform the games, in spite of all the traditions of the playing fields. His school sermons were deeply impressive. they rooted religion in the loyalties of the heart and the conscience, and taught that faith might dwell secure amid all the bewilderments of the intellect, if only the life remained rooted in pure affections and a loyalty to the sense of duty Two years after he had taken up his work at Rugby Essays and Reviews appeared The first essay in the book, "The Education of the World." was by Dr. Temple. Temple refused, so long as the storm lasted, to comply with the request that he would repudiate his associates. and it was only at a much later date (1870) that he saw fit quietly to withdraw his essay. In the meantime, however, he printed a volume of his Rugby sermons, to show definitely what his own religious positions were. His appointment by Gladstone as bishop of Exeter in 1860 raised a fresh storm.

G. A Denison, archdeacon of Taunton, Lord Shaftesbury, and others formed a strong committee of protest, whilst Pusey declared that "the choice was the most flightful enormity ever perpetrated by a prime minister." At the confirmation of his election counsel was instructed to object to it, and in the voting the chapter was divided. But Gladstone stood firm, and Temple was duly consecrated on Dec. 21, 1869 On the death of Dr. John Jackson in 1885, he was translated to London, the appointment gave general satisfaction In 1884 he was Bampton Lecturer, taking for his subject "The Relations between Religion and Science" In 1885 he was elected honorary fellow of Exeter College, Oxford

Temple led a strenuous life as bishop of London. His normal working day at this time was one of fourteen or fifteen hours, and he was felt by many of his clergy and by candidates for ordination to enforce almost impossible standards of diligence and efficiency. The working classes instinctively recognized him as their friend. When, in view of his growing blindness, he offered to resign the bishopric, he was induced to reconsider his proposal, and on the sudden death of Archbishop Benson in 1896, though now seventysix years of age, he accepted the see of Canterbury.

As archbishop he presided in 1897 over the decennial Lambeth Conference In the same year Temple and his brother archbishop issued an able reply to an encyclical of the pope which denied the validity of Anglican orders. In 1900 the archbishops again acted together, when an appeal was addressed to them by the united episcopate, to decide the vexed questions of the use of incense in divine service and of the reservation of the elements. After full hearing of arguments they gave their decision against both the practices in question. During his archbishopric Dr. Temple was deeply distressed by the divisions which were weakening the Church of England; and many of his most memorable sermons were calls for unity. His first charge as primate on "Disputes in the Church" was felt to be a most powerful plea for a more catholic and a more charitable temper, and again and again during the closing years of his life he came back to this same theme. While speaking in the House of Lords on Dec 2, 1902 on the Education Bill of that years was seized with sudden illness, and, though he revived sufficiently to finish his speech, he newer fully iscovered, and died on Dec 5, 1902. He was interred in Canterbury Catherial Four days large 1902. He was interred in Canterbury Catherial Four days large 1902.

bury cathedral rour days later

See Alchdeacon E G Sandford, Frederick Temple: an Appreciation
(1907), with biographical introduction by Wilham Temple, Memous of
Archbishop Temple, by "Seven Friends," ed. E. G. Sandford (1906).

TEMPLE, RICHARD GRENVILLE-TEMPLE, 1st Each (1711-2779). English statesman, eldest son of Richard Grenville (d 1721) of Wootton, Buckinghamshre, was borm on Sept 26, 1711 His mother was Hester (c 1690-1752), daughter, and ultimately herress, of Sir Richard Temple, Bart. (1634-1697), of Stowe, Buckinghamshire, and asster of Richard Temple, Vascount Cobham, whose title she inherited under a special remainded in 1749, in the same year, her husband having been long dead, she was created Countess Temple. Her son, Richard Grenville, was educated at Eton, and in 1734 was returned to parlament as member for the borough of Buckingham In 1752,

Grenville, was educated at Eton, and in 1734 was returned to parliament as member for the borough of Buckingham. In 1753, on the death of his mother, he inherited her titles together with the estates of Stowe and Wootton, and took the name of Temple in addition to his own surname of Gienville By the marriage of his sater Heister with William Pitt, afterwards earl of Chatham, Temple's career was linked with that of his prother-in-law

In November 175t Temple became first lord of the admirally in the ministry of Devonables and Pitt. He solidated by George II, who dismissed both him and Pitt from admirated from the coaliton cannot for Newsatle and Pitt from a first proposal to the property of the property of the same year, Temple received the office of pruy seal. He alone in the calonet supported PIt's proposal to declare war with Spain in 1761, and they resigned together on Ct 5. From this time Temple became one of the most violent and factous of politicians, and it is difficult to account for the andacance which he exerted over his brother-fa-way. He was at variance with his younger brother, George Grenville, when the had no place in that mind the return April 1765, and had no place in that mind the property of the proposed provided from the presunded Pitt to request livering to you were reconciled before 1765, when Temple refused to join the government, and

By 1765, however, the old friendship between the brothers-inlaw was dissolving; and when at last in July 1766 Pitt consented to form a government, Temple refused to join, being bitterly offended because, although offered the head of the treasury, he was not to be allowed an equal share with Pitt in nonmating to other offices. Temple forthwith began to inspire the most virulent bless against Pitt; and in compunction with his brother George he concentrated the whole Graville connection in hostility to the government. After George Grewille's death in 1770 Lord Temple retired almost completely from public life. He died on Sept. 12, 1770

Sept. 13, 2779
Sept. 13, 2779
Sec The Gresville Papers (1852), a considerable portion of which counsists of Earl Temple's correspondence; Horace Walpole, Memors of Gress III, 4, vol. (1843, and 1844); Memors of the Regn of George III, 4, vol. (1843, and 1844); Gress III, 4, vol. (1843, and 1844); Gress of Gress, Gress of Gress III, 4, vol. (1844, and 1844); S. Taylor and J. H. Primple, 4 vols. (1838-40); W. E. H. Ledy, W. S. Taylor and J. H. Primple, 4 vols. (1838-40); W. E. H. Ledy, Vols. 1849, and in the Explement Century, vols. II and in. (7 vols), 1892.

TEMPLE, SIR WILLIAM, Barr. (1628–1699), English statesman, diplomatist, and author, was born in London. He was the eldest son of Sir John Temple (1606–167). Inish master of the rolls, whose father was Sir William Temple (1555–1627), prevoved of Trinfly college, Dublin Temple was educated at the grammar-school at Bishop Stortford, and at the Puritan college of Emmanuel at Cambridge, where he came under the influence of Cudworth. In 1647 he started to travel abroad. In the Isle of Wight he met Dorrby Osborne, the daughter of the Royalist governor of Guernesy, Sir Peter Osborne; and though her family were opposed to the match, he married her in 1621.

In 1660 Temple sat in the convention parliament, and in its successor, at Dublin as member for Carlow. He removed to

England in 1663, attached himself to Arlington, secretary of state, and two years later was employed in various negotiations on the continent. In 1666 he became the English representative at the viceregal court at Biussels While the Dutch war continued, Temple's duties consisted chiefly in cultivating good relations with neutral Spain, which was threatened by the claims of Louis XIV, on the Spanish Netherlands Louis's designs became apparent in the spring of 1667, when he maiched an army into Flanders This event was one of those which led to the peace of Breda, and to the subsequent negotiations, which are Temple's chief title to fame. The French conquests were made at the expense of Spain, but were almost equally dangerous to the United Netherlands, whose independence would have been forfeited had Louis succeeded in annexing Flanders While the French were taking town after town. Temple made a journey into Holland and visited De Witt.

Temple had for some time pressed on his government the necessity of stopping the French advance, and had pointed out the way to do so, but it was not till December .667 that he received instructions to act as he had suggested He at once set out for The Hague, and in January .1668 a treaty was made between England and the Unted Netherlands, which, being joined shoitly afterwards by Sweden, became known as the Triple Alliance It was a defensive treaty, made against the encroachments of France. The skill and celetify with which the negotiations were conducted and the results of the treaty, reflect great credit on Temple. The French king was checked in mid-career, and, without a blow being struck, was obliged to surrender almost all his conquests.

Unfortunately the policy thus indicated was undone by Charles's personal policy embodied in the secret treaty of Dover which reversed the policy of the Triple Alliance (See CHARLES II) Meanwhile Temple had developed the good understanding with the Dutch by contracting a commercial treaty with them (February 1668), and had acted as English plenipotentiary at Auxla-Chapelle, where peace between France and Spain was made in May 1668 Shortly afterwards he was appointed ambassador at The Hague Here he lived for two years on good terms both with De Witt and with the young prince of Orange, afterwards William III The treaty of Dover led to Temple's recall, but Temple nominally held his post for another year He perceived, however, that his day was over and retired to his house at Sheen. In June 1071 he received his formal dismissal. The war with the Netherlands broke out next year, and was almost as discreditable to England as that of 1665 Want of success and the growing strength of the opposition in parliament forced Charles to make peace, and Temple was commissioned to carry through the change of front, After a negotiation of three days, carried on through the medium of the Spanish ambassador, the treaty of Westminster was made (February 1674).

As a recognition of his services Temple was now offered the embassy to Spain. This he declined, as well as the offer of a far more important post, that of secretary of state, but accepted instead a renewal of his embassy to The Hague. In the March following he was nominated ambassador to the congress at Nijmwegen; but, owing to the tortuousness of Charles's dealings, it was not till July 1676 that he entered that town. The negotiations dragged on for two years longer, for Charles was still receiving money from France, and English mediation was no more than a ruse. In the summer of 1677 Temple was summoned to England and received a second offer of the secretaryship of state, which he again declined. In the autumn of the same year he had the satisfaction of bringing about the marriage of William and Mary, an event which seemed to complete the work of 1668 and 1674. Louis still remaining obstinate in his demands, Temple was commissioned in July 1678 to make an alliance with the states, with the object of compelling France to come to terms. This treaty was instrumental in bringing about the general pacification which was concluded in January 1679.

This was Temple's last appearance in the field of diplomacy. His plan for the reform of the privy council failed. His name was removed from the list of the council in 1681, and thenceforward he lived in retirement, first at Sheen, and then at Moor Park

926 TEMPLE

pressed to take office, but refused His son became secretary at war, but committed suicide immediately afterwards. Temple died at Moor Park on Jan 27, 1699

Temple's works include An Essay on the Present State and Settlement of Ireland (1668), The Empire, Sweden, etc., a survey of the different Governments of Europe and their relations to England (1671), Ob-Governments of Delipse and their relations to England (1971), 100-servations spin: Essay upon the Original and Nature of Government (1672); Essay upon the Advancement of Trade in Ireland (1673) Some of these were published in the first part of his Miscellanea (1679). In the same year apparently his Poems were privately punted. In 1683 he began to write his Memori. The first

provately punted. In 1683 he began to write his Memors. The first part, extending from 1655 to 1571, he destroyed unpublished, the second, from 1672 to 1579, was published by with an 1793. The third, from 1675 to 1587, was published by 8941 in 1793. Which is 1794 to 1861, as published by 8941 in 1793. Which is 1794 to 1874 t

TEMPLE, WILLIAM (1881-1944), English divine, second son of Frederick Temple (q.v), archbishop of Canterbury, was born at Exeter on Oct 15, 1881, and educated at Rugby and at Balliol College, Oxford, where he was president of the Oxford Union. From 1904-10 he was fellow and lecturer in philosophy at Oueen's College, Oxford In 1914 he resigned the headmastership of Repton School, which he had held from 1910, to take charge of St. James's, Piccadilly. He was editor of The Challenge (1915-18). He resigned from St. James's in 1917, was made a canon of Westminster (1919) and in 1921 bishop of Manchester He was president of the Workers' Educational association (1908-24) In 1020 he became archbishop of York and in 1042 archbishop of Canterbury Temple died Oct 26, 1944.

TEMPLE, a city of Bell county, Texas, U.S., 73 mi. N. by E of Austin, on federal highway 81, and served by the Missouri-Kansas-Texas and the Santa Fe railway systems. Pop. (1950) 25,467. It is the trade centre and shipping point for a rich agricultural region, raising cotton, corn, small grains, grain soighums, fruits, vegetables and livestock. Industrial products are furniture, shoes, rock wool, shirts, cottonseed oil, feeds, woodworking machinery, window shades and blinds, blackboards, bottling-works and printing-shop products and others. Scott and White hospital and clinic, King's Daughters hospital and clinic, G.C. & S.F. railway hospital and McCloskey Veterans administration centre are in Temple. Fort Hood is 28 mi W Temple was founded in 1881 by the Santa Fe railroad and was chartered as a city in 1884.

TEMPLE, a word signifying, loosely, any enclosed space or structure erected for purposes of worship, or to protect a cult image or cult objects. In a figurative sense the word is used for (1) any shrine; (2) any building built in a style similar to that of a classic temple; (3) for the meeting houses of certain nonconformist denominations; (4) for synagogues; (5) for the meeting

places of certain fraternal orders

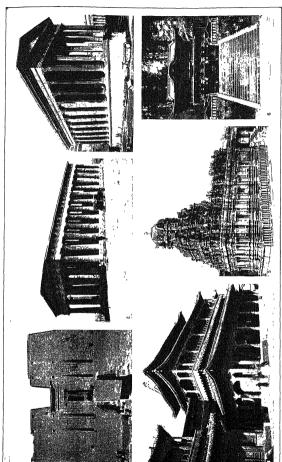
Cave Temples.-Although perhaps antedated by existing temple remains of the earliest Chaldean and Egyptian periods, a primitive type of cave temple culturally much earlier is that of certain cave temples of the Mediterranean basin, of which the most remarkable are those on the island of Malta, apparently dating originally to a neolithic culture, although undoubtedly in use for a thousand years afterwards. It is remarkable that in these temples. despite their early date (?5000 BC.), great care is shown in the decoration and finish of altar stones, doors and other important features, and that many steatopygous female statues were found in the temples. This, together with the large size and important position of many phallic stones, would seem to indicate that the temple was dedicated to a god or goddess of fertility, or perhaps to a pair. The most important sites are Hagar Kim, Hal Tarxien and Mnaidra. There is also at Hal Saffieni a large, neolithic series of caves which seem to have been both for habitation and worship; the presence of enormous numbers of human bones also indicates that part of it was used as an ossuary. The much later Egyptian cave temples at Abu Simbel (time of Rameses the Great) are merely highly developed descendants of such primitive

in Surrey. When William III. came to the throne Temple was cave structures, and the great groups of temple caves in India, as well as certain early cave temples along the Yangtse river. China. show that this tendency was wide spread

High Places .-- Not only do such primitive hill-top altars, common to many parts of western Asia, indicate the love for such positions, but also megalithic remains like those of Stonehenge (qv) indicate a similar feeling. It is noteworthy that even in China the great Temple of Heaven in Peking takes the form of a series of circular terraces, obviously pointing to a primitive desire to imitate hill forms, and the Assyrian ziggurat (q v ), as well as the Mexican and Central American pyramids are merely variant expressions of the same controlling emotion. This probably explains the situation of the temple at Jerusalem upon the hill top, and, combined with ease of military defence and love of architectural effect, the site of the temples of the Greek cities

Egyptian Temples .-- With the civilization of Egypt the structural temple assumes a controlling importance, for the cave temples of Egypt are exceptional and secondary. The developed Egyptian temple shows a complex type which is evidently the accretion of many stages. The earliest examples were probably simple, square or rectangular shrines of small size and with no openings but a door. Occasionally four columns supported the roof of flat stone. As worship grew more complex and wealth increased, additional halls were added in front of and around the original shrine, with a monumental, colonnaded hall open at the front, probably for the combined purposes of narthex (or vestibule) and prayer hall. Finally, a large court with entrance pylons of enormous size became part of the scheme, and by far the greater number of the Ebyptian temples existing show all of these elements. The result was characteristic, both the widest and the highest elements in the building were toward the front (pylons, forecourt, hypostyle hall) and the narrowest and lowest at the rear (the shrine) The mystical effect of this gradual narrowing down and darkening of the interior scheme is impressive In addition to these simple elements, the great temples of Thebes (Karnak and Luxor), representing the building of many generations and many dates, have the shrines surrounded with a maze of small rooms, courts and corridors, whose use is difficult to assign. The most perfect example of Egyptian temples, so well preserved that its ancient effect can be readily judged, is the late temple at Edfu (237-257 BC)

Western Asia.-The principal feature of Assyrian and Chaldean temples was the ziggurat (q v.) or stepped pyramid, with stairs or an inclined plane leading up to the terraces of the steps and the summit The walls were decorated with glazed brick or painted stucco, and in some cases, at least, each stage was dedicated to a separate divinity, as in the famous example at Babylon, in which each of the seven stages was dedicated to a separate planet. It is undoubtedly to a ziggurat that the biblical tradition of the Tower of Babel refers Besides a ziggurat the temple group comprised a court or courts and various rooms for priests and for the storage of temple treasures and archives Further west, on the Mediterranean coast, a different type occurs, in which a small, enclosed room is fronted with a monumental entrance, frequently flanked by columns This type is not only known from various small Phoenician models, but is also clearly represented in the biblical descriptions of the various temples at Jerusalem. The earliest description of Solomon's temple is that of I Kings, vi. 7, which, despite its completeness, is open to many interpretations and an enormous number of different restorations have been based upon it and indications found on the site. The essential elements are, however, clear and consist of a courtyard. a great altar of burnt offerings, traditionally placed upon the sacred rock now known as the sakhra, and the temple building itself. This was entered through a lofty porch or gateway of obviously Egyptian pylon type, which was flanked or fronted by two enormous free-standing columns, which were purely decorative or traditional and may represent a lingering of the same neolithic tradition that set the phallic stones in the Malta temples. Through the pylon one entered the naos (the holy place or hekal), 40 cubits long, 20 wide and 30 high (the cubit being roughly one and a half



TEMPLE ARCHITECTURE FROM THE 5TH CENTURY B.C. TO THE 17TH CENTURY A D

PHOTOGRAPHS, (1 5) EWING GALLOWAY, (4) DE COU TRON D' ING GALLOWAY

The great entrance pylons of the temple at Ediu (237–57 B.C.) These pylons embody, despite their late Polemais disk all of the magnificent grandeur of scale and claborate construction characteristic of Egyptient religious architecture.

Greek temples, on the other hand, sought and achieved repose and classic dignity through careful relationship of every potrion The Theorem at Ather, commisted before 421 B C and probably once dedicated to Relativative and Athers, is one of the best preserved before 421 B C.

The Yashamon gate of the tomb shrine of Ivemitar at Nikko, Japan, shows the graciousness, intricacy and occasional over elaboration typical of the Tokugawa style of the middle of the 17th century and vertical lines 3. The Roman variation of the classic tample form is well shown in the Maison Carries at Nipnes, France (c A D.). Its high potulour or base, entrance stops and superb Cornshinan order are typical of the governed layelines of the Roman against

The Subrahmanya shrine in the temple of the great pageds at Tanjore, India, is a much later addition to the carlier 11th century temple, typical of the Dravidian style, in its strongly contrasted horizontal

the Lam temple at Pakrap, China in its carefully spaced columns, nohly bracketed comisse and the Lam temple as characterized to Monther of Monther of Monther of Imperial yellow, columns isotrated deep red and comisse of thrilliant great, blue and gold give the much another them.

Chinese colour richness

feet). It was lighted by a row of lattice windows, probably a clerestory set high in the wall, like the somewhat similar clerestory windows at Karnak Behind the naos, and entered from it, was the Holy of Holies or debir, 20 cubits in all three dimensions Within this sanctuary was kept the Ark of the Covenant, flanked by two cherubim Surrounding the naos and sanctuary were three storeys of small chambers In the details described, this temple shows an interesting combination of forms with origins in all the surrounding countries Thus the pylon porch and the diminution of height from front to back are purely Egyptian, while the greater number of the ornamental motives (cherubin, etc.) are of Mesopotamian origin In construction, however, the combination indicated of stone, timber and metal is distinctively of the Mediterranean coast. The temple was destroyed (586 BC) and rebuilt 70 years later. largely in accordance with the older type, with certain differences, the most important of which was the use of a great curtain to separate the naos from the sanctuary and the existence of two courts instead of one In c 20 BC Herod built a third temple which was hardly completed in its entirety before the capture of the city and the razing of the temple by Titus (A D 70)

The Aegean World and Greece.—The Minoan civilization has left remains which indicate that both caves and high places were deemed sacred Representations on seals and wall paintings also show that small shinnes existed in great numbers, but up to the present time (1948) no large, monumental temples have been discovered The most ordinary type of Aegean shinn of pre-Greek date is well represented on a fresco in the palace at Knossos (6 1500 nc.), showing a wall surrounding a temenos or sacred area, planted with trees, and filled with two-shippers

In the early Hellenic Greek world it would seem that the temenos with its altar was the most common form of temple; the constructed building not appearing until two or three centuries had elapsed after the Dorian migration The earliest temples were of various forms, patterned on primitive dwellings, but the rec-tangular form was finally adopted and developed. The construction was apparently of sun-dried brick, with wall ends and openings cased in wood. A porch in front was early added, between solid end walls, which were the continuation of the side walls of the cella or enclosed portion. As building skill increased, and the need for larger and more splendid temples was felt, columns were added, first in one row down the centre, to decrease the unsupported span of the roof, and later in two rows, dividing the covered space into nave and assles. On the outside columns on the porch matched those within. Later, another porch was added at the rear, and finally a colonnade would be continued entirely around the building, giving the developed type which has been famous as the characteristic classic type ever since One of the earliest of large size, of which many remains exist, is the temple of Hera at Olympia (variously ascribed to many dates between the 10th and 7th centuries BC) Its stone foundations were obviously originally designed to carry sun-dried brick walls and its wood cased antae (q v.), or pilaster-like wall ends, and door nambs are of the most primitive type. It is reported by Pausanius that the original wooden columns of the colonnade were replaced by stone columns of various shapes and sizes during the entire history of classic Greece, differences in contemporary styles accounting for the relative delicacy or crudity of the columns. Naturally, the greater number of the architectural fragments found are of late date. By the middle of the 7th century B C the Greek temple type was thoroughly established and the ruined temple at Corinth, of this date, had a stone colonnade in which all the elements of the later perfected Doric order are found. There is also a large group of archaic temples in south Italy and Sicily, where the Greek colonies of the time had reached a high level of wealth and established civilization. Thus at Syracuse, at Segesta, Selinus, Agrigentum (Acragas) and Paestum there are many examples of archaic Doric temples of the late 7th and 6th centuries B.C. In all of these the columns are heavy and low, closely spaced and with widely projecting, heavily convex capitals, and the entablature above is heavy in proportion. Sculpture of a crude type appears during this period, notably in the metopes and the pediments, or gable ends.

The type of temple building thus set remained constant throughout the history of Greek architecture, although the refinements of taste and growing structural skill of the period succeeding the Persian wars led to the use of slenderer columns and more delicate entablatures. The typical temple was surrounded by a colonnade, usually with six columns at each end, and with 12 or more on the sides. The walls of the enclosed cella were usually separated from the columns of the colonnade by a space wider than that between the columns and, following the old tradition, frequently projected in front of the doorway proper, forming, as it were, a little subsidiary porch inside the main colonnade Within, the building was sometimes divided into two chambers, the larger in front, the smaller, rear chamber, being entered occasionally from the larger, but often, as in the Parthenon (447-438 BC), entered only from the rear porch. This rear chamber was frequently used as a treasury. The larger room was usually divided into a nave and aisles by two rows of columns, in most cases in two storeys, either with or without a gallery at the level of the lower entablature At the end of the nave, opposite the entrance, stood the statue of the deity, which might be either an antique and shapeless tree trunk, going back to prehistoric times, or the most perfect colossal work of a sculptor like Pherdias, whose gold and ivory statues of Zeus in Olympia and of Athena in the Parthenon at Athens were perhaps the two most ad-mired works of art of the ancient world The interior was probably lighted only by light entering through the door; this illumination, upon the rich colours of the painted architectural detail and the mass of votive offerings, and reflected from the white and gold of the statue, undoubtedly produced an effect of somble and impressive richness. The same richness of colour and sculpture decorated the exterior. The entablature glowed with deep blues and reds, against which the metope sculptures were sharply relieved In the pediments above, great groups of free-standing sculpture, brilliantly composed, gave an adequate crown. In some cases the exterior walls were probably painted, as well.

The typical Greek temple, however, consisted usually of more than a single building, which was only the most important feature of the temenos. The sacred enclosure might contain, as well, is smaller shrines of heroes or related deties, treasury buildings for gifts from special localities, like the treasures at Olympia and Delph, colonades, as at Argos; and, in special cases, halls for mysteries and the like. Thus, such temples or sacred areas as those at Eleusis, Argos, Delob, Delph and Olympia beginnerwast congeries of all sorts of buildings devoted to the common purpose and use of aiding in some way the cult, and usually representing many periods of Greek history down to, and even later than, the Roman conquest.

In Asia Minor the Ionian influence, working on the same basis, produced effects of a different type. Not only was the Ione order most commonly used in place of the Dorac, but also the sense of scale was different, and when the Dorac builders sought beauty through perfection of detail and every possible refinement, the Ionanas sought it through enormous size and lavish richness. Thus even the archaic temple of Artemis at Ephesus (early 6th century 8 c.) was of a scale scarcely ever attempted in Greece proper, prior to Roman times, and in the much later temples at Priene, Miclus and Sards, great size and scale was the controlling force.

Etruria and Rome.—Etruscan temples are little known except from literary descriptions and certain remains of terra-cottar revetments, or covering decorations for wooden members. It is well established that the cella was much shorter than in Oreek examples, approaching a square in plan, and that columns were limited to a porch in front, usually of great depth. The construction of the roof and entablature was apparently usually in wood, sometimes covered with terra-cotta plaques, and the spacing between columns was much greater than in Greek temples.

Roman temples, in plan, always retained the influence of their Ertuscan prototypes, and the great temple of junpier on the Capitoline hill preserved to the end its primitive Ertuscan lay outwide, shallow cells divided into three chambers, all opening out upon a deep, many-columned porch. The peripteral scheme, with columns on all four sides of the cells, appeared only in imperial 928 TEMPLE

times and was always rare, being reserved for the very largest and most monumental temples, such as the enormous double temple of Venus and Rome at Rome, designed for Hadrian, by Apollodorus of Damascus. The normal type, with a porch only in front, nevertheless, frequently had the cella walls decorated with pilasters or engaged columns Thus the temple of Fortuna Virilis at Rome (variously attributed to the beginning of the 2nd and the beginning of the 1st century B.C.), has a range of engaged columns around three sides of the cella, matching exactly the columns of the porch The same treatment, on a much larger scale, is found in the Maison Carrée at Nîmes (c AD 1), which is the most perfect example of a Roman temple extant Similarly based upon Etruscan tradition is the fact that all Roman temples were raised upon high podia (base or pedestal), whose side walls projected forward and received the ends of a great flight of entrance steps Roman temple interiors were usually both larger and more lavish than the interiors of Greek temples, and the larger examples were frequently vaulted with richly coffered barrel vaults This led also to a greater enrichment of wall design, and walls, beside being cased in rich marbles, were often enriched with pilasters or engaged columns, and further decorated with small niches pediment-crowned and flanked by columns. The most extraordinary examples of this type of development extant are the temples comprising the great group at Baalbek in Syria, the ancient Heliopolis (begun during the reign of Hadrian and completed early in the 3rd century). The cella of the temple of Bacchus, the smaller of the group, still remains, in large measure complete up to the cornice, and shows ranges of engaged Corinthian columns. and between them arched recesses below, and pedimented statue frames above. The great temple of Jupiter is chiefly remarkable for its enormous forecourt, colonnaded and with great niches, and in front of that an hexagonal court, and the colonnaded propylaea. Both of these temples have colonnades all around, in the Greek manner, and the same is true of the contemporary double temple of Venus and Rome at Rome, in which the surrounding colonnade was double. This temple is also remarkable for the two anses back to back in which the statues of the two divinities were placed. The side walls were treated with niches and columns in a way much resembling the Baalbek example. The surroundings of Roman temples never had the informal charm of the Greek temenos, but were usually surrounded by a rectangular courtyard with colonnades, like that of the temple of Venus and Rome, or the temple of Apollo in Pompeii (rebuilt c. AD. 65). Other temples were placed merely at street corners, like the temple of Fortune at Pompeii, of early imperial date, or the temple of Fortuna Virilis at Rome. Many temples were also placed in or facing the forum, which served, itself, as the temenos or sacred area.

Many exceptional types of Roman temples are found. Thus the temple of Vespasian at Brescia (A.D. 72) had three chambers in the cella with the six-columned portico in front of the central one projecting far beyond the small portices of the side chambers. That of Concord, at Rome (7 B.C. to A.D. 10) had the main entrance to the cells in the middle of one of the long sides, with a superb portico in front of it. Remarkable also is the great development of round temples, either of comparatively small size, like the temple of the Sybil at Tivoli (usually attributed to the beginning of the 1st century B.C.); the so-called temple of Hercules at Rome; or the so-called temple of Venus at Baalbek. in which the cells is surrounded with a portico of Corinthian columns, whose entablature is scalloped or star-shaped in plan. The most magnificent of the round temples is the Pantheon (q.v.) at Rome (A.D. 110-125), whose vast domed hall, over 140 ft. in diameter, is one of the most impressive interiors in the world-

Tassic Temples: Technical Definitions.—In architectural descriptions of the classic temple a number of technical words have become common. Many of these owe their origin to the work of Vitruvius, author of a complete Roman treatise on architecture of the time of Augustus. The most common of these terms descriptive of the general arrangement and of the position of columns may be shortly defined as follows:

A Those affecting general distribution of parts Prostyle—with a porch or portico in front

Amphiprostyle-with a porch or portico both at front and rear

Peripteral—with a colonnade completely surrounding the cella, either rectangular in plan, as in the typical Greek temple, or circular, as in the temple of the Sybil at Tivoh

Pseudoperipteral—with a porch or portico only in front, but with the exterior walls of the cella decorated by engaged columns or pilasters, as in the Maison Carrée at Nimes

B. Terms describing detailed arrangement or position of temple

In antis—columns placed between the pilaster-like decorations at the ends of the side walls of a naos or cella when these walls are projected forward beyond the front of the building to form a porch between them

Dipteral—with a double colonnade along the sides Pseudodipteral—with the columns of the side colonnade separated from the cella walls by a space wide enough to allow a double colonnade but without an inner row of columns.

Distyle, tetrastyle, pentastyle, hexastyle, octostyle, decastyle, etc—with two, four, five, six, eight or ten columns in front Such words composed of "style," with a Greek numerical prefix, may be multiplied indefinitely, to describe buildings or porticos with any number of columns

Indian Temples .-- Indian temples show clearly the development from sacred cave to free-standing structure. The earliest existing monumental temples are all rock-cut and developed with caves The earlier temples, such as those at Behar, and at Karli, near Bombay, show a great cave interior, divided by piers or columns into nave and aisles, with a small stupa, or solid masonry curve-topped structure enclosing a relic of Buddha, and a façade cut in the face of the rock, with doorway below and huge horseshoe-shaped window above, all in imitation of wooden construction A second common type of rock-cut temple consists of those in which, in addition to the shrine proper, there are great courtyards surrounded by cells for monks. These are known as viharas. The most remarkable groups of cave temples are those at Ajanta and Ellora In both there are temples of Buddhism and also Brahmanism, and the types of detail known as Dravidian and Jain are both found. The dates vary from the 2nd century B.C to the 6th and 7th centuries AD. The Dravidian and Jain constructed temples both show a power and heaviness of general mass with an amazing intricacy of carved detail that is more typical of rock-cut than free-standing structures, and the characteristic pyramidal towers, with their strongly marked horizontal mouldings and vertical projections have almost the character of artificial mountains and cliffs The rôle played by figure sculpture in its lavishness, its multitude of figures and their bold relief, is unlike that played in any other structural style, and without doubt owes much, also, to rock-cut prototypes. The plan type shows usually a vast rectangular enclosure entered through several monumental gateways, crowned with enormous, solid towers, Within are smaller enclosures and subsidiary buildings, and sometimes an additional closed court, also with monumental gates Near the centre is the shrine proper, containing the cult statue, sometimes approached by vast, colonnaded halls, and every exposed surface of the great towers and the interior columns and walls is covered with a rich network of sculpture and ornament.

East Indies—Indian influence is marked in the temple ruins found in scattered places through Cambodis, Burns, Java and nearby islands. All of the great temples are elaborations of the stips idea, and consist in essence of one or more stupas on raised terraces. Thus in the Shwo Dagon pagoda at Rangoon there are a multitude of small stupas crowned with high, spire-like finals, surrounding a contral stupa which rises to a height of over 350 ft., and the whole surface is heavily gilded. At Borobudur, Java, the great Buddhist temple (? the or 8th century a D) consists of a series of terraces around a hill ye of the had the top of which is a large stups aurrounded by of series ones. All of the stone himng of the terrace walls is covered united exquisite relief sculpture, not only illustrating the life of Buddha, but also containing many pictures of ordinary, every day events. The most remarkable of these eastern Buddhist temples is Angkor-Wat at Angkor in Cambodia (attributed to the 1st half of the 1st hentury, and apparently originally intended as a Brahmin temple, being converted to Buddhist uses later). This consists of three great symmetrical terraces with elaborate stars, consists of these great symmetrical terraces with elaborate stars, but the context of the star of the context of the sculpture and output production. The sculpture and output production of the context of the sculpture and output production. The sculpture and output production of the picture of some of the picture and column acquisits is noteworth character of some of the picture and column acquisits is noteworth character of some of the picture.

China and Japan.-Further east an entirely contradictory tradition governs temple design, that of the columned prayer halls of Japan and China The expression of this in China differs from that in Japan. The typical Chinese temple, whether Taoist or Buddhist, is basically symmetrical and rectangular. Through a gate-house, frequently vaulted, an outer court is entered, in which on either side of the main axis is a small tower, one containing a drum and the other a bell. Directly opposite is the main prayer hall of the temple, with many columns, and a richly beamed and coffered ceiling. Against the back wall is a large pedestal, usually supporting three statues, and in front of it a table-like altar with its ritual utensils. In temples of Confucius, a simple, richly decorated shrine replaces the statues . There is often, in addition, a court at the rear, with another hall shrine on its axis. In large groups, the number of courts and shrines is increased and additional halls at the sides of the courts. serve the purpose of chapels In Taoist temples, the most important shrine is sometimes in the centie of the court, and bell and drum towers are absent. There is also, at times, a long gal-lery containing statues of the 500 Lohans, or holy men. The architectural character varies with the locality Those in the north are full of the monumental grandeur of the Peking school. as in the temple of Confucius, or such monasteries in the western hills as that of Wo Fu Tsu (both of the Ming and subsequent dynasties) Those in the Yangtse valley are more picturesque, with exaggeratedly curved roofs, and slimmer supports, as in the 18th century Sheng Yan Sze monastery near Hangchow In those in the south, granite supports replace the wooden columns found further north. Roof ridges are of extraordinary intricacy and the wood carvings of the interiors exquisitely rich and delicate, as in the 18th century temple of the Chen family in Canton.

In Japan the elaborate formality of the typical Chinese temple is absent. In fact, the native Shinto temples are based upon exceedingly primitive house ideas, and are simple, rectangular buildings with heavily thatched roofs. Architectural effect is gained, however, through the monumental torni or gateways which cross the main entrance paths Many votive stone lanterns also decorate the grounds In the Buddhist temples the halls themselves are based entirely on Chinese prototypes, but the detail is typically Japanese in its composition and its mannered realism, and roof and cornice details are endlessly varied. In disposition there is little attempt at absolute symmetry Instead, there is a brilliant grasp of informal balance and composition, and a remarkable genius in adapting the exigencies of the plan to the picturesque hillside site so loved by the Japanese. Outstanding examples are the temples of the magnificent group at Nikko, largely of the 17th century, and the Hong Wanji temple at Kyoto. The genius for placing temples is well seen in the island temples that dot the Inland sea, especially those of the sacred island of Itaku Shima, near Hiroshima, where the chief temple was founded in 587.

(See also Chinese Architecture; Egyptian Architecture; Greek Acchitecture; Indona Architecture; Jaminer Architecture; Religious and Mamorial Architecture; Komam Architecture; Western Asiatic Architecture, from Egypt to Architecture; Western Asiatic Architecture, from Egypt to Architecture; (F. H.)

TEMPLE BAR, an historic site in London, England. In more than one of the main roads, converging upon the city of London

a bar or chain marked the exta-nural jurisdiction of the Coproporation Temple Bar stood at the junction of the present Strand and Fleet street, over against the Law Courts A bar is first mentioned here in 1301, but the name is most familiar in its application to the gateway designed by Sir Christopher Were, which replaced an older structure on this spot in 1672. This was removed in 1378, and set up in 1888 at the entrance to Theobalds park near Cheshunt, Hertfordshire. A pedestal surmounted by a dragon or "griffin" marks the old site. When the sovereign is about to enter the city in state, whether by Temple Bar or elsewhere, the Lord Mayor, in accordance with ancient custom, presents the swood of the city to him, and he at once returns it. Formerly the bai or gate was closed until this ceremony was carried out

TEMPO (It), term used in muse signifying literally time, though in practice it has come to mean more often the speed at which a composition is, or should be, performed It is however still used in the other sense in such expressions as tempo or distance, meaning "in common time"; it keewse in tempo rubato (literally "robbed time"), meaning the slight deviations from strict time which the performer makes for expression (See Time).

TENANT: see LANDLORD AND TENANT

TEMANT-RIGHT, in law, a term expressing the right which a tenant has, either by custom or by law, agant has landlord for compensation for improvements at the determination of his tenancy. In England it is governed for the most part by statute, eg, the Agnoultural Holdings Act, 1923, and the Small Holdings and Allotiments Acts, 1908-76 (see ALLOTMENTS, LANDLORD AND TEMANT; SMALL HOLDINGS) A right to compensation for improvements is created in favour of tenants of business premises by the Landlord and Tenant Act, 1927. In Ireland tenant-light was a custom, prevailing particularly in Ulster, by which the tenant action, the control of the state of the

No custom giving rise to tenant-right seems ever to have existed in the United States, and no right of compensation in favour of

tenants exists apart from agreement or local statutes

TENASSERIM, a division of Lower Rutma, bordening one Siam Area, 37,644 sq mi. Pop (1941) 2.17,420, nucluding over 70,000 Christians, the great majority of whom are Karner, The beadquarters of the commissioner are at Moulmein. His divided into six districts: Toungoo, Salween, Thatôn, Amherst, Tavoy and Mergui It formed the tract south of Pegu conquesed from Burma in 1846, which was for many years known as the Tenasserim province. The southern extremity of the division approaches the insular region of Malaya, and it is fringed along its entire the state of the

TEN BRINK, BERNIKADD ESCUDIUS KONRAD (1841-29). German philologist, of Dutch origin, was born at Amsterdam on Jan. 12, 1841, and educated origin, was born at Amsterdam on Jan. 12, 1841, and educated origin, was born at Amsterdam on Jan. 12, 1841, and educated Dimedelorf, Münster and Bom. In 1870 he became professor of in Dimedelorf, Münster and Farland and Bernard origin or the Strath origin and Amsterdam 1870 in conjunction with W. Saturders in Jan. Martin and E. Schmidt, Quellen und Forschungen zur Sprache und Kulturgsschichte der germanischen Välker In 1871 he published Chauser: Studien zur Geschichte seher Entwickelung und zur Verskunst. He also published citical editions of the Prologue and Verskunst. He also published citical editions of the Prologue and Verskunst. He also published citical editions of the Prologue and Verskunst. He also published citical editions of the Prologue and Verskunst. He also published contical on the English Chauser study in the United Kingdom as well as in Germany, and to him was indirectly due the foundation of the English Chauser society. His Bectwilf-Untersuchungen (1888) proved a hardly less valuable contribution to the study of Early English Herstmer. His best known work is his Geschichte der englischen Literatur, (1889-93) (English hy H. Kermedy in Bohn's Standard Libratur), which was never completed, and broke off just before the Elizabethan period. He died al Strasbourg Jan. 29, 1892.

TENBY, a municipal borough in the Pembroke county parliamentary division of Wales, 10 mi, E of Pembroke by road Pop. (1951) 4,597 Area 1 8 sq mi Standing on a promontory on the south coast of Pembrokeshire overlooking Carmaithen bay to the east, the walled town is built of the gray limestone of the peninsula It has a harbour and two sandy beaches. The alternation of chiffs of grav limestone and Old Red Sandstone along this coast is very beautiful and Tenby, with its mild climate, is visited all the year round Tenby is first mentioned as a Danish fishing station, and the old Welsh name, Dinbych-v-Pysgod, means "the precipice of fishes." Flemish clothworkers came there in the early 12th century and a 16th-century Flemish house still exists Ruins of the castle (12th-13th century) stand on a hill northeast of the town. St. Mary's church is mostly 15th century The early charters were confirmed in 1580 and the 15th-century town walls repaired in 1588 when a Spanish invasion was feared During the 15th and 16th centuries Tenby traded by sea with Bristol and had wealthy mercantile families It declined after the Restoration until the coming of the railway.

Caldey, 2½ mi. S. of Tenby, is an island privately owned by a priory of Cistecian monks of the Strict Observance (Trappists)

who went there in 1929 from Chimay in Belgium.

TENCH (Tinca tinca). A cyprinid fish of Europe, Asia Minor and Siberia, greenish, with small scales and rounded fins thrives in weedy ponds. Specimens exceeding 8 lb. are rare The flesh is more palatable than that of most cyprinids

TENCIN. CLAUDINE ALEXANDRINE GUÉRIN DE (1685-1749), French author and leader in society, was born at Grenoble in 1685 It was her family's wish that she become a nun, but a life among the Parisian social and intellectual leaders of the day was more to her taste Many of France's prominent men were counted among her lovers; most illustrious was the regent, Philip, duke of Orléans. Her salon, frequented by such hterary lions as Bernard le Bovier de Fontenelle, Claude Adrien Helvetius and Charles Louis de Secondat de Montesquieu, became one of the most brilliant in the reign of Louis XV Her son, by Louis Camus, Chevalier Destouches, was Jean le Rond d'Alembert,

who, with Denis Diderot, collaborated on the Encyclopédie, A woman of imagination and intelligence, Mme, de Tencin acquired a reputation as an author of some stature. Among her books were Le Stège de Calais (1739), Les Mémoires du comte de Comminges (1735), Les Malheurs de l'amour (1747), Les Anecdotes d'Edouard III (pub. 1776) and Lettres au duc de Richelieu

(pub. 1806). She died in Paris in 1749

TENDER. (1) An adjective meaning soft, either physically or figuratively (Fr. tendre, Lat. tener, soft, allied to tenuis, thin). (2) A legal term meaning an offer for acceptance, particularly an offer in money for the satisfaction of a debt or liability or an ofter to pay or deliver according to the terms of a contract; for "legal tender" see PAYMENT. The term is also applied to an offer to do a specified piece of work or to supply certain goods for a certain sum or at a certain rate or to purchase goods at a certain rate Contracts for important works or for the supply of large amounts of goods are usually put out to tender in order to secure the lowest price. In this sense the word is from "to tender," to offer (Fr. tendre, Lat. tendere, to stretch out). (3) A "tender" is also one who "attends" (Lat. attenders, to stretch toward, to give heed to), and so is applied particularly to a small vessel which brings supplies, passengers, etc., to a larger vessel or which is used to take or bring messages, and similarly to a carriage attached to a locomotive engine on a railway, which carries fuel and water

TENDON OF ACHILLES, the large tendon at the back of the ankle. It is the tendon of the calf muscles which extend and invert, the foot, and is inserted into the heel bone (calcaneus). These muscles often become shortened, as a result of overdevelopment or sometimes of the continued use of high heels, or they may be congenitally short. This defect sometimes leads to fallen arches and foot pain so severe that the tendon has to be lengthened by and pot pair so severe that the tendon has to be tengthened by structed operation. This tendon is named after Achilles, a famous here of the Rojan war. According to Greek legend when Achilles was born his mother plunged him into the Styx. This made his

TO MARKET BY

whole body invulnerable except the part of the heel by which she had held him, and in this heel he later received a mortal wound

TENEBRAE, an office sung in Roman Catholic churches on the afternoon or evening of Wednesday, Thursday and Friday of Holy Week Durandus (vi. 72, n. 2) derives the name from the fact that "the church on these days cultivates darkness (tenebras colit)" in sorrow for the Lord's Passion, celebrating His exequies on three days since for three days He was dead, and it symbolizes the darkness that fell on the earth while the Sun of Justice was crucified

TENERIFE (TENERIFFE), the largest of the Canary Islands. area, 795 sq mi Of irregular shape, 60 mi long, 30 mi wide, it is the main portion of the Spanish province of Santa Cruz de Teneiife (pop 1950, 418,101) The celebrated peak locally known as the Pico de Teyde (or Teide), with its supports and spurs, occupies nearly two-thirds of the whole island It has a double top. the highest point, El Piton, is 12,192 ft above the sea, the other, Chahorra, connected with the first by a short narrow ridge, has a height of 9,880 ft. They are both orifices in the same grand dome

of trachyte, where snow lingers four months,

For more than one-half of its circumference the base of the true peak rises from an elevated but comparatively level tract On the southeast, south and southwest there is a high curved ridge overlooking the Pumice Stone plains and presenting a very steep face to the peak Between the ridge and the sea the slope is more gradual, and there are intervening tablelands. Peaks rise from the ridge, one of which (Guajara) attains the height of 8,900 ft Both El Piton and Chahorra have craters on their summits, from which issue steam and a little sulphurous vapour. The crater on El Piton is partly surrounded by a wall of lava, which has been made white by the action of sulphuious vapours The crater is about 300 ft across, with a depth of 70 ft The crater on Chahorra has a diameter of 4,000 ft , its depth is scarcely 150 ft The entrance to the Llano at a sort of natural gateway (called Portillo) between two basaltic hills, is about 7,000 ft above the sea Between two and three hours are consumed in crossing the Llano to the base of the cone, the lower part of which is ascended to a point 9,750 ft above the sea

To the northwest of the grand cone, several thousands of feet below Chahorra, there are many small cones of eruption, showing that the intensity of volcanic action was greatest on that side. Eastward from the ridge bounding the Pumice Stone plains extends a chain of mountains to the northeastern extremity of the island The highest peaks are Izana (7,355 ft ), Perejil

(6,027) and Cuchillo (5,467).

There is no record of eruptions from either crater of Pico de Teyde In 1795 a great quantity of lava was poured out from three vents on the eastern side, and in the same year lava streams issued from a crater near Gumar, halfway between Santa Cruz and the peak. In the year 1706 a vent on the northwestern side of the peak discharged a copious stream, which flowed down to the sea and nearly filled up the harbour of Garachico For three months in 1798 much lava and other volcanic matter were ejected.

Santa Cruz, the capital of Tenerife and of the Canaries, and Laguna, the former capital, are described in separate articles. A good road connects Santa Cruz and Orotava, a town on the north coast 25 mi. W N.W Date palms form a striking feature in the landscapes. The town of Orotava (pop. 1940, 5,635) is 1,040 ft. above the sea. The houses are solidly built, but the town has a deserted aspect. A stream of water is conducted through every street

Puerto de la Cruz (pop. 1940, 5,134) 3 mi, N. of the town, is a clean place. The streets are broad and the houses well built. (See also CANARY ISLANDS.)

TENGYUEH (Burmese MOMEIN), a town in the province of Yunnan, southwest China, near the Burmese frontier, with an estimated Chinese population of 18,000. It is situated at an elevation of 5,400 ft., in a region of heavy monsoonal rainfall, between the parallel north-to-south valleys of the Salwen and Irrawaddy. The town dates from the 14th century, when the Shan principality of Nankao was conquered by the Chinese, and Tengyueh was built as an outpost. The town lies on the old trade upper Irrawaddy valley Trade was formerly by mule transport: the journey to Yunnan-fu, over difficult country, took about 24 days, while Bhamo was a seven days' journey. The town was opened to foreign trade in 1897, but the actual customs opening did not take place until 1902 Tengyuch became of new importance after the outbreak of the war in 1937. The road from Bhamo through Tengyueh became a northern branch of the Burma road Trade more than doubled in 1939. The total customs revenue which had been a little over St \$300,000 before the war was St \$878,890 84 (\$104,403,44 US) in 1939. In 1942 the Japanese took Tengyueh but lost it in Sept. 1944.

TENIERS, the name of a family of Flemish artists who

flourished at Antwerp and Brussels during the 17th century DAVID TENIERS, the elder (1582-1649), was born at Antwerp, the son of Julian Teniers, a mercer who settled at Antwerp in 1558 He received his first training in the painter's art from his brother Juliaen, then studied under Rubens in Antwerp, and subsequently under Elsheimer in Rome; he became a member of the Antwerp gild of painters in 1606 Though he tried his skill in large religious, historical and mythological compositions, his fame depends chiefly on his landscapes and paintings of peasants carousing, of kermesse scenes and the like, which are marked by a healthy sense of humour, and which are not infrequently confused with the early works of his son David A large painting by the elder Teniers at St. Paul's church in Antwerp, represents the "Works of Charity" At the Vienna Gallery are four landscapes painted by Temers under the influence of Elsheimer, and four small mythological subjects, among them "Vertumnus and Po-mona," and "Juno, Jupiter and Io." The National Gallery has a characteristic scene of village life, "Playing at Bowls," a "Conversation," and a "Rocky Landscape." Other examples of his work are to be found at the galleries of Leningrad, Madrid, Munich, Dresden and Berlin ("The Temptation of St. Anthony"). He died at Antwerp on July 29, 1649

DAVID TENIERS, the younger (1610-1600), his more celebrated son, was born in Antwerp and was baptized on Dec. 15, 1610 Through his father, he was indirectly influenced by Elsheimer and by Rubens We can also trace the influence of Adrian Brouwer at the outset of his career. In 1637 Teniers married the ward of Rubens, Anne Breughel, the daughter of John (Velvet) Breughel. He became a "master" in the gild of St. Luke in 1633. The Berlin Museum possesses a group of ladies and gentlemen dated 1634. Some first-rate works—the "Prodigal Son" and a group of "Topers" in the Munich Gallery, and a party of gentlemen and ladies at dinner, termed the "Five Senses," in the Brussels Museum-are instances of the perfection attained by the artist when he was probably scarcely twenty. His touch is of the rarest delicacy, his colour at once gay and harmonious. He was little over thirty when the Antwerp gild of St. George enabled him to paint the marvellous picture now in the Hermitage Gallery in Leningrad the "Meeting of the Civic Guards" Correct to the minutest detail, yet striking in effect, the scene, under the rays of glorious sunshine, displays acquired knowledge and natural good taste. Another work of the same year (1643), now in the National Gallery, London, is "The Village Fête."

Teniers was chosen by the common council of Antwerp to preside over the gild of painters in 1644. The archduke Leopold William, who had assumed the government of the Spanish Netherlands, employed Teniers not only as a painter but as keeper of the collection of pictures he was then forming. With the rank and title of "ayuda de camara," Teniers took up his abode in Brussels in 1651. Immense sums were spent in the acquisition of paintings for the archduke. A number of valuable works of the Italian masters, now in the Vienna Museum, came from Leopold's gallery after having belonged to Charles I. and the duke of Buckingham. De Bie (1661) states that Teniers was some time in London, collecting pictures for the duke of Fuensaldana, then acting as Leopold's lieutenant in the Netherlands. Paintings in Madrid, Munich, Vienna and Brussels show what the imperial residence was at the time of Leopold, who is represented as conducted by Teniers and admiring some recent acquisition. No picture in the gallery is

route from Yunnan-fu to Bhamo, a Burmese trade centre in the omitted, every one being inscribed with a number and the name of its author, so that the ensemble of these paintings might serve as an illustrated inventory of the collection. Still more interesting is a canvas, now in the Munich Gallery, showing Teniers at work in the palace, with an old peasant as a model and several on-lookers When Leopold returned to Vienna, the pictures travelled to Austria. Teniers remained in high favour with the new governorgeneral, Don Juan, a natural son of Philip IV.

Shortly after the death of his wife in 1656 Temers married Isabella de Fren, daughter of the secretary of the council of Brabant, and strove to prove his right to armorial bearings In

1663 Teniers founded the Academy at Brussels.

Temers died in Brussels on April 25, 1690. David, his eldest son, a painter of talent and reputation, died in 1685. One of this third Teniers's pictures—"St. Dominic Kneeling before the Blessed Virgin," dated 1666—is in the church at Perck.

Blessed Virgin," dated 1666—is in the church at Perck.
See T. Smith, Catalague Ranoual III (1834); J John Vermoelen,
Notice Interrupte sur David Tenters et sa famille (Antwerp, 1871),
Alph Wauters, Huitore des envenous de Brusellet (1851), and Les
tapisseries bruvellouses (1878), Max Rooses, Geschichte der Malerschie
Antwerpens (Munch 1850), A va Wurdbach, D'Tenters (1871); J
van den Branden, Geod. & Asiw, Schilderschool (1853), A. Rosenber (1971), TEMMAS, C. (1972), 
TENISON, THOMAS (1636-1715), English archbishop, was born at Cottenham, Cambs., on Sept. 29, 1636 He was educated at Corpus Christi college, Cambridge, of which he became a fellow in 1659. After holding cures at Cambridge, where he gave devoted care to sufferers from the plague, and at Norwich, he was presented in 1680 by Charles II. to the vicarage of St. Martin's-in-the-Fields, London, where he endowed schools, established a public library, and was a champion of Protestantism during the reign of James II. Monmouth sent for him before his execution. Under William III, Tenison was in 1689 named a member of the ecclesiastical commission appointed to prepare a reconciliation of the Dissenters, the revision of the liturgy being specially entrusted to him. He preached a funeral sermon on Nell Gwyn (d. 1687) in which he represented her as truly penitent-a charitable judgment which did not meet with universal approval. He was made bishop of Lincoln in 1691 and archbishop of Canterbury in 1605 He attended Oueen Mary during her last illness and preached her funeral sermon in Westminster abbey. During William's absence in 1605 Tenison was appointed one of the seven lords justices to whom his authority was delegated. With Burnet he attended the king on his death-bed He enjoyed little favour with Queen Anne, but was a commissioner for the Union with Scotland in 1706. A strong supporter of the Hanoverian succession, he was one of the three officers of state to whom on the death of Anne was entrusted the duty of appointing a regent till the arrival of George I , whom he crowned on Oct 31, 1714. Tenison died in London on Dec. 14, 1715.

Tenison's works include The Creed of Mr Hobbes Examined (1670) and Baconia, or Certain Genuine Remains of Lord Bacon (1679). He was one of the founders of the Society for the Propagation of the Gospel.

TENNESSEE, popularly known as the "Volunteer state," is a south central state of the United States of America. It lies between the extremes of approximately 35° and 36° 41' N. and 81° 40' and 90° 18' W of Greenwich. Tennessee is bounded on the north by Kentucky and Virginia, on the east by North, Carolina along the line of the crest of the Unaka mountains to within 26 mi. of Georgia, where the boundary turns due south; on the south by Georgia, Alabama and Mississippi along the 35th parallel of north latitude; on the west by the Mississippi river, which separates it from Arkansas and Missouri. The extreme length of the state from east to west is 432 mi., and the extreme breadth is 115 mi., its area being 42,246 sq mi., of which about 700 are water surface The popular name "Volunteer state" was given to Tennessee because of its remarkable record in furnishing volunteers in the Mexican War.

Physical Features.—The state is popularly divided into three large divisions known as east, middle and west Tennessee. The first extends from the heights of the Unaka ridges along the North Carolina border, across the valley of the Tennessee nver to the heights of the Cumberland plateau. The middle section includes a part of the Cumberland plateau, all the Highland rim plateau and the Central basin, and extends westward to the Tennessee river. The western division includes the plateau region from the Tennessee river to the steep slope which overlooks the Mississippi flood plain, also a narrow strip of lowland which extends to the Mississippi river From a maximum elevation of 6 642 ft at Clingman's Dome near the North Carolina border, in Sevier county, the surface descends to 182 ft on the Mississippi river in Shelby county The mean elevation of the state is approximately ooo ft The general slope, however, is west by north The Unaka mountains, which occupy a belt 8 to 10 mi. wide along the state's eastern border, are a series of somewhat irregular ridges developed on complexly folded and faulted crystalline rocks. Sixteen peaks exceed 6,000 ft in height. That part of the Great Appalachian valley which traverses Tennessee is commonly known as the valley of east Tennessee It consists of parallel ridges and valleys developed by erosion on folded sandstones, shales and limestones, the valley quality predominating because the weak limestones were of great thickness. The valley areas vary in height from 600 ft. in the southwest to 1.600 ft in the northeast. In the northeast the ridges are more numerous and higher than in the southwest, where White Oak ridge and Taylor's mountain are among the highest, although Missionary and Chickamauga ridges are better known because of their association with hattles of the Civil War

Along the southwest border of the valley a steep escarpment, known as Walden's ridge, rises to the Cumberland plateau. This plateau has a mean elevation of about 1,800 ft, and a rolling topography, the northern portion sloping toward the northwest.

The western edge of the plateau is much broken by deep indentations of stream valleys, and drops suddenly downward about 1,000 ft to the Highland rim plateau, so named from the scarp which forms an encircling rim around the Central basin. It is fairly level generally, except where it is cut by river valleys The Central basin lies for the most part 400 to 600 ft. below the rim: a few hills or ridges, however, rise to the level of the rim. The basin is elliptical in form, extending nearly across the state from northeast to southwest with an extreme width of about 60 mi.: near its centre is the city of Murfreesboro, and Nashville lies in the northwest

Between the Central basin and the lower Tennessee river is the western Highland rim Westward from the lower Tennessee river the surface rises rapidly to the summit of a broken cuesta or ridge and then descends gently and terminates abruptly in a bluff overlooking the Mississippi flood plain. This is called the plateau slope of west Tennessee, which is part of the east Gulf coastal plain The bluff, 150 to 200 ft, in height, traverses the state in a rather straight course; between it and the meandering Mississippi, except at a few points where that river touches it, lie low bottom lands varying in width according to the bends of the river and containing numerous swamps and ponds. In the northern portion, principally in Lake county, is Reelfoot lake, which occupies a de-pression formed by an earthquake in 1811. It is 18 mi, long, has a maximum width of 3 mi., and is the only large natural lake in

The whole of the Appalachian province of Tennessee and the Southern portions of the Cumberland plateau, the Highland rim, and the Central basin are drained southward and westward by the Tennessee river and its tributaries. The valley of the lower Tennessee is drained northward by the same river. The northern portions of the Cumberland plateau, Highland rim and Central basin are drained northward and westward by the Cumberland river and its tributaries. The western slope of the east Gulf plans is drained directly into the Mississippi by several small streams.

The Central basin, the less elevated parts of the valley of east Tennessee, and parts of the outer portion of the Highland rim have a fertile soll of limestone origin. There are narrow strips of rich alluvium along many rivers. The soils on the mountains, on the ridges of the valley of east Tennessee and on the eastern slope of the east Gulf plains vary greatly, according to the rocks "为我们!

from which they are derived. In the Cumberland plateau, in the inner portion of the Highland rim and in the higher parts of the western slope of the east Gulf plains, the soil for the most part is sandy and thin

Tennessee has a delightful climate. The mean summer temperature varies according to elevation from 62° F on the Unaka mountains to 72° on the Cumberland plateau, or 75° in the valley of east Tennessee and on the Highland rim, 77° in the Central basin and about 78° on the east Gulf plains The mean winter temperature for each of these divisions values little from 28°. and the mean annual temperature ranges only from 57° in east Tennessee to 58° in middle Tennessee and to 60° in west Tennessee Usually the highest temperatures of the year are in July and the lowest in January. Killing frosts are rare between the third week in April and the middle of October, especially in the southern and western parts of the state An average annual precipitation of about 50 in is quite equally distributed over the state, and a little more than one-half of it is well distributed through the spring and summer months. The average annual snowfall is about 8 in The warm, moisture-bearing winds blow low from the south or southwest with a free sweep across the state in a direction nearly parallel with the trend of the mountains. The commingling of these winds with upper cold currents from the north gives rise frequently to westerly and occasionally to easterly winds

History.-What is now Tennessee was visited and claimed in turn by Spaniards. French and English. The final success of the English was achieved only after the desperate struggle which ended in the treaty of Paris of 1763 By its provisions France was driven from North America and the power of Spain was

greatly limited

The daring Spanish explorer Hernando de Soto reached the Mississippi river in 1541, at a high bluff occupied by Chickasaw villages, believed to be the present site of Memphis After a brief halt to collect food from the Indians and to build rafts. De Soto left the territory by crossing the Mississippi It was 132 years before another white man saw Tennessee

Jacques Marquette, the French missionary and explorer, in his voyage down the Mississippi by canoe in 1673, camped upon the western boider, and eight years later La Salle and his companions left Canada to complete the exploration of the river. La Salle built Ft Prud'homme in 1682 upon the Chickasaw bluff, near the present site of Memphis, but it was soon abandoned. Later the French built Ft Assumption, where Memphis now stands, and kept a garrison there, but made no attempt at colonization. The territory was a part of the English grant to Sir Walter Raleigh in 1584, and of the later Stuart grants, including that in 1663 to the proprietors of Carolina Tames Adair of South Carolina, a fur trades and explorer, is supposed to have been the first to go from the English colonies into Tennessee. A party of Virginians led by Thomas Walker (1715-94) in 1750 reached the Cumberland river and Cumberland mountains and named them in honour of the royal duke In 1756 or 1757 Ft. Loudon, named in honour of John Campbell, earl of Loudon, was built on the Little Tennessee river, about 30 mi. south of the present site of Knoxville, as an outpost against the French who were then active in the whole Mississippi valley, and was garrisoned by royal troops. The fort was captured by the Cherokee Indians in 1760, and both the garrison and the neighbouring settlers were massacred

Eastern Tennessee was recognized as a common huntingground by the Cherokees, Creeks, Miamis and other Indian tribes, The Iroquois of New York claimed much of the central portion by right of conquest, and the western section was the home of the Chickasaws.

By the treaty of Ft. Stanwix, in 1768, the Iroquois ceded whatever claim they had to the English, and in 1769 several cabins were built along the Holston and Watauga rivers upon what was thought to be Virginia soil.

A settlement near the present Rogersville was made in 1771, and in the next year another sprang up about the store of Jacob Brown on the Nolichucky. After the failure of the Regulator insurrection in North Carolina in 1771, hundreds of the Regulators made 

between Virginia and North Carolina showed the settlements to be in North Carolina, but that colony made no effort to assert junisdiction not to protect the settlers from Indian depredations

Therefore in 1772 the residents of the first two settlements met to establish a form of government since known as the Watauga association A general committee of 13 was elected to exercise legislative powers This committee elected from its members a committee of five in whom executive and judicial powers were lodged A sheriff, an attorney and a clerk were elected, and regulations for recording deeds and wills were made. Courts were held, but any conflict of jurisdiction with Virginia or North Carolina was avoided In 1775 the settlement on the Nolichucky was forced to join the association, and in the same year the land was bought from the Cherokee Indians in the hope of averting THOP

With the approach of the American Revolution, the dream of becoming a separate colony with a royal governor was abandoned, and on petition of the inhabitants the territory was annexed to North Carolina in 1776 as the Washington district, which in 1777 became Washington county, with the Mississippi river as the western boundary The population increased rapidly, and soon several new counties were created

During the American Revolution the hardy mountaineers under John Sevier and Evan Shelby did valiant service against both the royal troops and the loyalists in South Carolina, chiefly as partisan rangers under Charles McDowell (1743-1815) Maj Patrick Ferguson, with several hundred loyalists and a small body of regulars, made a demonstration against the western settlements; but at King's mountain in South Carolina, he was completely defeated by the Americans

After the American Revolution the legislature of North Carolina in 1784 offered to cede its western territory to the general government, provided the cession be accepted within two years The Watauga settlers, indignant at this transfer without their consent, and fearing to be left without any form of government whatever, assembled in convention at Jonesboro on Aug 23, 1784. and chose delegates to a later convention to form a new state, Meanwhile North Carolina repealed the act of cession and created the western counties into a new judicial district A second convention, in November, broke up in confusion without accomplishing anything; but a third adopted a constitution, which was submitted to the people, and ordered the election of a legislature This body met early in 1785, elected Sevier governor of the new state of Franklin (at first Frankland), filled a number of offices, and passed several laws in anticipation of an autonomous existence On account of the scarcity of a circulating medium more than 20 articles were valued and declared legal tender Among them were fox skins, 1s. 6d., beaver skins, 6s; bacon, 6d per lb., rye whisky, 2s. 6d. the gallon. Four new counties were created, and taxes were levied Later in the year another convention, to which the proposed constitution had been referred, adopted instead the constitution of North Carolina with a few trifling changes, and William Cocke was chosen to present to congress a memorial requesting recognition as a state. Congress, however, ignored the request, and the diplomacy of the North Carolina authorities caused a reaction. For a time two sets of officials claimed recognition, but when the North Carolina legislature a second time passed an act of oblivion and remitted the taxes unpaid since 1784, the tide was turned. No successor to Sevier was elected

Sevier was arrested on a charge of treason, but was allowed to escape, and soon afterward was again appointed brigadier-general of militia.

Meanwhile, settlers had pushed on farther into the wilderness. On March 17, 1775, Col. Richard Henderson and his associates extinguished the Indian title to an immense tract of land in the valleys of the Cumberland, the Kentucky and the Ohio rivers (see KENTUCKY). In 1778 James Robertson (1742-1814), a native of Virginia, who had been prominent in the Watauga settlement, set out with a small party to prepare the way for permanent occupation. He arrived at French Lick (so called from

their way into the wilderness A survey of the western boundary a French trading post established there) early in 1779, and in the same year a number of settlers from Virginia and South Carolina arrived Another party, led by John Donelson, arrived in 1780, and after the close of the War of Independence the immigrants came in a steady stream A form of government similar to the Watauga association was devised, and blockhouses were built for defense against the Indians Robertson was sent as a delegate to the North Carolina legislature in 1783, and through his instrumentality the settlements became Davidson county Nashville which had been founded as Nashborough in 1780, became the county seat Finally, in 1843, it became the state capital Robertson, the dominant figure in the early years, struggled to counteract the efforts of Spanish intriguers among the Indians, and when diplomacy failed, he led the settlers against the Indian towns

On Feb 25, 1790, North Carolina again ceded the territory to the United States government, stipulating that all the general provisions of the ordinance of 1787 should apply except that forbidding slavery Congress accepted the cession and, on May 26, 1790, passed an act for the government of the "Territory south of the River Ohio" William Blount was appointed the first governor, and in 1792 Knoxville became the seat of government The chief events of Blount's administration were the contests with the Indians, the purchase of their lands, and the struggle against Spanish influence.

A census ordered by the territorial legislature in 1795 showed more than 60,000 free inhabitants (the number prescribed before the territory could become a state), and accordingly a convention to draft a state constitution met in Knoxville on Jan 11, 1796 The instrument, which closely followed the constitution of North Carolina, was proclaimed without submission to popular vote. John Sevier was elected governor, and William Blount and Wilham Cocke United States senators In spite of the opposition of the Federalist party, whose leaders foresaw that Tennessee would be Republican, it was admitted to the union as the 16th state on

June 1, 1796.

With the rapid increase of population, the dread of Indians and Spaniards declined Churches and schools were built, and soon many of the comforts and some of the luxuries of life made their appearance. The question of a circulating medium was acute



VIEW OF REMPHIS FROM THE HISSISSIPPI RIVER FRONT

during the first half of the 19th century, and state banks were organized, which suspended specie payments in times of financial stringency." The bank of Tennessee, organized in 1838, had behind it the credit of the state, and it was hoped that money for education and for internal improvements might be secured from its profits The management became a question of party politics, and during the Civil War its funds were used to advance the Confederate cause The development of the western section along the Mississippi was rapid after the beginning of the century Memphis, founded in 1810, was thought as late as 1832 to be in Mississippi, and not until 1837 was the southern boundary, which according to the North Carolina cession was lat 35°, finally established. As in other river towns, the disorderly element in Memphis was large, and the gamblers, robbers and horse thieves were suppressed only by local vigilance committees The peculiar topographical conditions made the three sections of the state almost separate commonwealths, and demand for better means of communication was insistent. The policy of state aid to internal improvements found advocates very early, in spite of the Republican affiliations of the state, but a definite program was not laid out until 1820 when commissioners for internal improvements were appointed and an expenditure of \$150,000 was authorized In 1835 the state agreed to subscribe one-third to the capital stock of companies organized to lay out turnpikes, railways, etc., and four years later the proportion became one half. Though these agreements were soon repealed, the general policy was continued, and in 1861 more than \$17,000,000 of the state debt was due to these subscriptions, from which there was

Though Pres. Andrew Jackson was for many years practically a dictator in Tennessee politics, his arbitrary methods and his intolerance of any sort of independence on the part of his followers led to a revolt in 1836, when the electoral vote of the state was given to Hugh Lawson White, then United States senator from Tennessee, who had been one of Jackson's most devoted adherents. White's followers called themselves anti-Van Buren Democrats, but the proscription which they suffered drove most of them into the Whig party, which carried the state in presidential elections until 1856, when the vote was cast for James Buchanan, the Democratic candidate. The Whig party was so strong that James K Polk (Democrat), a resident of the state, lost its electoral vote in 1844. With the disintegration of the Whig party, the state again became nominally Democratic, though union sentiment was strong, particularly in east Tennessee There were few large plantations and few slaves in that mountainous region. while the middle and western sections were more in harmony with the sentiment in Mississippi and Alabama. In 1850 representatives of nine southern states met in a convention at Nashville (q,v) to consider the questions at issue between the north and the south. The vote of the state was given for John Bell and Edward Everett in 1860, and the people as a whole were opposed

The proposition to call a convention to vote on the question of secsion was voted down on Feb. 9, 286t, but after Fres Abrahm Lincoln's call for troops the legislature submitted the question of secsion directly to the people, and meanwhile, on May 7, 286t, entered into a "Millitary league" with the Confederacy. An overwhelming vote was cast on June 8 in favour of secsions, and on June 24 Gov. I. G. Harris (1818-97) issued a proclamation dockining Tennessee out of the union. Andrew Johnson, then a United States senator from Tennessee, refused to resign his seat, and was supported by a large element in east Tennessee. A union convention, including representatives from all the eastern and a few of the control of the con

The state was, next to Virginia, the chief battleground during the Civil War, and a historian has counted 456 battles and skirmashes that took place within its borders. In Feb. 1867, Gen. U. S. Grant and Commodore A.-H. Foote captured Ft. Henry on the Tennessee river and Ft. Donelson on the Cumberland. The Confederate line of defense was broken and Gen. D. C. Buell cocupied Mashville. Grant next ascended the Tennessee river to Flittsburg Landing, with the intention of capturing the Memphis and Charleston railway, and on April 6 and 7 defeated the Confederates in the battle of Shiloh. The capture of Island No. 10

in the Mississippi on April 7 opened the river as far south as Membis, which was captured in June On Dec. 31 and Jan 2 Gen William S. Rosscrans (Federal) fought with Gen. Braxton Bragg (Confederate) the bloody but indecisive battle of Stone river (Murfresboro). In June 1863 Rosscrans forced Bragg to evacuate Chattanogas. Biagg, however, turned upon his pursuer, and on Sept 19 and 20 one of the bloodhest battles of the war was fought at Chickannagas. General Grant then assumed commard, and on Nov 24-25 defeated Biagg at Chattanooga, Ints opening first most with ancess, but was shut up in Knowlile by Gen James Longstreet, who was not able, however, to capture the city, and on the approach of Gen W. T. Sherman retured into Virgina Almost the whole state was now held by Federal troops, and no considerable multary movement occurred until after the fall of Alianta in Sept. 1864. Then Gen J. B. Hood moved into Tensees, expecting Sherman to follow him. Sherman, however, sent reinforcements to Thomas and continued his march to the sea

Hood fought with Gen. John M Schofield at Franklin, and on Dec. 15-16 was utterly defeated by Thomas at Nashville, the Federals thus securing virtually undisputed control of the state.

After the occupation of the state by the Federal armies in 1862, Andrew Johnson was appointed military governor by the president (confirmed March 3, 1862), and held the office until he was inaugurated vice-president on March 4, 1865. Republican electors attempted to cast the vote of the state in 1864, but were not recognized by congress Tennessee was the first of the Confederate states to be readmitted to the union (July 24, 1866), after ratifying the constitution of the United States with amendments. declaring the ordinance of secession void, voting to abolish slavery, and declaring the war debt void Tennessee freed its slaves by an amendment to the state constitution ratified by a vote of the people on Feb 22, 1865, but suffrage was not conferred upon the Negro until two years later (Feb 25, 1867) The state escaped "carpet bag" government, but the native whites in control, under the leadership of William G Brownlow, exhibited almost every phase of the reconstruction policy All persons who had either directly or indirectly taken part in the war against the union or had given aid to the Confederacy were denied the right of suffrage. In the election of 1869, the acting governor, D W C Senter, ordered the election commissioners to issue to all actual citizens of the state permits to vote. The Democrats united with the conservative Republicans and Senter was easily elected. At the same time a Democratic and conservative legislature was elected, thus placing the state government again in the control of officers elected by the majority of the people. The Ku Klux Klan, originating in 1865 as a youthful prank at Pulaski, Tenn., spread over the state and the entire south, and in 1869 nine counties in the middle and western section were placed under martial law because of the Klan's activities against the Loval league and the Negroes.

A constitutional convention, which met in Jan, 1879, revised the old constitution, and the revusion became the present constitution when ratified by the people the following May. In 1873 a school law was passed which provided for state and country super-intendents and separate schools for white and coloured children and levred a state tax to aid in paying the expenses of these schools. Another progressive step was the final compounding of the old state debt at 50 cents on the dollar by an act of the legislature in 1883.

With the exception of the administration of Alvin Hawkins, 1881-83, the Democratic party controlled the executive office from 1871 to 1971 and again 1975-21 and after 1923. In 1920, for the first time since 1886, and again in 1928, the state gave its electoral votes to the Republican party but Franklin Roosevelt won Tennessee back to the Democratic fold in 1932, where it still remained at mid-century.

In 1904 the Adams law, prohibiting the sale of intoxicating liquors in towns of 5,000 inhabitants or less, was passed, largely through the efforts of the Anti-Saloon league; an act prohibiting the manufacture of intoxicating liquor in the state became effects.

The second second second second second

tive on Jan 1, 1910, in Oct. 1913 Gov. Ben W Hooper called a special session of the legislature and secured the passage of the so-called Nuisance act, designed to close every saloon in the state by enforcing the law forbidding the sale of intoxicating liquor within four miles of any school; in 1915 provision was made for removal from office of state, county or city officials who failed to enforce the prohibition laws; and on Feb 2, 1917, Gov Tom C. Rye signed a bill forbidding the importation of liquor. Tennessee nevertheless turned against prohibition and voted for repeal in 1933 In 1915 a law was passed providing for mothers' pensions. In 1917 the letting of prison labour to private contractors was prohibited, and an act was passed forbidding the limiting of the output of coal in order to increase the price In the same year a state budget commission was created On Aug 18, 1920, the house, by 50 to 46, voted for concurrence in the senate resolution (adopted on Aug 13 by 5 to 4) ratifying the proposed amendment to the federal constitution, providing for woman suffrage As the 36th state to ratify, Tennessee brought the number to the requisite three-fourths In national elections Tennessee is usually Democratic, although it voted Republican in the presidential elections of 1920 and 1928 Pres Harry S. Truman carried Tennessee by 67,488 votes in 1948 State developments, especially in the eastern part, were closely associated after 1933 with the Tennessee Valley authority.

Government.—With the exception of the administrative recognization made in 1923, few alterations have been made in the government of Tennessee since the present constitution was adopted in 1870, and this was only a revision of the state's second constitution, which was adopted in 1834. If placed all executive departments directly under the governor, and eliminated many independent boards.

Every attempt to amend or revise the existing constitution has been unsuccessful because of the difficult procedure involved in such changes Amendments may be proposed not oftener than once in six years by a majority of the members elected to each house of the legislature, but before an amendment can be adopted, it must be agreed to by two-thirds of the members elected to each house of the next succeeding legislature, and later by a majority of all the citizens of the state voting for representatives at the next regular election. The legislature may also submit to the people the question of calling a convention to amend or revise the constitution, and such a convention must be called whenever, upon the submission of this proposition, a majority of the votes are cast in favour of it The election of the governor, members of the general assembly and congressmen is held biennially in evennumbered years on the first Tuesday after the first Monday in November, but the election of judicial and county officers is held on the first Thursday in August.

The governor is the only state executive officer elected by the people. He is elected for a term of two years and is not eligible for more than three consecutive terms. There is no lieutenant governor, in case of a vacancy in the office of governor, the speaker of the senate becomes acting governor.

The secretary of state, the treasurer, and comptroller of the treasury are elected by a joint ballot of the senate and the house of representatives, each for a term of two years; the attorney general is appointed by the judges of the supreme court for a term of eight years. In 1923 the administrative system of the state was reorganized, 64 hoards, commissions, agencies, etc., being combined into nine departments, each with a commissioner at its head. There were in 1950 ten departments, insurance and banking, highways and public works; labour; institutions; agriculture; finance and taxation; public health; education; public welfare; and conservation.

Both senators and representatives are elected for a term of two years by counties or by districts having approximately the same population. The number of representatives is limited by the constitution to 99, and the number of senators to one-three humber of representatives. The legislature meets biennially, in odd-numbered years, on the first Monday in January, and the length of the session is limited by a provision that the members shall be paid four dollars a day, besides an allowance for travelling expenses, for a period not exceeding 75 days. When the governor calls an extra session they are paid for not more than 20 days. Bills of whatever character may onginate in either-house, but no bill can become a law until it has passed both houses by a majority of all the members to which the house is stitled under the constitution, and if the governor vetoes a bill it cannot become a law until it has again passed both houses by such a majority. The constitution provides that no minister or priest is eligible to a seat in either house of the legislature.

The administration of justice is vested in a supreme court, a court of civil appeals, chancery courts, circuit courts, criminal courts, county courts, justice of the peace courts, and, in certain cities and towns, a recorder's court The supreme court consists of five judges elected by the state at large for a term of eight years, one for each of the three grand divisions (eastern, middle and western) and two for the state at large. The judges designate one of their number to preside as chief justice The court has appellate jurisdiction only The court of civil appeals, which in 1907 was substituted for the court of chancery appeals, is composed of nine judges elected for a term of eight years This court has jurisdiction of appeals from equity courts in which the amount in controversy does not exceed \$1,000, except in cases involving the constitutionality of a Tennessee statute, a contested election, state revenue or an ejectment suit, it has jurisdiction also of civil cases tried in the circuit and common law courts in which writs of error or appeals in the nature of writs of error are applied for It may transfer any case to the supreme court. The state is divided into 14 chancery districts, in each of which a chancellor is elected for a term of eight years, and at every county seat in each district a court of chancery is held; exceptions are the 10th district, which has three chancellors, and the 15th, which has four. There are also ten crimmal judges, principally in the larger cities. and there is one probate judge in the city of Memphis. The state is also divided into 20 circuits, in each of which a circuit judge is elected for a term of eight rears, and at every county seat in each circuit a circuit court is held. In several of the counties the county court is composed of a county judge, elected for a term of eight years, together with the justices of the peace in the county, and in the other counties it consists of the justices of the peace alone, who elect a chairman Each county is divided into civil districts. varying in number according to population or other factors, and each district elects at least two justices of the peace for a term of six years; each county town or incorporated town also elects one justice of the peace. A recorder has concurrent jurisdiction with a justice of the peace.

The government of each county is vested principally in the county court. This body represents and acts for the county as a corporation; has charge of the erection and repair of county buildings; levies the county taxes, divides the county into highway districts; chooses a highway commissioner for each district for a term of two years; and chooses a superintendent of schools (except where these are chosen by popular ballot), a surveyor, a public administrator and public guardian, a board for the equalization of taxes, a coroner and a county physician or health officer, each for a term of two years, three commissioners of the poor for terms of three years (one chosen each year) and a keeper and sealer of weights and measures to serve during the pleasure of the court. A county trustee, whose duty it is to collect state and county taxes, and a sheriff are elected by the people of the county for a term of two years; a clerk of the county court and a registrar are also elected by the voters of the county for a term of four

The capital city of Tennessee is Nashville.

Population.—The population of Tennessee in 1790 was 35,-691; in 1830 it was 681,004; in 1870, 1,258,520; in 1910, 2,184,-789; in 1940, 2,915,841; and in 1950, 3,391,718. This last figure represents an increase of 12.0% over the population in 1940. The population per square mile in 1950 was 78 8, as compared with 69,5 in 1940, and with 50.7 for the U.S. in 1950.

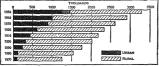
Of the 1950 population, 1,264,159 or 38 4%, lived in incorporated places of 2,500 or more, as compared with 35.2% in 1940 when these places constituted the urban area. The entire urban

population, under a new definition set up for 1050, which included also the thickly settled suburban area, or "urban finnge," adjacent to Memphis, Nashville, Chattanooga and Knoxville, and seven unincorporated places of 3,500 or more outside this fringe, amounted to 1,45,500, or 44 1% of the state total

The number of households in 1950 was 871,269, as compared with 714,894 in 1940 The average population pet household had

declined from 4.1 in 1940 to 3 8 in 1950

The population of the state was distributed by colcur and nativity in 1950 as follows: 83 4% native white, 05% foreign-born white; and 16.1% nonwhite, practically all Negro There were



ay country of the us suskin of the cassus

RRBAN AND RURAL POPULATION OF TENNESSEE, 1870 TO 1950

The crosshatched part of the 1950 bar represents the population of the additional areas counted as urban under the new 1950 definition

.98.1 males per 100 females in the native white population and 92 8 in the Negro population; 72% of the population was 65 years old or over; and 50.9% of the population 14 years old and over was in

Area		Population			Per cent of increase	
	1950	1940	1930	1040-50	1930-40	
The state Urban Rural Per cent urban	3,291,718 . 1,452,602 . 1,839,116 . 44 I	2,915,841 1,027,205 1,888,635 35-2	2,616,556 896,518 1,720,018 343	12.0 41.4 -2.6	#1 4 #4 6 9 8	
Principal cities: Memphis Nashville Chattancoga Knoxville	305,000 174,307 131,041 124,760	202,042 167,402 128,163 111,580	253,143 153,866 119,798 105,802	85 2 4 1 2 2 11 8	15.7 8.8 7.9 5.5	

\*Final figures for 1950 based on new definition. See comment in text the labour force.

Of the total number of employed males, 28 2% was engaged in agriculture, 9 3% in construction, 20.6% in manufacturing and 21.4% in transportation and trade

Finance—In common with the other states of the union, Tennessee has had a great increase in state expenditures. Also as in other states, highway expenditures rank first and educational second in importance.

The chief sources of revenue at mid-2-oth century were as follows: a general salest sar, motor car licences and other revenue of the highway department, a general property tax, a gasoline tax, a state tax on insurance companies, a sales tax on tobacco and alcoholic beverages, an excise text and an inheritance tax. Various privilege taxes, fines and forfeitures also help to augment the state's revenue.

Property taxes collected in 1948 amounted to \$1,792,000. State revenue in 1947 was \$127,967,000 or \$42 per capita; expenditures were \$123,700,000, of which \$100,420,000 was for operation, maintenance and interest and \$23,280,000 for outlays.

The gross debt in 1949 was \$97,469,000 (\$30.66 per capita).

Education and Charities.—The first steps toward the creation of a common school system for Tennessee were taken in 1823, when an act was passed setting aside for school purposes, the revenue and taxes accruing from public lands. From that beginning until the adoption of a uniform school code in 1925, more than 17000 different acts were passed pertaining to the educational system.

Under the new code the administration is vested in a state commissioner of education; a state board of education, consisting of the commissioner, the governor and nine other members, a county superintendent and a county board in each county; and in clies, city boards of education. The commissioner and the other members of the state bould are appointed by the governor. The county superintendent is elected biennally by either the county court or by popular ballot. The county board consist of seven members (unless otherwise provided), elected by the county court or by popular ballot, for a term of seven years, one returning annually.

The state board of education conducts examinations for county superintendents and issues certificates of qualification, classifies the high schools, maintains and controls the state colleges and establishes a salary schedule. No teacher may receive pay from the public-school funds unless he or she has received a certificate from the state commissioner of education

The quarterly county court has power to issue bonds, levy taxes and provide funds for buildings for the county schools The court is under obligation to maintain at least one four-year high school

within the county.

Public schools are free to all persons above the age of six years; attendance is compulsory between the ages of; and if ou lines high-school standing has been attained. Separate schools are manitained for the whites and for the Negroes. In 1948 the scholastic population between 6 and 18 years of age, inclusive, was 865,286 On the same date, 638,920 were enrolled in the public elementary and secondary schools. Of these, 463,611 were in county schools and 176,309 were in city schools. In 1946 there were 14,347 pupils enrolled in private and parochial schools. The average number of days attendance per pupil enrolled increased from 90 6 in 1910 to 140 in 1046.

From 1910 to 1946 the per capita expenditure for public schools based on population between 5 and 17 years of age, inclusive, in-

creased from \$6 71 to \$76 10.

The state provides for higher education in the University of Tennessee at Knoxville; Tennessee Polytechnic institute at Cookeville, East Tennessee State college at Johnson City, Mid-Tennessee State college at Murfreesboro: Austin Peav State college at Clarksville; and Memphis State college at Memphis. The Tennessee Agricultural and Industrial State College for Negroes is at Nashville Other schools maintained by the state are a school for the deaf at Knoxville; a school for the blind at Nashville, Tennessee Industrial school at Nashville, Tennessee Vocational school for girls at Tullahoma; a state training and agricultural school for boys at Nashville; a state training and agricultural school for Negro boys at Pikeville, and a vocational school for Negro girls at Nashville. Institutions of higher learning not under the control of the state are: George Peabody College for Teachers (see Peabody, George) and Vanderbilt university (nonsectarian) at Nashville; University of the South (Episcopal) at Sewanee; Southwestern at Memphis; Cumberland university (Baptist) at Lebanon; Union university (Baptist) at Jackson, Bethel college (Presbyterian) at McKenzie; University of Chattanooga (Methodist) at Chattanooga; Milligan college (Christian) at Milligan; Carson-Newman (Baptist) at Jefferson City; Lincoln Memorial university (nonsectarian) at Harrogate, Tusculum college (nonsectarian) at Greeneville; King college (Presbyterian) at Bristol; Maryville college (Presbyterian) at Maryville; Tennessee college at Murfreesboro; Lambuth college at Jackson; and Scarntt college (Methodist) at Nashville. Education for Negroes is provided by Fisk university at Nashville; Lane college at Jackson; Le Moyne college at Memphis; and Knoxville college at Knox-

The state maintains mental institutions at Knoxville, Nashville and Bolivar known as the Eastern, Central and Western state hospitals, respectively; and various schools, as mentioned above under Education. The main penitentiary is located at Nashville, and a branch, known as Brusby Mountain prison, is located at Petros in east Tennessee, where the prisoners are kept at labour principally in the state coal mines and on the farm.

The Fort Pillow state farm in west Tennessee at Cherry is primarily for first offenders. All charitable and corrective institutions are under the supervision of the state department of institutions.

Industry, Trade and Transport.—The interests of the state remain predominantly agricultural, though manufacturing is developing rapidly. The total land area in farms decreased from 17,90,000 as in 1936 to 17,858,973 cm 1936. The number of farms decreased from 25,6669 in 1935 to 234,431 in 1945; from 1910 to 1945 the average acrange per farm decreased from 3; 710 to 1945 the average acrange per farm decreased from 8; 10 fly 1936, 1957 to 1945. The sam population decreased from 1,271,708 in 1920 to 951,507 in 1945 of the 234,431 fainness in 1945; 206,603 were white and 27,539 were Negroes. Of all farmers in 1945; 50,663 were owners, 77,354 were tenands, and 350 were nanagers. In 1930 there were 11,113 women farmers. The total value of farm crops in 1934 was \$123,527,000, in 1948 it was \$327,058,000. In 1947 Tennessee ranked 23rd among the states of the umon in gross income from tarm products. The following table shows the comparative acreage, production and value of six important crops for 1939 and 1947.

	Cro	р		Year	Acreage	Production	Value
Indian core	1			1947	2,189,000	63,481,000 bu	\$142,832,000
				1939	2,635,000	52,700,000 "	38,908,000
Oats	٠			1947	230,000	6,095,000 "	6,704,000
				1930	85,000	1,445,000 "	621,000
Wheat				1947	346,000	5,190,000 "	12,456,000
				1939	358,000	4,117,000 "	3,409,000
Hay (all)				1947	1,855,000	2,297,000 tons	55,587,000
				1939	1,668,000	1,674,000 "	17,242,000
Cotton (lin	t)			1947	700,000	520,000 bales	84,251,000
				1939	707,000	449,000 "	20,200,000
Tobacco				1947	115,600	140,500,000 lb	58,616,000
				1039	120,300	110,167,000 "	15,735,000

The number of the principal domestic animals on Jan 1, 1949, were cattle 1,366,000; swine 1,269,000, sheep 279,000, hoises 133,000, mules 225,000 The total value of all livestock in Tennessee in 1945 was \$160,584,000

According to the forest service, department of agriculture, the acreage of national forests lying within the limits of Tennessee increased from 267,939 in 1925 to 555,789 in 1948 (287,000 in state and county foresis) In 1947, according to the bureau of mines, Tennessee ranked 24th among the states in the value of mineral products. Production in that year amounted to \$84,425,000 The principal products were coal, cement, copper, phosphate, clay products and stone The coal-producing area is a belt running from northeast to southwest, a little east of the centre of the state, production being reported in 16 counties. Valuable building marble is quairied in the eastern part of the state. Tennessee produces most of the copper mined in the southern states Its entire production of copper, gold and silver comes from mines worked primarily for copper in Polk county Rock phosphate is mined in five counties in the central and south central sections of The most important products in 1948 were coal, 5,910,000 short tons, worth \$33,214,000; stone, 8,011,360 short tons, worth \$12,932,537, cement 6,774,926 bbl., worth \$13,667,o6o; ferroalloys 144,599 short tons, worth \$11,072,047; rock phosphate 1,307,507 long tons, worth \$8,231,251, zinc 29,524 short tons, worth \$7,853,384. Other products of economic value are sand and gravel, lime, barite, lead, gold, silver and petroleum (see Petroleum)

Industry recovered from the 1933 low In 1933 there were only 1,561 manufacturing establishments employing 94,900 wage-earners, whereas in 1947 there were 3,246 establishments employing 192,357. The value added by manufacturing rose from \$172-939,000 to \$957,539,000. The chief industries in 1947 were textiles, with value added by manufacturing of \$171,949,000; purinting and publishming \$46,840,000; food processing \$132-489,000; primary metals \$85,040,000; faborized metals \$52,667,000; leather and leather products \$47,411,000; apparel and related products \$47,670,000.

The steam railway mileage of Tennessee increased continuously until 1920, when the total was 4,78, but by 1947 this had decreased to 3,491. The chief railways operating in the state in 1947 were: Louisville and Nashville, Nashville, Chattanoga and St. Louis; Southern; Tennessee Central; Illinois Central; and Gulf, Mobile and Ohio, 'In 1937 there were 293 mi. of electrical railway within the state, operated chiefly as city systems

The navigable waterways include the Mississippi, Tennessee and

The state highway department controlled 7,667 mi, of roadways in 1946, and local authorities 56,912 New surfacing placed from July 1, 1947, to June 30, 1948, amounted to 336 mi

July 1, 1047, to June 20, 1048, amounted to 356 mi Immonany—The best holography of material relating to Tennesce is Calium Margan McClinig Historical Collection (1921). There is no compute history of Informatic Collection (1921). There is no compute history of Informatic (1925), given a brief elementary vary up to 105? Fullip M Hamer, Tennesse, a History 167-1024, vol (1931) and Tennesce, the Volunteer State, 1976-1026, vol (1931) and Tennesce, 1977-1026, vol (

TENNESSEE RIVER, the largest tributary of the Ohio river, USA. It is formed by the confluence of the Holston and the French Broad rivers 45 mi. above Knoxville, Tenn, flows south south-west to Chattanooga, there turns west through the Cumberland plateau and into the northeast corner of Alabama. continues west across the northern part of Alabama, turns north on the boundary between Alabama and Mississippi, and continuing north across Tennessee and Kentucky unites with the Ohio at Paducah. Its principal tributaries rise in the Appalachian mountains: the Holston and the Clinch on the mountain slopes that flank the Appalachian valley in western Virginia; and the French Broad, the Little Tennessee and the Hiwassee in the mountains of western North Carolina. The Tennessee itself is 652 mi, long, and with the Holston and the North Fork of the Holston forms a channel about 900 mi. long. Its drainage basin covers about 44,000 sq mi, and its low-water discharge at Paducah is 10,600 cu ft. per second. Its average fall is 0.79 ft. per mi.— 0.056 ft, from Knoxville to Chattanooga: 1.10 ft, from Chattanooga to Florence, Ala., and 0.39 ft. from Florence to its mouth. The banks are everywhere easily accessible except at Knoxville and Chattanooga, where, for short distances, high elevations rise precipitously, from the water; and as the banks are mostly of clay or rock the channel is permanent and the river is unusually free from silt.

The Tennessee is navigable by steamboats throughout its entire course of 652 mi for several months of the year.

In 1904 the federal government authorized the construction.

with private capital, of a lock and dam at Hales Bar to provide a channel 6ft deep between it and Chattanooga, the water-power to be used by the company furnishing the capital. The Colbert and Bee Tree shoals were improved by the Colbert Shoals lock and canal, opened in 1911. In 1917 the U.S. Government undertook the construction of a navigation power dam (Wilson or dam No 2), 95ft high at Muscle shoals (qv) and by 1926 the work had been completed, except the lock, at a cost of \$43,387,709 for construction and \$359,592 for maintenance A second lock and dam (known as No. 1), below Wilson dam, was completed and put in operation in March 1926, at a cost of \$960,515. The Federal Government had spent, up to 1927, about \$30,000,000, exclusive of the Muscle Shoals dams, on improving navigation on the Tennessee and its tributaries. The total commerce carried on the various sections of the Tennessee had, in 1925, an aggregate value of \$12,441,364; the commerce of its principal tributaries amounted

to \$142,959
TENNGLER, ULRICH, German jurist, was born in the served as chief clerk of Nordlingen, 1479-83, and afterwards, until his death, was governor of Hochstadt He died sometime in the first four months of 1511. He is noted chiefly as the author of the Layenspiegal (1509 and later editions After 1516 the work was frequently issued in editions containing also Sebastian Brant's Klagspiegal). This was a systematic encyclopaedia of popular jurisprudence, which had wide influence and for more than half a century was the authority in Germany for the settlement of legal

questions TENNIEL, SIR JOHN (1820-1914), knighted 1893, English humorous and satirical artist-specially identified with Punch -was born in London on Feb 28, 1820. Although he became a probationer, and then a student, of the Royal Academy, he soon left the schools, where at that time there was little teaching. In 1836 he sent his first picture to the exhibition of the Society of British Artists, and in 1845 contributed a 16-ft cartoon, Allegory of Justice," to the competition, held in that year, of designs for the mural decoration of the new Palace of Westminster For this he received a £200 premium and a commission to paint a fresco in the Upper Waiting Hall (or "Hall of Poets") in the House of Lords. He was already known and appreciated as a humorist, and his early companionship with Charles Keene fostered and developed his talent for scholarly caricature. In 1850 he was invited by Mark Lemon to fill the position of joint cartoonist (with John Leech) on Punch, in succession to Richard Doyle. His first "cartoon" was "Lord Jack the Giant Killer"; it showed Lord John Russell, whose letter on the "aggression" had recently been published, valuantly assailing with the sword of truth and liberty Cardinal Wiseman armed with a crozier. In 1852 we find Tenniel's first superb lion, and his first obituary cartoon Gradually he took over altogether the weekly drawing of the political "big cut," which John Leech was happy to resign into his hands in order to restrict himself to his pictures of life and character. Leech's work consisted for the most part of farce; Tenniel's was high comedy, and not infrequently tragedy; and the freedom of the humorist heightened the severer beauties of the satirist, When Leech died his friend continued his work alone, About 2,300 cartoons, innumerable minor drawings, double-page cartoons for Punch's Almanac and other special numbers, and 250 designs for Punch's Pocket-books, comprise the sum of Sir John Tenniel's work for the periodical in the service of which he spent the greater portion of his life. He retired in 1901 In 1874 he had been made a member of the Royal Institute of Painters in Water Colours. He died on Feb. 25, 1914.

The main quality of Sir John Tenniel's work is accuracy of drawing, precision of touch, grace and dignity of conception, and so far as such things can be compatible—geniality of satire. Tenniel raised the political cartoon into a classic composition, from which a sense of nobility is rarely absent. The beauty and statuesqueness of his ideal figures recall the influence, perhaps, of Cornelius and Overbeck-that German manner which was characteristic of many of our finer draughtsmen upon wood in the middle of the 19th century. But Tenniel's work is always original,

unforced and fresh; and it never suggests, what is the fact, that the artist's work is drawn exclusively from memory, and never from the model It may be mentioned that Tenniel's wonderful observation has been conducted, and his knowledge accumulated, literally through a single eye, the other having been lost during a fencing bout in his youth. It was in recognition not only of his ability as an artist in black and white, but of his service in infusing good humour and good taste into one phase of political life, that a knighthood was conferred upon him on Mr. Gladstone's recommendation in 1893. Without pronounced political opinions of his own, Sir John Tenniel adopted in his work those of his paper, of which the Whig proclivities were to some degree softened by his pencil. The political history not of England only, but to some extent of the world, of half a century appears in Sir John Tenniel's weekly cartoons, which are dignified by a number of types invented by the artist, the classic beauty of which may be looked for in vain in kindred work by any previous cartoonist (Take, for example, Sir John's famous picture of "Dropping the Pilot, which appeared in Punch on March 20, 1890, xcviii 150-51) Public exhibitions of Sir John Tenniel's work were held in 1895 and in 1900 Sir John Tenniel is also the author of one of the mosaics, "Leonardo da Vinci," in the South Court in the Victoria and Albert Museum, while his highly stippled water-colour drawings appeared from time to time in the exhibitions of the Royal Institute of Painters in Water Colours, of which society he was elected a member in 1874 As an illustrator on the wood-block he stands very high, his "Lalla Rookh" is perhaps the finest of all his work in point of conception, refinement, power and technical excellence

Works Luusrakto—(1) Inventile Versa and Picture Rook (1846);
(2) Undune (1846), (3) desop's Fobles, not drawing, (1848);
(3) Blart's Grave (1858); (3) Shirley Brooks's The Gordans Knot (1860),
and (6) The Shire Cord (1863), (7) Mooris Lalla Roohs, 69 discovered (1864), (7) Mooris Lalla Roohs, 69 discovered (1864), (8) The Murage of Lyie (1867), (10) Carrollis Through the Loohing-Glass (1870), and the following on Colharation: (1870), (12) Peols of the Mirage certain Century (1850), (15) Carrollis Through the Cooling-Glass (1870), and the following on Colharation (1865), (16) The Pallah Scarzet Peols (1864), (16) The Araban Nights (1863), (17) English Sacred Peolsy (1864), (18) Legends and Lyuna (1865), (10) Tuppes' Preverbal Phinoidely Carrollis (1865), (10) Tuppes' Preverbal Phinoidely Works Illustrated -(1) Juvenile Verse and Picture Book (1846):

TENNIS: see LAWN TENNIS AND TENNIS

TENNON, in architecture, a projecting tooth, peg or lug, cut upon the end or edge of a structural member, and arranged to fit into a socket or mortice designed to receive it in an adjacent structural member, in order to strengthen and stiffen the connection between them.

TENNYSON, ALFRED TENNYSON, 1st BARON (1809-1892), English poet, was born at Somersby, Lincolnshire, on Aug. 6, 1809. He was the fourth of the 12 children of the Rev. George Clayton Tennyson (1778-1831) and his wife Elizabeth Fytche (1781-1865). The Tennysons were an old Lincolnshire family settled at Bayon's Manor. The poet's grandfather, George Tennyson, M.P., had disinherited the poet's father, who was settled hard by in the rectory of Somersby, in favour of the younger son, Charles Tennyson D'Eyncourt The rich pastoral scenery of this part of Lincolnshire influenced the imagination of the boy, and is plainly reflected in all his early poetry. At a very early age he began to write in prose and verse At Christmas 1815 he was sent to the grammar school at Louth, where he remained for five years, and then returned to Somersby to be trained by his father. In the rectory the boys had the run of an excellent library, and here the young poet based his wide knowledge of the English classics The news of Byron's death (April 19, 1824) made a deep impression on him. "It was a day," he said, "when the whole world seemed to be darkened for me"; he went out into the woods and carved "Byron is dead" upon a rock Tennyson was already writing copiously—he had constructed "an epic of 6,000 lines" at the age of twelve, composed a drama in blank verse when he was 14, and so on.

a tradition of the same of the same in

In 1827 Frederick Tennyson (1807-1898), the eldest surviving came "variable and his spirits indifferent" The earliest effect tions predominated), and who shared the surprising profits, £20 On Feb 20, 1828, Charles and Alfred matriculated at Trinity college, Cambridge, where Frederick was already a student poet subsequently told Edmund Gosse that his father would not let him leave Somersby till, on successive days, he had recited from memory the whole of the odes of Horace The brothers took 100ms at 12 Rose Crescent, and afterwards moved into Trumpington Street (now 157 Corpus Buildings) They were shy, and at first made few friends, but they gradually gathered selected associates around them, and Alfred grew to be looked up to in Cambridge "as to a great poet and an elder brother" by a group which included Richard Chenevix Trench, Monckton Milnes (Lord Houghton), James Spedding, W H Thompson, Edward FitzGerald, W H Brookfield, and, above all, A H Hallam (1811-1833) Charles Tennyson (1808-1879) afterwards took the additional name of Turner. He published four volumes of sonnets which have been highly praised In June 1829 Alfred Tennyson won the Chancellor's prize medal for his poem called "Timbuctoo" With great imperfections, this study in Miltonic blank verse displays the genius of a poet, in spite of obscurity both of thought and style. Here are already both richness and power But by this time Tennyson was writing lyrics of still higher promise, and, as Arthur Hallam early perceived, with an extraordinary earnestness in the worship of beauty. The results of this enthusiasm and this labour of the artist appeared in the volume of Poems, chiefly Lyrical, published in 1830 This book would have been astonishing as the production of a youth of 21, even if, since the death of Byron six years before, there had not been a singular dearth of good poetry in England Here at least, in the slender volume of 1830, was a new writer revealed, and in "Mariana," "The Poet," "Love and Death," and "Oriana," a singer of wonderful though still unchastened melody Through these, and through less perfect examples, was exhibited an amazing magmificence of fancy, at present insufficiently under control, and a voluptuous pomp of imagery, tending to an over-sweetness.

In the summer of 1830 Tennyson and Hallam volunteered in the army of the Spanish insurgent Torrijos, and marched about a little in the Pyrenees, without meeting with an enemy Tennyson came back to find his father ailing, and in Feb 1831 he left Cambridge for Somersby, where a few days later Dr. George Tennyson died The new incumbent was willing that the Tennysons should continue to live in the rectory, which they did not leave until six years later Arthur Hallam was now betrothed to Emily Tennyson (afterwards Mrs. Jesse, 1811-1889), and stayed frequently at Somersby. This was a very happy time, and one of great physical development on Alfred's part. He took his share in all kinds of athletic exercises, and it was now that Brookfield said, "It is not fair that you should be Hercules as well as Apollo." This high physical zest in life seems to have declined after 1831, when his eyes began to trouble him, and he became liable to depression The poetical work of these three years, mainly spent at Somersby, was given to the world in the volume of Poems which (dated 1833) appeared at the end of 1832.

This was certainly one of the most astonishing revelations of finished genius ever produced by a young man of less than fourand-twenty Here were "The Lady of Shalott," "The Dream of Fair Woman," "Oenone," "The Lotus-Eaters," "The Palace of Art," and "The Miller's Daughter," with a score of other lyrics, delicious and divine. The advance in craftsmanship and command over the matériel of verse shown since the volume of 1830 is astonishing. It was well that its publication was completed before the blow fell upon Tennyson which took for a while all the light out of him. In Aug 1833 Arthur Hallam started with his father, the historian, for Tirol. On the way young Hallam died suddenly (Sept. 15) of a broken blood-vessel at Vienna. His body was brought back to England, and buried on Jan. 3, 1834

Hallam's death affected Tennyson extremely. He grew less than

brother, uniting with his younger brothers Charles and Alfred, of Hallam's death upon his friend's at was not much published at Louth an anonymous collection of Peems by Two Brothers The I'vo' were Charles and Alfred (whose contribute) beginnings of the Ring and of I Memoram, over the Brothers The I'vo' were Charles and Alfred (whose contribute) beginnings of the Ring and of I Memoram, over the Ring and of I Memoram, over the Ring and of I Memoram, over the Ring and of I Memoram, over the Ring and of I Memoram, over the Ring and of I Memoram, over the Ring and of I Memoram, over the Ring and of I Memoram, over the Ring and of I Memoram, over the Ring and of I Memoram, over the Ring and I Ring an both of which he meditated long In 1835 he visited the Lakes, and saw much of Hartley Coleridge, but would not "obtrude on the great man at Rydal," although "Wordsworth was hospitably disposed" Careless alike of fame and of influence, Tennyson spent these years mainly at Someisby, in a uniform devotion of his whole soul to the art of poetry. In 1837, to their great distiess, the Tennysons were turned out of the Lincolnshire rectory where they had lived so long They moved to High Beech, in Epping Forest, which was their home until 1840 The poet was already engaged, or "quasi-betrothed," to Emily Sellwood, but ten years passed before they could afford to marry. At Torquay, in 1838, he wrote Audley Court on one of his rare excursions, for he had no money for touring, nor did he wish for change; he wrote at this time, "I require quiet, and myself to myself, more than any man when I write" In 1840 the Tennysons moved to Tunbridge Wells, and a year later to Boxley, near Maidstone, to be close to Edmund Lushington, who had now married Cecilia Tennyson Alfred was from this time frequently a visitor in London.

In 1842 the two-volume edition of his Poems broke the ten years' silence which he had enforced himself to keep. Here, with many pieces already known to all lovers of modern verse, were found rich and copious additions to his work. These he had originally intended to publish alone, and an earlier privately printed Morte d'Arthur, Dora, and other Idylls, of 1842, is the despair of book-collectors Most of those studies of home-life in England, which formed so highly popular a section of Tennyson's work-such as "The Gardener's Daughter," "Walking to the Mail," and "The Lord of Burleigh"-were now first issued, and in what we have grown to consider a much higher order, "Locksley Hall," "Ulysses," and "Sir Galahad" To the older and more luxurious lyrics, as reprinted in 1842, Tennyson did not spare the curbing and pruning hand, and in some cases went too far in restraining the wanton spirit of beauty in its youthful impulse It is from 1842 that Tennyson took his place as the leading poet of his age in England Among the friends whom he now made, or for the first time cultivated, were Carlyle, Rogers, Dickens, and Elizabeth Barrett

Material difficulties now, however, for the first time intruded on Tennyson's path. He became the victim of a certain "earnestfrothy" speculator, who induced him to sell his little Lincolnshire estate at Grasby, and to invest the proceeds, with all his other money, and part of that of his brothers and sisters, in a "Patent Decorative Carving Company"; in a few months the whole scheme collapsed, and Tennyson was left penniless. He was attacked by so overwhelming a hypochondria that his life was despaired of, and he was placed for some time under the charge of a hydropathic physician at Cheltenham, where absolute rest and isolation gradually brought him round to health again. The state of utter indigence to which Tennyson was reduced greatly exercised his friends, and in Sept. 1845, at the suggestion of Henry Hallam, Sir Robert Peel was induced to bestow on the poet a pension of £200 a year. Tennyson's health slowly became restored, and in 1846 he was hard at work on The Princess; in the autumn of this year he took a tour in Switzerland, and saw great mountains and such "stateliest bits of landskip" for the first time. In 1849 nervous prostration again obliged him to undergo treatment at Prestbury: "They tell me not to read, not to think; but they might as well tell me not to live." Dr. Gully's water-cure was tried, with success.

The Princess was now published, in a form afterwards considerably modified and added to. Carlyle and FitzGerald "gave up all hopes of him after The Princess," or pretended that they did. It was true that the bent of his genius was slightly altered. in a direction which seemed less purely and austerely that of the highest art; but his concessions to public taste vastly added to the width of the circle he now addressed. The home of the Hallam's death affected Tennyson extremely. He grew less than tever willing to come forward and face the world; his health bemore, Browning and Macready, as well as older fitends, but be avoided "society" in fads, while making a tour in Cormula, Tennyson met Robert Stephen Hawker of Morwenstow, with whom he seems—but the evidence is uncertain—to have talked about King Arthur, and to have resumed his intention of writing an entic on that theme.

In his absent-minded way Tennyson was very apt to mislay objects: in earlier life he had lost the ms of Poems, chiefly Lyrical, and had been obliged to restore the whole from scraps and memory. Now a worse thing befell him, for in February 1850, having collected into one "long ledger-like book" all the elegies (In Memoriam) on Arthur Hallam which he had been composing at intervals since 1833, he left this only ms in the cupboard of some lodgings in Mornington Place, Hampstead Road By extraordinary good chance it had been overlooked by the landlady, and Coventry Patmore was able to recover it In Memoriam was published, in its original anonymous form, in May 1850 The public was at first greatly mystified by the nature and object of this poem, which was not merely a chronicle of Tennyson's emotions under bereavement, nor even a statement of his philosophical and religious beliefs, but, as he long afterwards explained, a sort of Divina Commedia, ending with happiness in the marriage of his youngest sister, Cecilia Lushington In fact, the great blemishes of In Memoriam, its redundancy and the dislocation of its parts, were largely due to the desultory manner of its composition. The poet wrote the sections as they occurred to him, and did not think of weaving them together into a single poem until it was too late to give them real coherency

On June 13, 1850, Tennyson was married at Shiplake to Emily Sarah Sellwood (1813-1866) Of this union no more need be said than was recorded long afterwards by the poet himself, "The peace of God came into my life before the altar when I wedded her." On Nov. 19, 1850, Queen Victoria appointed Tennyson poet laureate, in succession to Wordsworth. The salary connected with the post was very small, but it had a secondary value in stimulating the sale of his books. The young couple took a house at Warninglid, in Sussex, which did not suit them, and then one in Montpelier Row, Twickenham, which did better In April 1851 their first child was born dead. At this time Tennyson was brooding much upon the ancient world, and reading little but Milton, Homer and Virgil This condition was elegantly defined by Carlyle as "sitting on a dungheap among innumerable dead dogs". In the summer of 1851 was made the tour in Italy, of which The Daisy is the immortal record. Of 1852 the principal events were the birth of his eldest son Hallam, the second Lord Tennyson, in August, and in November the publication of the Ode on the Death of the Duke of Wellington.

In the winter of 1853 Tennyson took a little house and farm called Farrington, near Preshwater; in the Isle of Wight, which he leased at first, and afterwards bought; this beautiful place, ringed round with liexes and codars, entered into his life and coloured it with its deheate enchantment In 1854 he published The Charge of the Light Brigade, and was busy composing Mand and its accompanying lyracs; and this volume was published in July 1855, just after he was made D.C.L at Oxford he was received on this occasion, which may be considered his first public appearance, with a "temendous ovation." The reception of Mand from the critics, however, was the worst trial to his equanimity "which Tennyson had ever had to endure, nor had the future anything like it in store for him. He had risen in Mand far above his ordinary seeming of still provide the control of the contr

ties of expression which were scarcely intelligible to his readers. It is odd that this irregular poem, with its copious and varied music, its sphendid sweep of emotion, its unfailing richness of exture—this poem in which Tennyson ries to heights of human sympathy and mutuiron which he reached nowhere else, should have been received with hitter healthy, have been styled "the dead level of prose run mad," and have been reproved more than the state of the st

the Authuran traditions. He had now become an object of boundless personal curiously, being already difficult to find, and the centre of amusing legends. It was in 1857 that Bayard Taylos saw him, and carried away the impression of a man "fall and broad-shouldered as a son of Anak, with hair, beard and eyes of southern darkness." This period of retirement embraced a toru in Wales in 1857, a visit to Norway in 1858, and a journey through Portugal in 1850.

In 1857 two Arthurian poems had been tentatively and privately printed, as Enid and Nimue, or the True and the False, to see how the idylic form would be liked by the inner circle of Tennyson's friends In the summer of 1859 the first series of Idylls of the King was at length published, and achieved a popular success far beyond anything experienced before by any English poets, save perhaps Byron and Scott. Within a month of publication, 10,000 copies had been sold. The idylls were four in number, "Vivien" (no longer called "Nimue"), "Elaine" and "Guinevere"
These were fragments of the epic of the fall of King Arthur and the Table Round which Tennyson was so long preparing, and which he can hardly be said to have ever completed, although nearly thirty years later he closed it. The public and the critics alike were entranced with the "sweetness" and the "purity" of the treatment A few, like Ruskin, were doubtful about "that in-creased quietness of style", one or two already suspected that the "sweetness" was obtained at some sacrifice of force, and that the "purity" involved a concession to Victorian conventionality

Ugsed by the duke of Aegal, Tenayson now turned his attention to the them of the Holy Grail, though be progressed such that but fitfully and slowly. In 1861 he travelled in Auvergne and the Pyrenees, with Clough, who was to due a few months later; to this year belong "Helen's Tower" and the "Dedication" of the 1891st to the prince consort, These to his Memory. The latter led to Tennyson's presentation in April 1862 to the queen, who "stood pale and statue-like before him, na a kind of stately smocence," which greatly moved his admiring homage. From this time forth the poet enjoyed the constant favour of the sovereign, though he could never be moulded into a conventional courter He now put the Arthuran legends saids for a time, and devoted himself to the composition, im 1862, of "Enoch Arden," which, also contained "Sea Dreams," "Alymer's Pelel" and, above and law The Northern Farmer," the first and finest of Tennyson's remarkable studen in dule.

In April of this year Garibadi vasited Farrangford; in Feb 1865 Tennyson's mother date at Hampstead in her Sgth year, in the ensuing summer he travelled in Germany. The time slipped by with incidents but few and slight, Tennyson's populative in Great Sritan growing all the time to an extent unparalleled in the whole annals of English poetry. This universainty of fame led to considerable practical discomfort; he was besieged by sightseers, and his nervous treputation led him perhaps to exagerate the intensity of the infliction. In 1867 he determined to and bought some land on Blackdown, above Hadermore, tion a secluded corner of England; here Mr (afterwards Sir) James Knowles began to build him a house, ultimately named Aldworth. This is the time of two of his rare, privately printed pamphlets, The Windows, or, the Lowes of the Werner (1867), and The Victim

(1868)
The noble poem Lucretsus, one of the greatest of Tennyson's versified monographs, appeared in May 1868, and in this year The Holy Grail was at last finished; it was published in 1869, together with three other idylls belonging to the Arthuran epic, and various miscellaneous lyrics, besides Lucretius. The reception of this volume was cordual, but not so universally respectful as that which Tennyson had grown to expect from his adoring public. The fact was that the heightened reputation of Browning, and still more the sudden vogue of Swinburne, Morris and Rossetti (1866-70), considerably disturbed the minds of Tennyson's most ardent readers, and exposed himself to a severer criticism than he had lately been accustomed to endure. His next volume (1872), Grarth and Lynette and The Last Tournament, continued, and, Grarth and Lynette and The Last Tournament, continued, and,

offered a baronetcy by Gladstone, and again by Disraeli in 1874; in each case the honour was gracefully declined.

Beheving that his work with the romantic Arthurian epics was concluded, Tennyson now turned his attention to the diama. He put before him a scheme of illustrating "the making of England" by a series of great historical tragedies His Queen Mary, the first of these chronicle-plays was published in 1875, and played by Sir Henry Irving at the Lyceum in 1876 Although it was full of admirably dramatic writing, it failed on the stage Extremely pertinacious in this respect, the poet went on attempting to storm the theatre, with assault upon assault, all practically failures until the seventh and last, which was unfortunately posthumous. Meanwhile Harold, a tragedy of doom, was published in 1876; but, though perhaps the finest of its author's dramas, it was not staged During these years Tennyson's thoughts were largely occupied with the building of Aldworth. His few lyrics were spirited ballads of adventure, inspired by an exalted patriotism-"The Revenge" (1878), "The Defence of Lucknow" (1879)-but he reprinted and finally published his old suppressed poem, The Lover's Tale, and a little play of his. The Falcon, versified out of Boccaccio, was produced by the Kendals in 1879

In 1880, when he was over 70, he published the earliest of six important collections of lyrics, this being entitled Ballads and other Poems, and containing the sombre and magnificent "Rizpah" In 1881 The Cup and in 1882 The Promise of May, two little plays, were produced without substantial success in London theatres: the second of these is perhaps the least successful of all the poet's longer writings, but its failure annoyed him unreasonably In September 1883 Tennyson and Gladstone set out on a voyage round the north of Scotland, to Orkney, and across the ocean to Norway and Denmark At Copenhagen they were entertamed by the king and queen, and after much fêting, returned to Gravesend this adventure served to cheer the poet, who had been in low spirits since the death of his favourite brother Charles. and who now renewed his vigour. During the voyage Gladstone had determined to offer Tennyson a peerage. After some demur, the poet consented to accept it, but added, "For my own part, I shall regret my simple name all my life." On March 11, 1884, he took his seat in the House of Lords as Baron Tennyson of Aldworth and Farringford. He voted twice, but never spoke in the House In the autumn of this year his tragedy of Becket was published, but the poet at last despaired of the stage, and disclaimed any hope of "meeting the exigencies of our modern theatre" Curiously enough, after his death Becket was the one of all his plays which enjoyed a great success on the boards.

In 1885 was published another interesting miscellany, Tiresias and other Poems, with a posthumous dedication to Edward Fitz-Gerald. In this volume, it should be noted, The Idylls of the King was completed at last by the publication of "Balin and Balan"; it contained also the superb address "To Virgil." In April 1886 Tennyson suffered the loss of his second son, Lionel, who died in the Red Sea on his return from India The untiring old poet was steadily writing on, and by 1886 he had another collection of lyrics ready, Locksley Hall Sixty Years After, etc ; his eyes troubled him, but his memory and his intellectual curiosity were as vivid as ever. He was past 80 when he published the collection of new verses entitled Demeter and other Poems (1889), which appeared almost simultaneously with the death of Browning, an event which left Tennyson a solitary figure indeed in poetic literature. His latest drama, The Foresters, was produced in New York in March 1892, with Miss Ada Rehan as Maid Marian. During this year Tennyson was steadily engaged on "Akbar's Dream," "Kapiolani" and other contents of the posthumous volume called The Death of Oenone, 1892.

Soon after entering his eighty-fourth year, however, symptoms of weakness set in, and early in September his condition began to give alarm. He retained his intellectual lucidity and an absolute command of his faculties to the last, reading Shakespeare with obvious appreciation until within a few hours of his death. With the splendour of the full moon falling upon him, his hand clasping

as he then supposed, concluded *The Idylls of the King*, and for his Shakespeare, and looking, as we are told, almost unearthly the time being he dismissed it from his mind. In 1873 he was in the majestic beauty of his old age, Tennyson passed away at Aldworth on the night of Oct 6, 1892 Cymbeline, the play he had been reading on the last afternoon, was laid in his coffin, and on the 12th he received a public funeral at Westminster Abbey. Lady Tennyson survived until Aug 1896.

The physical appearance of Tennyson was very remarkable. Of his figure at the age of 33 Carlyle has left a superb portrait: "One of the finest-looking men in the world A great shock of rough, dusky, dark hair, bright, laughing, hazel eyes; massive aquiline face, most massive yet most delicate; of sallow brown complexion, almost Indian-looking, clothes cynically loose, freeand-easy, smokes infinite tobacco His voice is musical, metallic, it for loud laughter and piercing wail, and all that may he between; speech and speculation free and plenteous; I do not meet in these late decades such company over a pipe" He was unusually tall, and possessed in advanced years a strange and rather terrifying air of sombre majesty But he was, in fact, of a great simplicity in temperament, affectionate, shy, still exquisitely sensitive in extreme old age to the influences of beauty, melancholy and sweetness Although exceedingly near-sighted, Tennyson was a very close observer of nature, and at the age of eighty his dark and glowing eyes, which were still strong, continued to permit him to enjoy the delicate features of country life around him, both at Aldworth and in the Isle of Wight His Life, written with admirable piety and taste by his son, Hallam, second Lord Tennyson, was published in two volumes in 1897

No living poet has ever held England-no poet but Victor Hugo has probably ever held any country-quite so long under his unbroken sway as Tennyson did. As he recedes from us, however, we begin to see that he has a much closer relation to the great Georgian writers than we used to be willing to admit He is more the last of that great school than the first of any new one. The qualities in which he seems to surpass his immediate predecessors are exactly those which should be the gift of one who sums up the labours of a mighty line of artists. He is remarkable among them for the breadth, the richness, the substantial accomplishment of his touch; he has something of all these his elders, and goes farther along the 10ad of technical perfection than any of them. We still look to the earlier masters for supreme excellence in particular directions to Wordsworth for sublime philosophy, to Coleridge for ethereal magic, to Byron for passion, to Shelley for lyric intensity, to Keats for richness.

Tennyson does not excel each of these in his own special field, but he is often nearer to the particular man in his particular mastery than any one else can be said to be, and he has in addition his own field of supremacy This consists, perhaps, in the beauty of the atmosphere which Tennyson contrives to cast around his work, moulding it m the blue mystery of twilight, in the opaline haze of sunset: this atmosphere, produces an almost unfailing illusion or mirage of loveliness, so that, even where (as must sometimes be the case with every poet) the thought and the imagery have little value in themselves, the fictive aura of beauty broods over the otherwise undistinguished verse. In his luminous subtlety and his broad undulating sweetness, his relationship with Virgil has long been manifest; he was himself aware of it. But he was also conscious that his exquisite devotion to mere lucidity and beauty might be a snare to him, and a happy instinct was always driving him to a study of mankind as well as of inanimate nature.

Few English writers have known so adroitly as Tennyson how to bend the study of Shakespeare to the enrichment of their personal style. It should be added that he was a very deep and original student of literature of every description, and that the comparatively few specimens which have been preserved of his conversation contain some of the finest fragments of modern appreciation of the great poets which we possess. This is worthy of consideration in any attempt made to sketch the mind of a man who was above all other masters of recent literature an artist. and who must be studied in the vast and orbic fullness of his accomplishment in order to be appreciated at all.

The standard biography is Alfred, Lord Tennyson: A Memoir, by

Hallan, and Bayan Tempon. (s. vols., 1897), who also drived Tempon's Work with a memor in a 31, (2) vols.). A E Baker published a Concordance to the poetsed and dramatical works of Tempons in 1914 For bibliography see R. H. Shepherd, Temposomana (1865, new ed. 1894). For biography and criticism consult A. Lang, Afferd Tempons, 1917, A. C. Henson, The Life of Lord Tempons (1904). T. R. Lownsbury, Life and Teme of Lord Tempons (1904). Nicolson, Tennyson (1925)

TENNYSON-D'EYNCOURT, SIR EUSTACE (HENRY WM.) BART. (1868-1951), British naval architect,

was boin on April 1, 1868, and educated at Charterhouse and at the Royal Naval college, Greenwich. He was apprenticed at the Elswick works to which he returned as naval architect in 1902, after four years at Fairfield. He subsequently received an Admiralty appointment, which he held until 1924 He continued to advise the Admiralty on naval construction after his appointment as managing director of Armstrong Whitworth and Co's Newcastle shipyards Tennyson-d'Eyncourt was also closely as-sociated with the development of tanks during World War I He presided over the first Admiralty committee on the question, and in 1918 became vice-president of the Tank board He was responsible for the successful design and construction of many tanks He was created K.C.B. in 1917, a baronet in 1930, and elected F.R.S. in 1921. He died at Hailsham, England, Jan. 31, 1951.

TENREC (Tenrec ecaudatus), one of the largest representatives of the Insectivora, the length being from 12 to 16 in It is restricted to Madagascar. The coat consists chiefly of bristles and hairs, with an admixture of flexible spines, in the adult limited to the back of the neck. The general bue is brown tagged with yellow. From 12 to 16 or even 20 young are produced at a birth. In habits the tenrec is nocturnal; its home is in the brush in the mountain regions, and in the cool season it hibernates in deep burrows The long flexible shout is used to root up worms and grubs. and ground-insects form part of its nourishment When fat before hibernation, tenrecs are much valued as food by natives

(See INSECTIVORA.)

TENSOR ANALYSIS. The concept of tensors and the knowledge of some of their properties can be traced back to Karl Gauss, Georg Riemann and Elwin Christoffel, but their algebra and analysis have been shaped into a systematic method only recently, 1900, by G. Ricci and T. Levi-Civita, who coined for this powerful branch of mathematics the name of absolute differential calculus. Its chief aim is to construct and discuss relations or laws generally covariant; such, that is, as remain valid in passing from one to any other system of co-ordinates. This makes the subject of prime importance for differential geometry It has especially become the object of a very widespread interest after the advent of generalized relativity (1916), whose principal requirement is precisely such unrestricted covariance of physical laws. There are interesting applications of tensor analysis-both finite and infinite dimensional—to classical mechanics, quantum mechanics, fluid mechanics, elasticity and aeronautics.

Definitions, Algebra of Tensors.—Consider a continuous n-dimensional manifold or "space"  $S_n$  (see Manifolds), whose element or point  $P(x_i)$  is determined by assigning the values of nreal independent variables or co-ordinates  $x_i$ . Let  $Q(x_i+dx_i)$  be another point of  $S_n$ . Then the ordered point-pair  $P_i$ , Q or the set of differentials  $Ax_i$  is called a sector. (To begin with, the idea of "size" or "length" is foreign to this concept,  $S_n$  being thus far a nonmetrical manifold.) Let the x, be transformed into any other system of n co-ordinates  $x'_i$ , the former being continuous functions of the latter with continuous derivatives  $\partial x_i/\partial x'_k$  and non-

vanishing, finite Jacobian  $J = \left| \frac{\partial x_i}{\partial x'} \right|$ ; then  $dx_i$  are transformed into

$$dx'_{i} = \frac{\partial x'_{i}}{\partial x} dx_{\alpha}$$

to be summed over  $\alpha = 1$  to n, and vice versa,  $dx = (\partial x_i/\partial x'_{\alpha})dx'_{\alpha}$ (The convention will be adopted that every term in which an index occurs twice, is to be summed over all its values ) Any set this rule, se., into

$$A'_{\iota} = \frac{\partial x'_{\iota}}{\partial x} A^{\alpha}$$

form a contravariant tensor of rank one, the A' being its n combonents. For contravariant tensors upper indices are used, an exception being made for  $dx_i$ , the prototype of all such tensors Next, any n magnitudes A, which are transformed as the differentiators  $\partial/\partial v_i$ , ie, into

$$A'_{i} = \frac{\partial x_{\alpha}}{\partial x'} A_{\alpha},$$

form a covariant tensor of rank 1, lower indices being used for such tensors. These two kinds of tensors, of rank 1, are also termed vectors, e g , three-vectors, four-vectors (such as the relativistic four-velocity or four-potential, in space-time, S4), etc., according as n=3, 4, etc Similarly, any n2 magnitudes A. transformable into

$$A'_{is} = \frac{\partial x_{\alpha}}{\partial x'} \frac{\partial x_{\beta}}{\partial x'} A_{\alpha\beta}$$

form a covariant, and any  $A^{\iota}$  transformable into  $A^{\prime \iota \kappa} = \frac{\partial x^{\prime}_{\iota}}{\partial x_{\theta}} \, \frac{\partial x^{\prime}_{s}}{\partial x_{\theta}} \, A^{\alpha \theta}$ 

$$A'^{\iota \kappa} = \frac{\partial x'_{\iota}}{\partial x} \frac{\partial x'_{\kappa}}{\partial x_{0}} A^{\alpha \beta}$$

form a contravariant tensor of rank two Again, n2 magnitudes A.\* transformable into

$$A'_{i}^{\kappa} = \frac{\partial x_{\alpha}}{\partial x'} \frac{\partial x'_{\kappa}}{\partial x_{\alpha}} A^{\beta}_{\alpha}$$

are said to form a mixed tensor of rank 2, covariant in a and contravariant in & The extension to any rank is obvious. Any  $n^{r_1+r_2}$  magnitudes  $A_{ik}^{th}$  , with  $r_1$  lower and  $r_2$  upper indices, which are transformed according to the rule

$$\left( A^{ik}_{i\kappa} \quad \right)' = \frac{\partial x_{\alpha}}{\partial x'_{i}} \frac{\partial x_{\beta}}{\partial x'_{\kappa}} \cdots \frac{\partial x'_{i}}{\partial x_{\alpha}} \frac{\partial x'_{\kappa}}{\partial x_{b}} \cdots A^{ab}_{\alpha\beta} \quad . \tag{1}$$

form a mixed tensor of rank  $r=r_1+r_2$  This is the most general concept of a tensor

A tensor of rank zero, called also a scalar, is a single function of the x, invariant with respect to any transformations of coordinates, f'=f.  $A_{1x}$  is symmetrical if  $A_{1x}=A_{x1}$ , and antisymmetrical or a skew tensor if  $A_{ij} = -A_{ij}$ , implying  $A_{ij} = 0$  Similarly for At. Analogous definitions hold for mixed tensors, and for higher ranks. Symmetry and antisymmetry are invariant properties.

The transformed tensor components being linear homogeneous functions of the original ones, the sums of corresponding components of tensors of same rank and kind form again a tensor. Thus,  $A_i$ ,  $B_i$  being covariant vectors, so is  $A_i + B_i = C_i$ . Similarly,  $A_{ik} + B_{ik} = C_{ik}$ , etc. The addends, functions of  $x_i$ , must be taken at the same point of  $S_n$ . If a tensor vanishes in one, it will vanish also in any other co-ordinate system. Consequently, any tensor equation, if valid in one, holds also in any other co-ordinate system. This is the chief reason of the importance of tensors in pure geometry and physics.

The outer product of two tensors of ranks r and s, i.e., the array of n7+s products of their components is again a tensor, of rank r+s. Thus  $A_iB_k=C_{is_i}$ ,  $A_{is}B_k=C_{is_k}$ ,  $A_{is}B^k=C^k_{is_i}$ . The contraction, an operation of almost magical efficiency, applicable to any mixed tensor, consists in equating one of its r, lower to one of its  $r_2$  upper indices and summing over it from 1 to n. The result is again a tensor, with r1-1 covariant and r2-1 contravariant indices; e.g., a contraction of  $A_{ix}^{\lambda}$  gives  $A_{ix} = A_{i}$ , a vector;  $B_{ix}^{\lambda\mu}$ contracted once becomes  $B^{\lambda x} = B^{\lambda}$ , and this yields  $B^{x} = B$ , a

The inner product is the outer product (supposed mixed) contracted once or more. Thus, the inner product of  $A_i, B^i$  is  $A_i, B^r$ , a scalar; that of  $A_{ii}, B^i$  is  $A_i^i, B^r$ , a mixed tensor, and after a second contraction,  $A_{ii}B^{ii}=C_i$ , a mixed tensor, and after a second contraction,  $A_{ii}B^{ii}=C_i=C_i$ , a scalar. (Unlike A,B, A,B, is not invariant, it has no tensor character, and likewise for A\*B\*. Conversely, if A\*B\* is a scalar for any covariant of n magnitudes A', functions of the x, which are transformed by vector A<sub>n</sub>, B\* is a contravariant vector. Similarly, if A<sub>n</sub>B\* is A scalar for any covariant  $A_{ix}$ ,  $B^{ix}$  is contravariant. This is an efficient method of establishing the tensor character of a set of

m,  $\eta^{*}$ , etc., magnitudes Differentiation of tensors with respect to the co-ordinates yields, in certain circumstances, further tensors. If f as scalar function of the g, or scalar field  $g/(\partial_{1} - \eta_{1})$ , is a covariant vector, the gradient of f (but  $\partial^{0}f/\partial_{1}\partial_{1}\partial_{1}$ , is not a tensor, again, if d be an invariant,  $d_{1}/dh$ , is d, is not a tensor, again, if d be an extension f and f as the sector f for f and f and f are a vector f for f and f and f and f are a vector f for f and f and f and f and f and f are a sea as we tensor, the station of A. Finally, if A, be antisymmetric,  $B_{1,0} = \partial_{1}A_{1}/\partial x_{1} + \partial_{1}A_{1}/\partial x_{2} + \partial_{1}A_{1}/\partial x_{3}$  is again such a tensor, the scalars of f and f and f are the scalar f and f are the scalar f and f and f are the scalar f and f are the scal

In what precedes only such properties of tensors were treated as are independent of any metrical considerations, the space, being thus far a nonmetrical, amorphous manifold. Let now its metrics be fixed by laying down the fine-denent, a quadratic differential form with coefficients  $f_{aa} = f_{ab}$  prescribed functions of the x.

$$ds^2 = g_{is}dx_idx_i$$

to be considered as invariant and to serve as the measure of the squared size or length of the vector dx. Then, dx, being the contravariant, gw. will be covariant. Equivalently we may say that a certain symmetrical tensor, gw is being impressed upon Sx as the fundamental or metrical tensor, converting it into a metrical manifold, a Remannian space.

The minors  $g^{sc}$  of  $g = |g_{sc}|$ , divided by g, form again a symmetrical tensor, the contravariant metrical tensor, to be used along with  $g_{sc}$ . The outer product and contraction can be used in rais-

mg and lowering tensor indices. Thus  $g^{ad}A_{+}=d^{a}$  and  $g_{+}B^{a}=g^{a}$ . The  $angle \theta$  between two (copuncial) vectors  $d^{a}$  and B is defined by the invariant  $\cos\theta = g_{+}A^{a}B^{a}/dB$ , A, B being their sizes. The unit vector  $x_{+}=da,ds$  determines, locally, a direction in  $S_{a}$ . The angle between two directions  $x_{a}$ , y, is given by  $\cos\theta = g_{+}x_{+}\theta$ .

Integrals.—The integral  $f_{d_{2}}$ , ...,  $d_{m_{2}}$  briefly  $f_{d_{2}}$  de, catended over a region of  $S_{n_{1}}$  is transformed into  $f_{d_{2}}$  and the determinant g into  $g' = J_{g}$ . Consequently,  $f \vee gds$  is an invariant metricially impressed upon that region, its size or coolines (area, if m = 2). This concept is readily extended to any submanifold of  $S_{n_{1}}$  characterized by  $g_{n_{2}}$  as functions of  $m \sim n$  param

eters 
$$p_a$$
, the rôle of metrical tensor being taken over by
$$h_{ab} = g_{ia}(\partial x_b/\partial p_a)(\partial x_b/\partial p_b).$$

If, by a proper choice of the co-ordinate system, all components  $g_M$  are reducible to constants, the metrical space  $S_1$  is Euclidean or homaloidal (flat) This is but a very special case of a Riemannan space In general such a reduction is not possible, and  $S_4$  is non-Euclidean  $(v.\ intra)$ .

Differentiation of tensors, aided by metrics, yields an unlimited number of new tensors. The oldest of such is Riemann's set of four-index symbols, of 1861. The simplest metrically differential tensor, however, was discovered in 1869 by Christoffel. This is the covariant derivative of a vector A<sub>2</sub>.

$$A_{i,\kappa} = \frac{\partial A_i}{\partial x_i} - \{\omega, \lambda\} A_{\lambda_i}$$
 (3)

where  $\{\iota\kappa, \lambda\} = g^{\lambda\mu}[\iota\kappa, \mu] = \{\kappa\iota, \lambda\}$  and

 $[\iota \kappa, \mu] = \frac{1}{2} (\partial g_{\mu\nu}/\partial x_{\kappa} + \partial g_{\kappa\mu}/\partial x_{\nu} - \partial g_{\nu\kappa}/\partial x_{\mu})$ are Christoffel's symbols (not forming a tensor). Again,

$$B^{\lambda}_{,\kappa} = \partial B^{\iota}/\partial x_{\kappa} + \{\alpha\kappa, \iota\} B^{\alpha}$$

is a mixed tensor.

$$C_{,\nu\lambda} = \partial C^{\nu\kappa}/\partial x\lambda + \{\lambda\alpha, \iota\}C^{\alpha\kappa} + \{\lambda\alpha, \kappa\}C^{\kappa\alpha},$$
  
 $C_{,\nu\lambda} = \partial C_{,\nu}/\partial x^{\lambda} - \{\iota\lambda, \alpha\}C_{,\alpha\kappa} - \{\kappa\lambda, \alpha\}C_{,\alpha}$ 

are the covariant derivatives of  $C^{ix}$  and  $C_{ix}$ . The covariant derivative of  $g_{ix}$  itself vanishes identically. Noteworthy for their applications are

$$A^{i} = \text{Div}(A^{ii}) = \frac{1}{\sqrt{g}} \frac{\partial}{\partial x_{i}} (\sqrt{g}A^{ii})$$
 and  $\text{div}(A^{i}) = \frac{1}{\sqrt{g}} \frac{\partial}{\partial x_{i}} (\sqrt{g}A^{i})$ ,

the vector divergence of a skew  $M^a$  and the scalar divergence of  $A^a$ ,  $e_B$ , one group of Maxwell's equations is represented by  $DV(P^a) = C$ , where C is the four-current and  $F^a$  the electromagnetic skew tensor (as vector), the second group being expressed by equating to zero the "expansion" (v  $mpr_0$ ) of

Expressed by expansing between the most characteristic curves of the Geodesics, Null lines.—The most characteristic curves of the metrical  $S_a$  are its null or minimal lines, ds = o, and "shortest" curves or geodesics defined by  $\delta f ds = o$ , with fixed terminals The equations of a geodesic are

$$x_i + \{\alpha \beta, \iota\} x_{\alpha \beta} = 0,$$
 (6)

where -e d v/ds. They determine,  $e_s$ , in the case of space time, the motion of a free particle in the metrical, and gravational, field  $p_s$ . The null lines are imaginary or real according as (s) at a definite or nondefinite form. The former is the case of spaces proper as contemplated by the pure geometer, and the latter that of space time with one positive and there negative  $g_{ss}$ . The null lines of space time with one positive and there negative  $g_{ss}$  the finiteness or nondefiniteness of the quadratic form and its

under of menta (number of negative g, s) are invariant properties Parallel Displacement of Vectors—A furtiful contribution to tensor analysis, due to Levi-Civita (1917) is the concept of parallel displacement of a vector with respect to a curve. The metrical  $S_0$ , can in general be imagined as inbedded locally in a Euclidean space E of  $\frac{1}{2}u(s) + 1$ ) dimensions. Levi-Civita defined parallel displacement in  $S_0$  as a consequence of a parallel displacement in E. In spite of the ultra-spacial construction, parallelism is intrinsic, expressible by the  $S_0$ -metrics alone

If  $x_i = f_i(s)$  are the parametric equations of any chosen curve C, then the differential equations along C

$$\frac{dA^{i}}{ds} + \{\alpha\beta, i\} A^{\alpha}x^{\beta} = 0 \qquad (7)$$

with the initial vector  $A^{i}(s_0) = A^{i}_s$  determine uniquely a contraviant vector  $A^{i}$  at each point of the cuive. The vector  $A^{i}$  at the point corresponding to s=s is said to be obtained by a parallel displacement of the vector  $A^{i}_s$  this respect to the given curve  $C_s$  and is said to be parallel to  $A^{i}_s$ . Any two vectors generated as above, one at each point, are parallel with respect to  $C_s$ .

Let the required to construct a curve whose tangents follow from each other by parallel displacement along the curve-tiself. This gives the equations (6), so that the curve is a geodesic. The latter is thus throughout "parallel to itself"—an interesting generalization of the property of Euclidean straights. Accordngly, a vector transferred along a geodesic remains equally inclined to it.

If a vector X' be carried by parallel displacement along two different paths a, b from o to o; the two vectors at o1, equal in sue, generally differ in direction. One is parallel to X' via a, the other via b. In fine, parallelsm depends on the route of transfer or is nonintegrable (unless  $S_*$  is esentially Euclidean). Thus also, if the vector be carried around a circuit, it returns at O with its direction changed.

The covariant derivative (v-supra) of the vector is the tensor  $X_{ij\alpha}$ . Its covariant derivative  $X_{i,\alpha,\beta}$  is not symmetric in  $\alpha$  and  $\beta$ . A straightforward calculation shows that

$$X_{\iota,\beta,\alpha} - X_{\iota,\alpha,\beta} = R^{\kappa}_{\iota\alpha\beta}X_{\kappa_{\iota}}$$
 (8)

where  $R^{\kappa}_{\alpha\beta} = \frac{\partial}{\partial x_{\alpha}} \{ \iota \beta, \kappa \} - \frac{\partial}{\partial x_{\beta}} \{ \iota \alpha, \kappa \} + \{ \alpha \gamma, \kappa \} \{ \iota \beta, \gamma \}$ 

$$\mathcal{K}_{\alpha\beta} = \frac{\partial z_{\alpha}}{\partial z_{\alpha}} \{ \iota \mathcal{D}, \kappa \} - \frac{\partial z_{\beta}}{\partial z_{\beta}} \{ \iota \alpha, \kappa \} + \{ \iota \mathcal{D}, \kappa \} \{ \iota \mathcal{D}, \gamma \} - \{ \beta \gamma, \kappa \} \{ \iota \alpha, \gamma \}.$$
 (9)

This is the Riemann-Christoffel or curvature tensor whose vanishing is the necessary and sufficient condition for the reducibility of g<sub>to</sub> to a constant tensor, or the criterion of a homaloidal

(bucklidean) space Themann's Pour-Index Symbols and Curvature.—Riemann's own set of four-index symbols is the covariant tensor  $(\mu_1, \lambda_0) = R_{\mu\lambda} = g_{\mu\alpha}R_{\alpha\lambda}^*$ . Conversely,  $R^{\alpha}_{\lambda} = g_{\alpha\beta} = g_{\alpha\beta}R_{\alpha\lambda}^*$ . Conversely,  $R^{\alpha}_{\lambda} = g_{\alpha\beta} = g_{\alpha\beta}R_{\alpha\lambda}^*$ . A. Three more linear nore linear

relations hold between them. This reduces the number of inin Native (1944) is illuminating. One of the most interesting dependent symbols to  $\frac{1}{2}n^2(n^2-1)$ , e.g., six for a three-space, applications of non-Riemannian tensor analysis was made by twenty for an S4, and but one for a surface, say (12, 12). This symbol divided by g is a scalar of the surface, its Gaussian curvature (K ) (See DIFFERENTIAL GEOMETRY ) If a vector is parallelly displaced around a circuit on a surface, it returns with its direction changed by an amount equal to  $\int K d\sigma$ , the Gaussian curvature of the surface integrated over the surface area enclosed by the circuit As a consequence, the excess (over  $\pi$ ) of the angle sum in any geodesic triangle is  $\int Kd\sigma$ , a famous theorem due to Gance

In the case of three or more dimensions the curvature properties can no longer be expressed by a single magnitude, but require for their description the knowledge of the whole curvature tensor or the associated Riemann symbols. The concept of Gaussian curvature is now replaced by that of Riemannian curvature. This is, at any point O(v) of Sn, the set of Gaussian curvatures K of geodesic surfaces of all possible orientations laid through O. If haft be the metrical tensor of such a surface as submanifold, then  $K = \frac{1}{h} (12, 12)_{L}$ , the symbol to be calculated with  $h_{\alpha\beta}$ . This

and the determinant h can be expressed in terms of the tensor give of the manifold and the vector pair, &, n, fixing the orientation. The result is

$$K = \frac{(\iota \kappa, \lambda \mu) \xi^{\iota} \eta^{\kappa} \xi^{\lambda} \eta^{\mu}}{(g_{\iota \lambda} g_{\iota \mu} - g_{\iota \mu} g_{\iota \lambda}) \xi^{\iota} \eta^{\kappa} \xi^{\lambda} \eta^{\mu}},$$
 (10)

In general, K will depend on position and on orientation. in other words, with regard to curvature, Sn may be nonhomogeneous as well as anisotropic (e.g., space time within or around matter); but if K is everywhere isotropic, it is also constant throughout S, This is Schur's theorem By (10) the necessary and sufficient condition for isotropy of Riemannian curvature becomes  $(i\lambda, \kappa\mu) = K(g_{i\kappa}g_{\lambda\mu} - g_{i\mu}g_{\lambda\mu})$  or  $R^{\alpha}_{i\kappa\lambda} = K(\delta^{\alpha}_{\kappa}g_{i\lambda} - \delta^{\alpha}_{\lambda}g_{i\kappa})$  with constant K.

The tensor (9), being mixed, yields the contracted curvature tensor Range Rus which turns out to be symmetrical. Its scalar,  $R = g^{\mu}R_{\mu\nu}$ , is the curvature invariant of the manifold. For an isotropic n-fold, R = -(n-1)nK and  $R_{is} = g_{is}R/n$  A capital use of Rix was made by Albert Einstein for constructing the gravitational field equations,  $R_{i\alpha} - \frac{1}{2}Rg_{i\alpha} = -\kappa T_{i\alpha}$ , where  $\kappa \sim \text{gravita}$ tion constant, and Tig is the tensor of matter, embodying energy, momentum, and stress. The covariant derivative of Rix is connected with grad R by the n relations  $g^{\kappa\lambda}R_{\kappa\kappa,\lambda} = \frac{1}{2}\partial R/\partial x_{\kappa}$ , which were again utilized by Einstein and which follow from the identical relations  $(\kappa, \lambda \mu)_{,\nu} + (\kappa, \nu)_{,\mu} + (\kappa, \nu)_{,\mu} = 0$ . These remarkable identities, discovered by Luigi Bianchi, give also a very simple proof of Schur's theorem.

Non-Riemannian Tensor Analysis .- The year 1918 saw the beginning of epoch-making generalizations of the Riemannian tensor analysis. It was first observed that many of the results of the Riemannian tensor calculus were independent of the metric structure of the Christoffel symbols [14, h] in terms of the metrical tensor gives but were merely dependent on the law of transformation of the Christoffel symbols under a transformation of co-ordinates. There thus arose the fruitful conceptions of non-Riemannian geometries and tensor calculi in which the fundamental geometric object is not a metrical tensor gir but a linear connection with components  $\Gamma_{ii}^{\lambda}$ , which undergo the nontensorial transformation

$$\Gamma_{\alpha\beta}^{\gamma} = \Gamma_{\alpha}^{\lambda} \frac{\partial x_{\epsilon}}{\partial x_{\alpha}} \frac{\partial x_{\epsilon}}{\partial x_{\beta}} \frac{\partial x_{\gamma}}{\partial x_{\lambda}} + \frac{\partial^{2} x_{\lambda}}{\partial x_{\alpha}} \frac{\partial x_{\gamma}}{\partial x_{\lambda}}$$
(11)

under a transformation of co-ordinates x, to new co-ordinates x, This transformation law is the same as the one for the Christoffel symbols [u, h] in the Riemannian tensor analysis.

Both the symmetric case  $\Gamma_{ii}^{\lambda} = \Gamma_{ii}^{\lambda}$  and the asymmetric case have been studied in many papers and books. The numerous attempts at unified field theories in general relativity theory have often shown the need for further researches in non-Rie-mennian tensor analysis. A historical survey by E. Schrödinger

E. Cartan (1927) to the differential geometry of an n-dimensional continuous group manifold. There exist two fundamental asymmetric (nonsymmetric) connections which in turn define uniquely the symmetric linear connection with the property that the covariant derivative of the curvature tensor is zero. In the special case of a semisimple group, the group manifold reduces to a Riemannian space which is not necessarily of constant Riemannian curvature.

We cannot dwell here on the extensive developments of non-Riemannian tensor calculus in connection with projective and conformal differential geometries, non-Riemannian metric spaces

(Finsler spaces) and other related topics.

The development of non-Riemannian tensor analysis is associated with the names of L Berwald, E Bortolotti, E Cartan, A S Eddington, A Einstein, L. P Eisenhart, V Hlavatt, A D Michal, J. A. Schouten, E Schrödinger, T Y Thomas, D Van Dantzig, O. Veblen, H Weyl, J H. C. Whitehead and many others

General Tensor Analysis.-The differential calculus and theory of functions used in most of the topics discussed so far are classical (prior to 1906). The phenomenal rise of general function theory and topology in the decade 1927-37 was accompanied by a searching investigation of the foundations of differential geometry and tensor analysis in n-dimensional spaces. This necessitated the introduction of the theory of topological spaces into the treatment of co-ordinates and co-ordinate transformations. Only a beginning has been made in this important and difficult subject.

classical cases we now have an element v or these more genera matne-matical spaces—which in some instances may be function spaces or other infinitely dimensional spaces. The subject is still in its infancy, but there is a growing opinion to the effect that it will become one of the great branches of mathematics. There are numerous applications of general tensor analysis to the vibrations of elastic media and to the

there is a growing opinion to the effect that it will become one of the prest branches of mathematics. There are numerous applications of great branches of mathematics. There are numerous applications of earlier of the property of the pro

1832), lord chief justice of England, was born at Canterbury on

bury King's school and Corpus Christi college, Oxford, and entered at the Middle Temple in 1787 For several years he practised as a special pleader under the bar, and was finally called at the Inner Temple in 1796. He joined the Oxford cucuit and made rapid headway. In 1801 he was appointed recorder of Oxford In 1802 appeared his Law relative to Merchant Ships and Seamen, which is still an authoritative work. Its publication brought to him so much commercial and other work that in 1808 he was in a position to refuse a seat on the bench, this, however, he accepted in 1816, being made a judge of the court of common pleas On the resignation of Lord Ellenborough in 1818 he was promoted to the chief justiceship of the king's bench, and presided over several important state trials, notably that of Arthur Thistlewood and the Cato Street conspirators (1820) He was raised to the peerage in 1827 as Baron Tenterden of Hendon. Never a great lawyer and with no pretence to eloquence. Tenterden made his way by sound common sense and steady hard work. He was an uncompromising Tory, and had no sympathy with the reform of the criminal law carried out by Romilly, while he strongly opposed the Catholic Relief bill and the Reform bill. He died on Nov 4, 1832

See Foss, Lives of the Judges (1870).

TENTERDEN, a market town and municipal borough in the Ashford parliamentary division of Kent, England, 53 mi. ESE. of London by the S. railway. Pop. (1938) 3,431 Area 14 sq mi It lies on an elevation above the Newnill channel, a tributary of the Rother, whose flat valley, called the Rother Levels, was an estuary within historic times, and even as late as the 18th century the sea was within 2 mi. of Tenterden, which is a member of the affiliated Cinque Port of Rye The church of St Mildred is Early English and later, and its tall, massive Perpendicular tower is well known for the legend connecting it with Goodwin Sands. The story is that the abbot of St. Augustine, Canterbury, diverted the funds by which the sea-wall protecting Earl Godwin's island was kept up, in order to build Tenterden steeple, the consequence being that in 1099 an inundation took place and "Tenterden steeple was the cause of the Goodwin Sands" The church of High Halden, in the neighbourhood, is remarkable for its octagonal wooden tower constructed of huge timbers, with a belfry of wooden tiles (shingles), of the time of Henry VI

Tenterden (Tenterdenne, Tentyrden) figures frequently in contemporary records from 1300 onwards. In 1449 it was united to Rye, and granted a charter which, however, did not come into operation till 1463 under Edward IV In return for these and other privileges it was to contribute towards the services due from Rye as one of the Cinque Ports, In 1600 it was incorporated under the title of the "Mayor, Jurats and Commons" of the town and hundred of Tenterden, in the county of Kent, the members of the corporation ranking henceforward as barons of the Cinque Ports. A weekly corn market on Friday and a yearly cattle and wool fair on the first Monday in May were granted, both of which are held at the present day. In 1790 a contemporary writer mentions the market as being little frequented, whilst the fair was large and resorted to by all the neighbourhood. The size and importance of Tenterden can be estimated from a receipt of 1635 for £90 shipmoney, as compared with \$70 contributed by Faversham, and \$60 by Hythe. Under Edward III. several refugee Flemings settled in the town and established the woollen manufacture. By 1835 this trade had died out.

TENURE, in law, the holding or possession of land. The holding of land in England was originally either allodial or feudal. Allodial land was land held not of a superior lord, but of the king and people. Such ownership was absolute (see Allorum). The Saxon invasion tended, without doubt, to re-establish the principle of common village ownership which formed the basis of both Celtic and German tenure. In the later Saxon period, however, private ownership became gradually more extended. Then the feudal idea began to make progress in England, much as it did about the same time on the Continent of Europe, and it received a great impetus from the Norman conquest. When English law began to settle down into a system the principle of feudalism was

Oct. 7, 1762, the son of a hairdresser He was educated at Cantei-taken as the basis, and it gradually became the undisputed maxim of English law that the Sovereign was the supreme lord of all the land and that every one held under him as tenant (see FEUDAL-ISM). All tenures, except free and common socage tenures, were abolished by the Law of Property Act, 1925 (s 56), and provision has been made for the abolition of copyhold and customary tenure and the extinction of manorial incidents, with a saving for grand and petty serjeanty services (ibid. ss 128, 136, 139-143) The following modern cases may be consulted with regard to native tenures of land: In re Southern Rhodesia (1919) A.C. 211, 233 (aboriginal rights generally); Sobhn Za II v Miller (1926) A C 518 (West African), Amadu Tijani v. Secretary for Southern Nigeria (1921) 2 A.C. 399 (West African), A.G. for Quebec v. AG. for Canada (1921) I AC. 401 (Indian Reserves). but it should be noted that in several colonies the matter has been the subject of legislation. In the United States the term tenure ordinarily is used to denote the manner whereby lands or tenements are held, excluding lands held in fee simple As an example, a person may have a life estate or tenure in land, or a tenure for a term of years. (See also Estate; Land; Manor)

TEOSINTE (Euchlaena mexicana), a tall, stout, annual grass, native to Mexico, very closely allied botanically to maize (q.v.). Usually branching at the base, it grows in large clumps, with tassels (staminate flowers) like those of maize. The bundles of fruiting spikes, enclosed in husks, with the silk (long styles) hanging from the upper ends, are somewhat similar to the ears of maize. Teosinte is grown in Mexico as a fodder plant and sparingly in the southern parts of the United States as a soiling crop In Mexico hybrids of teosinte and maize are found, giving rise to the view that the two plants have developed from a common ancestral form

TEPIDARIUM, the warm room of a Roman bath (see BATHS), or a similar chamber in a modern bath establishment In the great imperial thermae at Rome the tepidarium constituted the large central hall and served, apparently, as a general lounge and meeting room as well as for bathing.

TEPLICE-ŠANOV or TEPLITZ-SCHÖNAU, a spa in Bohemia, in the valley of the Bilina It owes its popularity as a wateringplace to its mild climate and to the thermal mineral springs of the locality. The salme-alkaline waters, 79° to 122° F, are used almost exclusively in the treatment of gout, rheumatism and some skin complaints and are prescribed as an "after-cure" to Carlsbad, etc. Although traditionally beheved to have been known and used since the 8th century, the springs are not historically mentioned until the 16th century, and the function of the town as a watering-place is disappearing in face of the advance of industry, for the rich lignite field of Brux-Komotau-Teplitz led to the establishment of numerous manufactures Hardware, machinery, glass, pottery, chemicals, cotton and woollen goods are the principal products and in all of these Teplice has a brisk trade. Industrial life grew mainly in the suburbs. Pop. (1930) 30,911, of whom about 25,000 were Germans.

In 1938 the town was ceded to Germany by the Pact of

Munich.

TERAMO, an episcopal see of the Abruzzi, Italy, the capital of the province of Teramo, 16 mi. by rail W.S.W. of Giulianova, a junction on the Ancona-Brindisi railway. Pop. (1936) 16,229 (town); 33,796 (commune). The town stands on the left bank of the Tordino, where it is joined by the Vezzola, at an altitude of 876 ft. above sea-level. The cathedral has a Romanesque Gothic portal of 1332 by a Roman marble worker named Deodatus; it contains a splendid silver antependium by Nicolo da Guardiagrele (1433-48). The tower is fine. The church of S. Antonio is also in the Romanesque Gothic style. Under the church of S. Anna dei Pompetti remains of Roman houses and of the original cathedral have been discovered. Two miles away is an important astronomical observatory, presented to the State by Vincenzo Cerulli in 1917. The ancient Interamna Praetuttiorum was the chief town of the tribe of the Praetuttii.

TERAPHIM, a Hebrew word, found only in the plural, of uncertain etymology. The name appears to be applied to some form of idol (cf. Gen. xxxi. 19 and 30), but details as to its precise configuration, etc., are lacking. From I Sam xix 13, 16 it would seem that in the early monarchical period a regular place in every household was still reserved for the teraphim; while in the 8th century, Hosea (ii. 4) speaks of "ephod and teraphim" as essential elements in the national worship. Later the teraphim were banned by the prophets The meaning of the story in Gen. xxxv. 2-4 clearly is that the employment of teraphim was given up by Israel in order that they might serve Jehovah alone at Bethel. In Judges and Hosea the teraphim are closely associated with the ephod; both are mentioned in connection with divination (cf. 2 Kings xxni 24; Ezek xxi. 21 & 26; Zech x 2) In view of Ezek. xxi. 21 and Hosea iii 4, it is difficult to suppose that the teraphim were purely household idols See also EFHOD TERBIUM, a very rare metallic element (symbol Th, atomic

number 65, atomic weight 159 2) of the rare-earth group, was discovered by Mosander, who originally named the oxide erbia. The first pure compounds were obtained by G. Urbain in 1905 It is best separated from the other members of the group by the fractional crystallization of the bromates The ignition of terbium oxalate or sulphate gives a black peroxide which slowly dissolves on heating with mineral acids, giving almost colourless solutions characterized by a rather faint absorption band in the blue region (C. J.)

of the spectrum. See RARE EARTHS.

TER BORCH (or TERBURG), GERARD (1617-1681), Dutch subject painter, was born in 1617 at Zwolle, Holland. He received an excellent education from his father, also an artist, and developed his talent very early. The inscription on a study of a head proves that Ter Borch was at Amsterdam in 1632. In 1634 he studied under Pieter Molyn in Haarlem. A record of this Haarlem period is the "Consultation" (1635) at the Berlin gallery. In 1635 he was in London, in 1640 in Rome, when he painted the small portraits on copper of "Jan Six" and "A Young Lady" (the late Six collection, Amsterdam). In 1648 he was at Munster during the peace congress and executed his celebrated little picture, painted upon copper, of the assembled plempotentiariesa work which, along with the "Guitar Lesson" and a portrait of a "Man Standing," now represents the master in the National Gal-lery in London. The picture was presented to the nation by Sir Richard Wallace. At this time Ter Borch was invited to visit Madrid, where he received employment and the honour of knighthood from Philip IV., but, in consequence of an intrigue, it is said, he was obliged to return to Holland. He seems to have resided for a time in Haarlem, but he finally settled in Deventer, where he became a member of the town council He died at Deventer on Dec. 8, 1681

Ter Borch is excellent as a portrait painter, but still greater as a painter of genre subjects. He depicts with admirable truth the life of the wealthy and cultured classes of his time His colouring is clear and rich, but his best skill lies in his unequalled rendering of texture in draperies, which is seen to advantage in such pictures as the "Letter" in the Dutch royal collection, and in the "Paternal Advice" (known as the "Satin Gown")-engraved by Wille-which exists in various repetitions at Berlin and Amsterdam, and in the Bridgewater gallery. Hofstede de Groot enumerates 464 works by Ter Borch. Seven of these are at the Hermitage, 12 at the Berlin museum, seven at the Louvre; six at the Dresden museum, two at the Wallace collection and 15 at the

Amsterdam museum.

See Hofstede de Groot, Catalogue of Dutch Painters (1913).

TERCEIRA, an island in the Atlantic ocean, belonging to Portugal, and forming part of the Azores archipelago. Pop. (1940) 53,233; area, 153 sq.mi. Terceira, i.e., "the third," was so called as being the third island of the archipelago to be discovered by the Portuguese From its central position it was long the seat of administration, but its capital, Angra (q.v.), has lost much of its commercial importance. The other chief towns are Ribertinka (3,170), and Praia da Vitoria (2,029). See Azores.)

TEREBINTH, botanical name Pistacia terebinthus, a member of the family Anacardiaceae, usually a small tree, common in

the south of Europe and the whole Mediterranean area. It has a purplish grey bark and compound leaves with two to four pairs. and an odd terminal one. The very small numerous unisexual flowers are borne on panicles. The fruit is a small roundish bright red drupe with a scanty pulp. A liquid resinous exudation, known as Chian, Scio or Cyprus turpentine, is obtained by cutting the stem. Allied species include P lentiscus, the mastic tree and P. vera, which yields the pistache nut.

TEREDO. From time immemorial seafaring men have known and dreaded the shipworm, which bores into and destroys the stoutest timbers in the sea Nowadays, although the danger to ships is no longer to be feared, the timber of harbour works is still exposed to damage by the same pest. How serious the danger may become is shown, for example, by the outbreak of shipworm in San Francisco bay during the four years 1917-21 when the destruction of wharves and letties was estimated to have cost the enormous sum of 25 million dollars.

The writers of antiquity did not distinguish clearly between the marine timber worm and the wood-boring insect larvae of the land and they sometimes applied the name Teredo to both, but it was later restricted to the marine borer and is still in use as a general term for the shipworms, although in the nomenclature of zoological taxonomy it is the name of only one of the genera

forming the family Teredinidae.

It was Godfrey Sellius who, in 1733, first showed that Teredo is a bivaive molluse members of that group When its burrow in the wood is laid open it is seen to have a long worm-like body bearing at its inner end a pair of small shelly plates which represent the valves of the shell At the outer end, where the burrow narrows to a small opening, the body ends in a pair of siphons which can be extended from the surface of the wood and serve for the entrance and exit of the respiratory current of water. When the siphons are withdrawn the opening of the burrow is blocked by a pair of paddle-shaped plates of shell known as the pallets. The interior of the burrow is lined with shelly material which is usually merely a thin film but when exposed by the decay of the wood may be considerably thickened. The valves of the shell are nearly hemispherical, with a deep right-angled notch occupying the ventral half of the anterior margin. In the gap left by these notches is the round sucker-like foot with which the animal adheres now to one part and now to another of the interior of its burrow Parallel with the edges of the notch, the surface of each valve is marked with two sets of fine ridges which are seen under the microscope to be rows of minute teeth like those of a file. It is by means of these teeth that the excavation of the wood is effected. While the foot is adhering to the wood a rocking movement is imparted to the valves by alternate contractions of the anterior and posterior adductor muscles and the wood is rasped away as a fine dust This is swept into the mouth and passes into the stomach. It has been shown beyond doubt that the wood is acted on by the digestive ferments and utilized as food, but in addition the stomach is usually found to contain minute floating organisms drawn in with the respiratory current.

In some species of Teredo the eggs are discharged and float freely in the sea, in others they are retained in the gill cavity and pass through the early stages of their development before they are set free. In either case, the earliest stage is a free-swimming ciliated larva which soon develops a bivalve shell. After a time the larva settles on the surface of the wood, creeping about by means of a large tongue-shaped muscular foot. Settling on a suitable spot it begins to scrape away the wood with the edges of the valves and soon disappears below the surface. As the burrow deepens the body lengthens so that the siphons can protrude from the surface while the valves are working at the inner end. In temperate seas shipworms rarely exceed a foot in length but some tropical species may reach six feet.

Many species of shipworms have been described and grouped in a number of genera forming the family Teredinidae, but the taxonomy is not in a satisfactory condition and much more work is required before the limits of species or genera can be properly defined. What is of importance to the engineer is that the different species differ considerably in their physiological requirements. Thus while many species are only able to flourish in places where the salinity of the water is nearly the same as that of the open sea, the typical species Teredo navalis can survive a considerable reduction in the salinity and is enabled to invade estuaries and harbours where the influx of fresh water excludes other species It happens from time to time, as in the case of the San Francisco outbreak alluded to above, that a temporary increase of salinity resulting from reduced rainfall extends the brackish water area still farther, and thus allows T navalis to gain a footing in places where it had not previously existed

Numerous methods have been tried for protecting timber against the attacks of shipworms Metal sheathing for the hulls of wooden ships was employed in Greek and Roman times and copper sheathing came into extensive use in the 18th century At the present day the piles of harbour works are sometimes sheathed with metal or enclosed in concrete "jackets." methods, however, are only effective when the surface is completely covered A small space left unprotected may admit enough shipworm larvae to destroy completely the interior of the timber. Certain kinds of timber are comparatively resistant to shipworm attacks, but it appears that this resistance is only temporary and that no kind of wood is permanently immune Many methods for impregnating the wood with poisonous substances have been tried. the most effective being creosote Heavy impregnation with creosote greatly lengthens the "life" of timbers exposed to attack, but lasting immunity is not attained owing to the gradual washing out of the creosote from the wood

Besides the shipworms several species of Crustacea are the cause of serious damage to timber in the sea. The best known of these is the "gribble." a tiny 1sopod which burrows in the superficial layers of the wood, reducing them to a spongy mass which is easily washed away, exposing fresh layers to attack. It is common in European waters and has been found in many other parts of the world. The damage done by it is visible on the surface and is less likely to attain serious proportions without being noticed than is (W T C, X.) that caused by the shipworm.

TEREK, a river of Russia flowing from the Caucasus Range to the Caspian Sea, rising in glaciers on Mount Kasbek. It skirts the Kasbek group on the south and west, and flows through a series of gorges The most famous is the Darial gorge by which the Terek escapes to the plains on the north, its furious torrent flowing between wild granitic bare rocks and forming a contrast to the wooded limestone mountains beyond The Georgian military road, built 1811-64, passes through the gorge and enabled Russia to establish her rule among the wild Caucasian mountain tribes. Below Vladikavkaz at the foot of a vast declivity, it collects the waters of the Gusel-don, Fiag-don, Ar-don and later receives the Urukh, and the Malka, with its affluents the Cherek and Baksu. It then flows through the steppe country at the northern foot of the Caucasus to the Caspian, being joined before it reaches the delta by the Sunja, a tributary receiving the Chanti or Argun, and fed by numerous sulphur streams, one of them, the Melchihi, rising in five hot springs which affect the temperature of the Melchihi for some distance. In spite of losses by evaporation and irrigation, the Terek still has a sufficiently large volume to enable it to spread out in a great delta, with branches shifting in flood time and changing their relative importance. This delta stretches for 70 m. along the coast. The coast line, like that of the Volga delta, is encroaching on the Caspian, and old shore lines may be traced considerably west of the present coast. Fishing villages which in 1825 stood on the coast line were 10 m. inland in 1855 Among the more important irrigation canals are the Eristov and Kurskiy, fed from the Malka; plans are under considera-, tion for irrigation of part of the Nogal steppe, recently included in the Dagestan A.S.S.R. In its lower course the Terek flows above the level of the surrounding country.

TEREK PROVINCE: see Caucasian Area, North.

TERENCE (PUBLIUS TERENTIUS AFER) (c. 190-c. 159 B.C.), Roman comic poet, was born in Carthage and came to Rome as a slave in the house of Terentius Lucanus, a senator, by whom he was educated and manumitted. The little that is known of his life is almost entirely derived from a fragment of Suetonius, De viris illustribus. At Rome he was on friendly terms with Scipio Africanus the younger, C. Laelius, and Furius Philus. His six plays

were produced 166-160 BC After the production of the last he went to Greece, apparently to procure more of Menander's plays. From this voyage he did not return The place and manner of his death are very variously given.

His first play, the Andria, was produced in 166 B C The plot, which may be taken as typical, tells of the adventures of an Atheman girl, Pasibula, who is left in the charge of an uncle while her father goes abroad, how she is shipwrecked off the coast of Andros, where she is brought up, under the name of Glycerium, as the daughter of an Andrian, and returns to Athens; of her love affair with Pamphilus and its threatened frustration, and of her rediscovery of her father and her eventual marriage with Pamphilus, whose crafty slave, Davus, is as usual the mainspring of the plot. The play is an adaptation from two plays-a procedure known as contaminatio-of Menander, as we learn from the prologue 9 seq. "Menander wrote the Andria and the Permthia; he who knows either, knows both, for the plots are not very different, though they differ in language and style. The poet's enemies object to this and maintain that plays should not be contaminated (contaminari non decere fabulas). Their knowingness shows that they know nothing, for the same criticism applies to Naevius, Plautus and Ennius, whom the poet takes as his models, preferring their 'negligence' to the 'obscure diligence' of his detractors."
The opening scene is twice referred to by Cicero, who in De Inventione, i. 23, cites lines 50-53, 157, 168, and in De Oratore 40, hic parvae consuetudinis-faciet patri (Andr. 110-112).

His second play, Hecyra, or the Mother-in-Law, adapted from a play by Apollodorus, was produced in 165. The third, Heautontimorumenos, or the Self-Avenger, appeared in 163, the fourth, the Eunuchus (Eunuch), a "contamination" (cf., prol. 30 seq.) of two plays of Menander, the Eunuchus and the Kolax (flatterer), in 161, and in the same year also the Phormio, adapted from the Epidicasomenos of Apollodorus. His last play, the Adelphoe, or the Brothers, a "contamination" of the "Adelphoi" of Menander and the Sunapothneskontes of Diphilus, was produced in 160.

With regard to the economy of his plays, it is to be noted that Terence uses the prologue no longer to introduce a play by an exposition of the plot, but after the manner of the Aristophanic parabasis, chiefly to reply to his critics—cf. Andria, prolog. 5
"Nam in prologis scribunds operam abutitur Non qui argumentum narret sed au malevoli Veteris poetae maledictis respondeat;" i e., the poet wastes his labour in writing prologues, not to explain the plot, but to reply to abuse of a malevolent old poet (Lavinius Luscus, preferred by Vulcatius Sedigitus to Ennius as a comic poet. Aul. Gell. xv. 24).

The comedy of Terence, like that of his exemplars, is a comedy of manners. The reader is conscious of having travelled a long

way from the Olympian humour of Aristophanes. His meritpurity of Latinity-and his demerit-lack of comic power (vis comica)-are summed up in the famous epigram of Julius Caesar (Sueton Vita Terentii) :

Tu quoque, tu in summis, O dimidiate Menander, Poneris et merito puri sermonis amator Lenibus atque utinam scriptis aduncta forct vis Comica, ut aequato virtus polleret amore Cum Graecis neque in hac despectus parte iaceres, Unum hoc maceror et doleo tibi desse, Terenti,

(Thou too, O halved Menander, art placed among the highest and deservedly-lover of pure speech. And I would that to thy mild writings there had been joined comic power, so that thy excellence might have had equal honour with the Greeks and thou be not despised in that part. This one thing, Terence, thou lackest -to my distress and sorrow.) In his own time he appears to have been accused of plagiarism and also of receiving help in writing his plays from his friends-a charge which he several times refers to in his prologues and in that of the Adelphoe apparently admits to be true.

In using his Greek models, apart from "contamination" referred to above, he permits himself various liberties Names are altered, individual scenes remodelled, e.g., Eumechus, 539 seq. or abbreviated, cf. Hecyra, 835, and new characters, e.g., Charinus and Burria in the Andria, introduced.

The judgment of Caesar already quoted seems to have been

pretty generally endorsed in antiquity Vairo found his chief merit in the exhibition of character (in othesin Terentius boscit

pulmam); Cicero in his choice language

In another passage-De obtimo genere oratorum, i-Cicero speaks of Terence as generically differing from Accius; Horace, Epist, 11, 1 59 quotes as a received opinion that Caecilius (who, according to legend, Sueton Vit. Ter, encouraged the young poet) excelled in dignity, Terence in ait Ovid, Trist ii, 359 seq contrasts him with Accius Accius esset atrov, conviva Terentius esset Quintilian (x, 199) says that the Romans make a poor show in comedy . . . "though the writings of Terence are ascribed to Scipio Africanus-writings which in this kind are most elegant and could have been still more pleasing if they had been confined to trimeter lines"-a criticism which seems to refer to some departures in prosody from the strict Menandrian model According to Servius, Terence is preferred to the other comic poets solely on the ground of propriety, being in other respects inferior Aulus Gellius, xv, 24 has preserved some lines of Vulcatius Sedigitus, in which the Roman writers of comedy are arranged by him in order of merit, thus-Caecilius, Plautus, Naevius, Licinius, Atilius, Terence Turpilius, Trabea, Luscius and lastly, added, causâ antiquitatis. Ennius In England and on the continent, Telence has been popular and influential and imitations of his plays have been numerous, e g , the Andria was copied in the Conscious Lovers of Sir Richard Steele, the Heautontimorumenos in the All Fools of Chapman, the Eunuchus in Sedley's Bellamira, and La Fontaine's L'Eumague, the Phormio in Molière's Les Fourberies de Scapm, the Adelphoe in the same author's Ecole des Maris ress de Scapin, the Acasphoe in the same author's Looie des Acar's See Editio prince's Strasbourg (1470). R. Bentley (Cambridge, 1796), Fleckelsen (Leipzig, 1898). Editions of single plays are numerous TERENTIANUS, surnamed Maurus (a native of Maure-

tania), Latin grammarian and writer on prosody, flourished probably at the end of the 2nd century AD. His references to Septimius Serenus and Alfius Avitus, who belonged to the school of "new poets" (poetae neoterici or novelli) of the reign of Hadrian and later, seem to show that he was a near contemporary of those writers He was the author of a hexameter treatise in four books. on letters, syllables, feet and metres, of which considerable use was made by later writers. The most important part of it is that was made by later writers. The most important part of 11 is that which deals within extres, based on the work of Caesius Bassus Bassus Bestim, 18-21, see also Tended Latint, 91; with commentary by Saction, 18-21, see also Tended-schwing. Hart, of Roman Literature (Eng ti), 31; see also Tended-schwing. Hart, of Roman Literature (Eng ti), 31; see also Tended Latint, 18-21, and 18-21,

mouth. City population was 53,425 (1950) and municipio 93,352. It is situated on an open plain and is laid out regularly with broad straight streets and large squares. The town is characteristically Portuguese in appearance, its buildings being one or two stories in height, plastered and frequently coloured outside, with large rooms, thick walls and tile roofs to ensure coolness Its manufacturing industries include cotton mills, sugar refineries, a foundry and soapworks. A steamboat service, with small boats. maintains regular communication with Parnaiba, near the mouth of the river, besides which there are a number of independent freight-carrying boats. A railway connects Senador Furtado, across the river Parnaíba, with the port of São Luís on the coast of Maranhão. Teresina was founded in 1852, its site being originally called Chapada de Corisco, and was named after the Empress Teresa Cristina.

TERGESTE: see TRIESTE.

TERM, in logic, means the subject or predicate of a judgment (or proposition). It is, however, commonly used in a much wider sense so as to include also any word or combination of words that is capable of being used as the subject or predicate of a proposition. Of the different kinds of terms usually distinguished, the following are the most important. (a) Connotative terms are those which have a standard (or conventionally fixed) meaning. In this sense practically all terms except proper names are connotative. Non-connotative terms have no such fixed meaning. It is usual to restrict this distinction to concrete terms, on merely

primarily indicate or suggest the presence of something (though indirectly they may also imply the absence of something) Negative terms primarily indicate the absence of something (though indirectly, and perhaps rather vaguely, they may also imply the presence of something) (c) Singular terms are such as are applicable in the same sense to one object only (or to one group treated as one object) General terms are those which can be applied in the same sense to any one of a class (or kind) of obiects. (d) Concrete terms are those which denote anything that can be regarded as a whole having attributes and standing in various relations, even if it is not tangible (e.g., mind, character, logic, as well as table, chair, etc.) Abstract terms are the names of some attribute, aspect or relationship considered apart from the things in which it exists (e.g., size, beauty, friendship, etc.). (e) Relative terms are those the special function of which it is to draw attention to some definite relationship in which the object named stands to some other object (e.g., husband, wife, partner, etc.) Absolute terms are those which have no such special function, although the things named will as a matter of fact stand in all sorts of relationships to other things (eg, John Smith, table, chair, etc.) Relative terms usually go in pairs, for every relationship requires at least two terms—"parent" and "child," "brother" and "brother" (or "sister"), and so on (f) Collective terms denote groups of similar separate units as groups (e.g., "army." "company," "library," etc.). Non-collective (or unitary) terms denote units that are not groups of similar separate units (eg, "table," "chair," "house," etc ).

Of the above classifications or distinctions the first (a) is mainly concerned with verbal terms or names. The others are primarily concerned with differences in the way in which we think about things, even the same things it may be Sometimes a thing is regarded in all its individuality (as singular); sometimes as one of a kind (general); sometimes it is considered in relation to sometime else (relative), sometimes for its own sake (absolute), sometimes we think of what a thing is (positive), and sometimes of what it is not (negative); and so on, (See Logic and the

bibliography given there )

Dibliography given there:

A Term of Years, in English law, is the time during which an interest in an estate for life on for years is enjoyed, also the interest lastly, because such an interest must determine at a definite time. If the interest be for life, it is an estate of freehold; if for years, only a personal linterest in real estate, and so personally, even though the length of the term—for instance, 1,000 years—may far exceed in duration any possible life estate (See the Law of Property act, 1935) The same act gives power to enlarge the unexpired residue of a term of 200 years in certain cases into the fee simple, and the Places of Worship (Enfranchisement) act 1920 gives power to enlarge leases for

lives or even 21 years.

Terms, in the sense of a limited and certain period of time during which the law courts are open, used to affect only what were called in England the superior courts—that is, the king's bench, common

in England the superior course—time is, the Ampa weath, common, pleas and exchesped terms, Halay, Easter, Trithy, Michaelma, the average duration of each being about three weeks. By the Judicature act of 1875 terms were abidished so far as related to the administration of justice and sittings substituted. The dining terms at the Inns of Court correspond in point of time with the old terms and not with

Court correspond in point to some water up on a constraint of the sittings.

At the University of Cambridge the academic year is divided into these terms, Michaelmas, Lent and Easter; while at the University of these terms, Michaelmas, Lent and Easter; while at the University of and Trinity. School years now generally consist of three terms, divided and Trinity. School years now generally consist of three terms, divided. and Trinity. School years now generative consist or times terms, wavener by Christmas, Easter and summer holidays, the old half-years having gradually been abolished.

In Algebra, an expression not connected to another expression by the sign + or the sign —. For example, ab<sup>5</sup> is a single term (monal). (See Davidson and the sign + and the sign - ab<sup>5</sup> are to terms (binomial). (See Davidson - ab<sup>5</sup> are sign - ab

POLYNOMIAL.)
TERMINATOR, in astronomy, the bounding line between light and darkness on the apparent disc of the moon or of a planet. At places on the terminator the sun is either rising or setting.

TERMINI IMERESE (anc. Thermae Himerenses), a seaport town of Sicily, in the province of Palermo, 23 mi. E.S.E. of it by rail, Pop. (1931) 16,689, It was founded in 408 B.C. by the Carthaginians, after their destruction of Himera, in the vicinity of hot springs mentioned by Pındar (Od. xii, 19) which are usual to restrict this distinction to concrete terms, on merely still resorted to (temperature x10° F.). Agathocles (g.v.). was etymological grounds (b) Positive terms are those which born here. It was taken by Rome in the First Punic War, A Roman road ran from it to Catana Scanty remains of buildings of Roman times (baths, an amphitheatre and a so-called curia) exist in the upper part of the town, and outside it on the south are considerable remains of two Roman aqueducts.

TERMINOLOGY: See NAME

TERMINUS [Lat. a boundary stone], a stone or post which was set up in the ground with the following religious ceremonies A hole was dug and a fire lighted; a victim was sacrificed and its blood poured into the hole, together with incense and finits, honey and wine, and the ashes of the sacrifice. Then the boundary stone, which had been previously anomted and crowned with garlands. was placed upon the hot ashes and fixed in the ground. Any one who removed a boundary stone was accursed (sacer) and might he slam with impunity; a fine was afterwards substituted for the death penalty From this sacred object evolved the god Terminus On Feb. 23 (the end of the old Roman year) the festival called Termmalia, according to Wissowa a festival not of the god but of the boundary stones (termini), was held. The owners of adjacent lands assembled at the common boundary stone and garlanded each his own side of the stone. An altar was set up and offerings of cakes, corn, honey and wine were made Later a lamb or a sucking pig was sacrificed. The proceedings closed with songs to the god and a general merrymaking, in which all the members of the family and the servants took part

A similar festival was held at the old boundary of the Roman territory between the fifth and sixth milestone on the 10ad to Laurentum, When the Capitoline temple was to be built the auguries forbade the removal of

one of these termina (a houndary mark of some old precinct?) and it was enclosed within the walls of the new sanctuary, an indication of the immovability of such stones and of the permanence of the Roman territory,

Sec Wissowa, Religion und Kultus der Romer (2nd ed ), p. 136, W. W. Fowler, The Roman Festivals, p 324 (1899).

TERMITE, the name given to usually pale-coloured, softbodied insects living in large societies below ground or in other concealed situations. These so-cieties consist of wingless, sterile individuals generally of two types -the soldier and the workerand among them there develop reproductive forms, some of which are wingless, and others are endowed with two pairs of long. narrow, membranous wings. The latter individuals leave the colony in periodic swarms, cast their wings and proceed to establish new colonies. Termites form the scientific order Isoptera THE ROYAL PAIR OF TERMES NE-(see Insects) and are popularly MOROSUS, THE LARGER FIGURE (see INSECTS) and are popularly BEING THE QUEEN. THE SMALLER known as white ants, but as they

THE KING, FOUR TIMES THE AC- differ fundamentally from true TUAL SIZE ants and are rarely white, this designation is open to objection. Owing to their gnawing propensities these insects cause immense damage to the woodwork of buildings, and some species attack the roots of growing crops. For further information on termites see Social Insects.

TERMITE-PROOF CONSTRUCTION. Damage caused by termites to buildings or their contents can be prevented by proper construction of the buildings and chemical treatment of all wood with coal-tar creosote. Building codes are being revised in many American cities to require termite-proof construction. The

best rule is to make the foundations entirely of stone, brick or conciete, including stone or metal columns or pillars in the basement Basement floors should be of concrete on a gravel base Where it is impracticable to use these materials all wood used near the ground should be chemically treated. Complete dryness of the foundation and basement floors and walls is important. Since subterranean termites can not live or work without access to moist earth, it is only necessary to shut off this source of moisture to prevent damage by this type. Non-subterranean termites can be killed in infested wood by furnigation with hydrocyanic-acid gas

TERMONDE (Flem Dendermonde), a town in the province of East Flanders, Belgium, 25 mi S W. of Antwerp, at the junction of the Dender and Scheldt. Pop. (1939) 9,395. It was before Termonde that Louis XIV, in 1667, was compelled to re-treat through the opening of the dikes. The fortifications were demolished in 1910. The church of Our Lady contains two fine pictures by Van Dyck, and one masterpiece of Crayer's. The fonts are of the 12th century The town suffered greatly in World War I, the town hall and the church of Our Lady being much damaged.

TERN, sea birds forming the sub-family Sternmae of the gulls (Landas)

The largest British species is the Sandwich tern (Sterna sandvickensis), as big as a small gull, with a dark bill tipped with yellow, and dark legs. The common (S. hirundo) and Arctic (S. macrura) terms are only to be distinguished by the all-red bill of the latter, which is a bolder species with a more northern range, though both breed at Blakeney point in Norfolk The little term

-0

LEAST TERN (STERNA ANTIL-LARUM), SHOWING ITS NEST OF

(S. albifrons) is known by its white forehead and vellow bill. S caspia, the Caspian tern, is the largest species known, measuring 2ft. in length In addition to the last three British species, S dougalli, the Roseate tern, is also common to Europe and North America

In North America there also occur the noddy (qv), the sooty tein (S fuscata), and the black tein (Hydrochelidon nigra)

Terns breed usually on sand dunes and shingle banks and lay up to four eggs, two being the commonest number, great variation occurring with the season and the locality They are said by fishermen to damage the fishing, but this has been proved to be a mistake, the birds feeding largely

EGGS IN THE BACKGROUND on crustacea, insects and sand eels, which they obtain by plunging into the water from a height of 3-8ft, and emerging with the food in their bills. The male usually feeds the female while she is brooding, often accompanying the presentation with the same play ceremony used in courtship. In the same way, in courtship, food is often presented by the male.

About 75 species are known; the group is cosmopolitan.

TERNATE, the northernmost of the line of islands off the western coast of Halmaheira, Netherlands Indies, which stretch southwards to the Bachian archipelago. It has an area of 25 sq.mi., a width of six miles, and consists mainly of a conical volcano 5,600 ft. in height, with three peaks (Arfat, Madina and Kekan). its curious formation being due to many extremely destructive eruptions. Within the last four centuries there has been volcanic activity at Ternate on no less than 70 occasions, the worst recorded being the eruption in 1763, which overwhelmed the thriving little village and Ft. Takomi, which is situated on the north-west coast, and so completely devastated one slope with lava flow that it has since been known as Burnt cape (Batu Angus), whilst two small crater lakes were formed where the village stood. An eruption in 1840 destroyed nearly every house in the town of Ternate, and when A. R. Wallace was there in

canic activity.

1858 he experienced an earthquake and noted the destructive long as suited their purpose, and then, in their efforts to confine

effects of former shocks The northern half of the island has suffered most from vol-

There, lava streams have flowed down the mountain side right to the sea, and there are numerous bare tracts of land, but on the southern and eastern coast there is forest and luxuriant vegetation, with a good deal of cultivated land on the flat strip by the shore; vegetation extends even far up the mountain side.

Rice and maize are grown, also sago, coffee, pepper, nutmegs and fruit (good mangoes and durians), Ternate was once a leading centre of spice cultivation.

It has a population of 19,533, including 440 Europeans and Eurasians, 1,031 Chinese and 575 Arabs, the native population being of very mixed blood, probably Malay preponderating, but with Papuan elements, having a language of their own, written in the Arabic character, and Mohammedan by religion (also Crang Seracci descendants of natives converted to Christianity by the Portuguese).

Ternate is also the name of the administrative unit comprising all of Halmaheira and adjacent islands

The population of this district in 1930 was 178,487, including

649 Europeans and 3,680 Chinese and other foreign Asiatics. It forms part of the residency of the Moluccas

Ternate Town, population 7,126, hes on a flat strip of land on the south side of the island, at the foot of the mountain. It is a very picturesque settlement, the houses interspersed among a wealth of trees, with the volcano for a background, and, being close to other volcanic islands, one of which, Tidore, is so close that it helps to form the fine harbour of Ternate, and to the coast

of Halmaheira, it has magnificent views.

The port, which possesses piers and a coaling jetty, is a regular place of call for vessels of the Royal Packet Navigation company, affording frequent communication with Celebes, Amboina and New Guinea. This service was, of course, entirely disrupted by World War II.

Although it is the headquarters of a district. Ternate has only the shadow of its former greatness. Its trade is small (chiefly copra and nutmegs), its sultan before World War II was a pensioner of the Dutch government, and many of its inhabitants

fived by his bounty on his lands

History.-Ternate became known to Europe through the Portuguese, who settled there in 1521, and made it one of their chief spice-collecting centres. Conflict with the sultan, or king, as he was styled then, who objected to the establishment of a Portuguese spice monopoly, led to the expulsion of the Portuguese from the island in 1581. In the meantime, in 1579, Sir Francis Drake had called at Ternate, being received favourably by the king, and allowed to ship between four and five tons of cloves, but the visit was never followed up. Drake was much impressed with the wealth and state of the king of Ternate, and wrote, of his visit to the monarch. "The King had a very rich canopy with embossings of gold borne over him, and was guarded with twelve lances.

"From the waist to the ground was all cloth of gold, and that very rich; in the attire of his head were finely wreathed diverse rings of plaited gold, of an inch or more in breadth, which made a fair and princely show, somewhat resembling a crown in form; about his neck he had a chain of perfect gold, the links very great and one fold double, on his left hand was a diamond, an emerald, a ruby, and a turky (turquoise); on his right hand in one ring, a big and perfect turky, and in another ring many diamonds of a smaller size."

When the Dutch visited Ternate, at the beginning of the 17th century, the sultan, who was anxious to extend his power over the Moluccan islands generally, and even over a part of Celebes, arranged to give the Dutch a spice monopoly for their assistance against the Spaniards and Portuguese (Portugal had become incorporated with Spain and the Spaniards had reconquered Ternate). So Ternate rose to power and made many of the Moluccan islands, the eastern and northern part of Celebes and Buton, suzerain, but the Dutch bolstered up the power of Ternate only so

Moluccan spice cultivation to cloves in Amboina and nutmegs in the Banda ıslands, they destroyed the spice gardens of the northern Moluccas, Ternate included, causing Ternate to revolt, an example which was followed in neighbouring islands. They found it convenient (in 1683), to declare all contracts with Ternate void, and the chiefs who had looked to Ternate as their suzerain were informed that henceforth they would hold their lands directly from the Dutch

After that time, although the power of the sultan of Ternate as their vassal was recognized by the Dutch nominally, and he was given certain privileges regarding the native population, the executive, in Ternate, and throughout the lands of the residency, remained in Dutch hands

Ternate, as well as all the other islands on the west coast of Halmaheira, fell under Japanese occupation during World War

[
See A. R Wallace, The Malay Archipelago (London, 1890)
(E. E. L., X.)

TERNEPLATE: see Tin Plate and Terneplate TERNI (anc. Interamna Nahars), a town, episcopal see, and

capital of a province of Umoria, Italy, situated among the Apennines, 426 ft above sea-level, in the valley of the Nera (and Nar), from which the town took its distinguishing epithet, below its junction with the Velmo, and 70 mi N by E of Rome by rail Pop (1936) 37,295 (town), 68,890 (commune). It has important iron and steel works and iron foundries, at which armour plates, guns and projectiles are made for the Italian navy, also steel castings, machinery and rails, a royal arms factory, a large jute factory, a carbide factory, a wool spinnery, etc., and lignite mining. Terni lies on the main railway line from Rome to Foligno and Ancona, and is the junction for Rieti and Sulmona. Its most interesting buildings are the cathedral (restored in 1653 with remains of the earlier 13th century facade and an early crypt), and the Romanesque churches of S Pietro and S Francesco Its antiquities include traces of the city walls of rectangular blocks of travertine incorporated in the well-preserved mediaeval walls, remains of an amphitheatre, a temple, now the round church of S Salvatore, theatre and baths (?), and numerous inscriptions Five miles to the east are the falls of the Velino (Cascate delle Marmore), which took a very high place among European waterfalls; the cataract has a total descent of about 650 ft., in three leaps of 65, 330 and 190 ft, respectively.

The falls owe their origin to M Curius Dentatus, who in 272

BC. first opened an artificial channel by which the greater part of the Lacus Velinus in the valley below Reate was drained. They supply the motive power for the factories of the town and have

lost much of their former beauty.

Terni is the ancient Interanna (inter annes, "between the rivers," ie the Nar and one of its branches), originally belonging to Umbria, and founded, according to tradition in the year 672 B.C. The recent discovery of a neolithic village, and of cemeteries of the Villanovan period, with numerous inhumation graves of Picenes of 1200-1000 BC. (see Randall MacIver, Iron Age in Italy, 1927, 140-144) shows that the site was occupied much earlier. It is first mentioned in history as being, along with Spoletium, Praeneste and Florentia, portioned out among his soldiers by Sulla. During most of the middle ages and up till 1860 Terni was subject to the popes.

Terni was the scene of the defeat of the Neapolitans by the French on November 27, 1798

TERPANDER, of Antissa in Lesbos, Greek poet and musician. About the time of the Second Messenian War, he settled in Sparta, whither, according to some accounts, he had been summoned by command of the Delphian oracle, to compose the differences which had arisen between different classes in the state. He is regarded as the real founder of Greek classical music, and of lyric poetry; but as to his innovations in music our information is imperfect. According to Strabo (xiii, p. 618) he increased the number of strings in the lyre from four to seven; others take the fragment of Terpander on which Strabo bases his statement (Bergk, 5) to mean that he developed the citharoedic nomos

Frank Derivation of Santa to the Substitution of the Santa Santa Comment

(sung to the accompaniment of the cithara or lyre) by making the divisions of the ode seven instead of four

Fragments (the genuineness of which is doubtful) in T Bergk, Poetae Lyrici Gracci, in, see also O Lowe, De Terpandri Leibii aetate (1869), who places him about 676 B C

TERPENES. The terpense derive their name from oil of turpentine, from which source several of the earlier known member were obtained. Oil of turpentine is itself a generic term applied to the oils obtained from the looresans exued by several spots of trees. The word turpentine is a corruption of the Greek \*\*crousfilm\*\* meaning the semifluid resin of the terebuilth tree.

The tempenes are a group of bydrocarbons  $\langle q^+ v \rangle$  of the general formula (C.H.d.). The group is divided into subgroups—hemi-terpenes, C.H.d., true terpenes  $C_{\rm ad}H_{\rm sc}$ , assguiterpenes, C.H.d., diverpenes, C.H.d., and the polyterpenes, (C.H.d.). Of the polyterpenes, the traterpenes,  $C_{\rm ad}H_{\rm sc}$ , have now been extensively meetingsted. The terpenes and polyterpenes may be classified, according to their chemical structures as (1) acyclic or open-chain, and (2) cyclic compounds According to the number of rings in the structure they are classified as monocyclic, dicyclic or morg generally as polycyclic. (See CiteMistra  $V_{PQRIMC}$ )

There is only one hemiterpene, isoprene, and in this compound the carbon atoms are arranged as in I.

The true terpenes, and the higher terpenes and their derivatives, are nearly all built up from isoprete units arranged in a head to tail fashon, r./c, carbon atom t' of one unit is attached to carbon atom 4 of the previous unit as in II. This arrangement is also found in the cyclic terpenes. The arrangement of the isopreme units in monocyclic and dicyclic terpenes and also in one group of the secouterneese is shown in III. IV and V.

This isoprene rule for the structural formulas was first suggested by O. Wallach, and it is noteworthy that when isoprene is treated with sulphuric acid in acetic acid solution, a mixture of geraniol, ac-terpineol, 1:8-cuncole and a sesquiterpene is obtained. (See POLYMERIZATION)

Terpenes are widely distributed in the plant kingdom, in the essential oils obtained from the leaves, stems, flowers and, in some cases, the wood. The eleoresins exuded by certain trees and shrubs give, on distillation with or without the help of steam, the various kinds of turpentine which have long been known. The residue left after distillation constitutes rosm. The various turpentines obtained in this way are important sources of terpenes. One terpene alcohol, citroneliol, has been identified as the substance known as yucarol, the dooffierous principle produced by alligators. In the essential oils terpenes are very frequently associated with oxygenated derivatives, which, like the terpenes themselves, are nearly always built up from isoprene units. In a few cases the oxygenated compounds do not contain a multiple of five carbon atoms but their close structural relationship to the terpenes makes it reasonable to regard them as derived from the terpenes.

The essential oils have long been used as perfumes and in mediione and cookery. In the last use the essential oil is not usually extracted, the steen destination of the cooking process that the steen destillation. Among the medical uses may be mentioned that of ascandole for hookworm and sandalwood oil for a warely of sim disease. The oleversins, turpentures and rossns have long been used in painting, linoleum manufacture and wherever waterproofing and preservation are required

wnetever waterprooning must pleas, plant physiology is still incompletely understood. Their scent still test bases and so helps pollunation, but the scan still test bases and so helps pollunation, but the scan because the presence in leaves, stems and wood because the presence in leaves, stems and wood whomat also is uncertain. Schemes because the scan because

It is noteworthy that both forms of an optically active terpene are frequently found in nature. The sugars and other carbohydrates, amino acids, alkalotds and other optically active substances are usually found in only one form.

at Hamilton Protest — Largeme, B-meltylbutadiene, C.H., was first behannd in 1860 by Gerelle Williams by the distillation of cautchous. In 1883 Sir William A. Tilden obtained it by passing dipentene through a red-hot tube. It is a colouries liquid, boiling point 35 °C, density 0.69, and on long-standing at turns into a rubberlike substance as the result of nodymerization. This process

is accelerated by the action of heat or of various catalysts Many attempts have been made to prepare isoprene from sources other than rubber, but none has been commercially successful It has been prepared from paracresol via β-methyladipic acid, and its structural formula thus confirmed.

## TRIFE TERPENES

Most of the naturally occurring true tempeses,  $C_0H_{1a}$ , are colourleas, highly refractive liquids, builing at  $\tau_2 \circ ^2 - 18 \circ ^2$ . And with densities from 0.8 to 0.9. They are readily volatile in steam, practically insoluble in water but soluble in all proportions in common organic solvents like bearene, ether and ethyl alcohol. Aeral oxidation causes them to resinify and they are very reactive chemically, a dilute solution of potassium permanganate readily oxidizes them. They unite with hydrogen, hydrogen chloride, bromune, introsyl chloride, caone, etc. forming additive compounds, and the reactions may involve a change of molecular structure. The additive compounds often show ofs and trous isomerism.

These hydrocarbons are divided into four classes: (1) openchain or acyclic; (2) monocyclic; (3) dicyclic; and (4) tricyclic. The open-chain terpenes are not found naturally in any quantity but their coygenated derivatives are important, numerous and abundant

Myrcne, (CH<sub>2</sub>),C:CH.CH, CH<sub>2</sub> (C CH<sub>3</sub>),CH.CH<sub>4</sub>, lp., 169–168° C., as present in oil of bay verbens oil and other sources and can be obtained by thermal decomposition of pinene. It contains three double bonds and can be reduced to 2.6-dimethyl octane, six, atoms of hydrogen being taken up. At 3.30° C. It polymerizes. Ocimene, lp. 1.762–178° C. differs only in the arrangement of the double bonds and is found in the leaves of Ocimism Box Stations. It is reactly oxidized by air.

Monocyclic Terpenes.—These are more widely spread in nature and the naturally occurring members of the group are all derived from paracymene, VI, which can readily be reduced to paramenthane, VII. Derivatives of metameathane, VIII, do not occur in nature, but one of them, sylvestrene, a mixture of IX and an isomer, is obtained when Swedish pine-needle oil is distilled, and from other sources.

The carbon atoms in paramenthane and its derivatives are usually numbered as shown in VII. Double bonds are described as  $\Delta^1$  X,  $\Delta^{1/3}$  XI and  $\Delta^{1(7),2}$  XII, the symbol  $\Delta$  indicating a double

bond and the numeral the number of the carbon atom from which the double bond starts. In structure XII, in the text above, the figure 7 is bracketed to indicate that it marks the evocycle (outside the ring) carbon atom on which terminates the double bond

stating from carbon atom: Paramenthane exists in two forms, the exist and froms, according as the groups at carbon atoms; and 4, respectively are on the same aido, or on opposite sides of the ring. In compounds such as X and XII the molecule is dispumentic and the carbon atom at 4 is asymmetric. (See STEREOCHEMISTRY.)

Nearly all the true teapenes are liquid al ordinary temperatures, and identification is made easier when crystalline derivatives can be obtained. When the original teapene can be regenerated from the crystalline derivative, then this method can be used for the punification of the terpane. For these purposes considerable use has been made of the compounds formed by the addition of introsyl globride or nitrous fumes, giving respectively the nitrosocolionde and the nitrosite. When a hydrogen atom is attached to the same carbon atom as the nitroso group, an isonitrosy compound, on oxine, is formed and thus from the terpenes derivatives of related ketones can be obtained. The preparation of carvoxime from dipenteen entrosochloride is an example of this seatono. Pinene pairtosochloride was prepared by Sii William Tilden in 1875 and dipenteen entrosochloride in 1877.

and the distance of the control of t

250~250° C. It tendity combines with bromine to form a crystaline tetrabromide, Call-Half, from which, by the action of measum, the pure hydrocarbon has been obtained. On catalytic reduction paramenthane, Call-Is, is formed. By the action of a mixture of dilute sulphinic acid and acetic acid, a-terpineol acetate, Call-iO COCHs, is formed by the addition of acetic acid, which readily gives a-terpineol, Call-HoH, by hydrolysis a Terpineol adds on water and gives terpin hydrate, Call-HoH, other Half, the hydrated form of ar-sterpin, Call-HoH); is 8-dhydroxparamenthane. From terpin and from terpineol dipentene is readily formed by loss of water.

In 1904 W H Pekin, Jr., synthesized ce-terpined and from it prepared dipentine. This was the first synthesis of a naturally occurring terpene. The structure of terpined has been determined by a study of the products obtained on condation, a method greatly used to determine the structure of the terpenes, and the argument may be briefly indicated. The first product of oxidation, a keto-laction, Culfa(O<sub>2</sub>, containing the same number of carbon atoms as does terpined, was presumed to have the same general structural arrangement and gave, on further oxidation, terpenylic acid, CaH<sub>2</sub>O<sub>3</sub>, the liatione of a dibasic acid. This on reduction gave a dibasic acid, 3-fisopropylgituriar acid, XIII, whose constitution was proved by synthesis and which on oxidation reformed terpenylic acid, XIII of the card, XIII of the card, XIII of the card, XIII of the card

Thus the arrangement of eight of the ten carbon atoms in terpineol was determined, and is represented in XIII and XIIIa Terpenylic acid, XIIIa, was formed from the ketolactone by the

loss of two carbon atoms, and the conversion of a third into a camboxyl group. Presumably the carboxyl group marks the point of attachment of the two lost carbon atoms. The lectolaction therefore is formed from terpenylic and by the reverse change, by attaching two carbon atoms to the carboxyl group in terpenylic acid the keto group has also to be fitted in at this position because at disappeared with the two carbon atoms lost on oxidation. Structure XIV is therefore given to the ketolactions, because a compound of such a structure would be expected, by analogy with compounds of anomy astructure, to break down on oxidation, given the structure of the property of the compounds of anomy astructure, to break down on oxidation, giving in mind the relationship of terpined to paracymene, VI, the most probable structure for terpined is XV, the first attack of the oxidation gaven being at the double bond. By loss of water terpined gave depentency: the loss of water may give two products

and Markey of processing a second control of

(XVI and XVII), but in view of the existence of dipentene in optically active forms, the structure must be XVII

The study of the structure of the terpenes and their derivatives owes much to the work of Sir William Tilden, Adolf von Baeyer, O Wallach, W H Perkin, P Barbier, F Tiemann and F W Semmler

Other monocyclic terpenes are teapmolene. NVI, found in Manila elemi oil,  $\alpha$ -teapmone, in cardiamon oil,  $\gamma$ -terpenene in coriandei oil,  $\beta$ -phellandrene, in water fennel (Phellandriam questieum) oil,  $\alpha$ -tephellandrene, in oil of bitter fennel and in several species oil eucalyptus. They possess the same carbon skeleton as limonene and differ only in the positions of the two double bonds from the properties of the corient of the correction of the corient of the corient of the corient of the corient of the corient of the corient of the corient of the corient of the corient of the corient of the correction o

Dicyclic Terpenes.—These all contain two ring systems. One ring is the sax-membered ring found in the monocyclic terpenes, the other is founded by a "bindige" statung from carbon atom; and ending on carbon atom; a, 5, 6 i. I. Examples are Δ<sup>c</sup> carene, XVIII, bp 170° C. found in the oil of Puru longloida, sibinene, XIX, α-pinene, XXX, bp 150° C, and camphene, XXII, mp. 51° "52° C.

bp 158°-159° C, found in the oil from Abies sibusca and the only naturally occurring solid terpene a-Pinene is one of the most abundant and most thoroughly investigated terpenes and is the chief constituent of ordinary oil of turpentine. It was first analyzed by Antoine Lavoisier in the 18th century, but the correct molecular formula C10H16, was first given by J B A Dumas (1833) Earlier, m 1815, J B Biot, in the course of his early studies on optical activity in liquids, showed that French oil of turpentine was laevorotatory American and Russian oils are dextrosotatory Oxidation by air readily converts pinene to a viscid liquid and then to a resinous product. In the presence of air, water and sunlight, the first product is sobierol, XXII, in which it will be observed that the four-membered ring has been The smaller ring is often readily opened in dicyclic terpenes Pinene is especially easily converted to substances of different structures. When heated to 250°-270° C it is condifferent structures. When heated to 250°-270° C it is converted to dipentene, XVII. The action of hydrogen chloride at the ordinary temperature forms the so-called "pinene hydrochloride," a colourless crystalline solid, mp 132° C, that smells like camphor, and was first made by R. Kindt in 1802. This substance, also known as "artificial camphor," is now known to be bornyl chloride, and to have the structure XXIII. At -50° C a true hydrochlo-

ride of pinene is formed. The nitrosochloride, (C10H10ONCl)2, m.p. 215° C. with decomposition, is himolecular and was first pre-

paned by Tilden in 1875. By the auton of aniline it reforms expinene which can be prepared pure in this way. Capeful reduction by hydrogen and a catalyst gives pinane, C<sub>m</sub>H<sub>0</sub>, in which the double bond is now saturated. Pinene adds on water when tred with dilute acids the four-membered ring is broken and a-texpined with the control of the structure of pinene is based upon its relationship to terpined and to paracymene, and the formation of normal control of the cont

membered ring and its structure was deduced from its behaviour and confirmed by synthesis. The three-membered ning in carene, XVIII is readily opened to give derivatives of dipentene, XVIII, or of sylvestrene, IX. Sabinene behaves similarly and readily gives derivatives of dipentene. Camphene, tound in nature, is also formed when borrylene chloride gives up hydrogen chloride on treatment with alkali. The tournation of borrylene chloride from pinnene and of camphene from borrylene chloride are examples of the Wagner-Meerwein transformation. The tormation of camphene can perhaps be better undeststood by reference to structure XXV, which is formed if nom XXIII by breaking the bond between calubon atoms it and 6 and joining 6 to 2. This gives XXV which is only another way of writing XXI. Planar diagrams are somewhat misleading in these cases.

No tricyclic terpenes occur in nature but their derivatives do. Teresantalic acid, XXVI, is present in sandalwood oil

## OXYGENATED DERIVATIVES

The oxygenated derivatives of the open-chain or asyclic tepienes occur abundantly in nature, chiefly as alcholos and aldehydes, one ketone, artemian ketone, has been described. They are readily converted to cyclic compounds, generally by the action of acids, and these cyclic compounds are often identical with naturally occurring terpienes or their oxygenated derivatives. Thus nerol, XXVII, teadily gives a-terpinene The carbon to carbon double bond often shows special teactivity, adding such reagents any hydroxylamine and sodium bisulphite, which usually react only with the carbonyl or carbon-oxygen double bond. Several of the oxygenated terpienes apparently contain a mobile double bond and

behave as though they were mixtures of the two structures XXVIII and XXIX, where R represents the rest of the molecule.

The double bonds in these compounds often show cis-trans or generatical isomerism, thus geraniol, XXXa, and nerol, XXXb, form a pair, represented as in XXXa and XXXb where R represents the rest of the molecule. An important open-chain terpenelachol is citronellol, CaH<sub>20</sub> OH, (CH<sub>2</sub>)<sub>2</sub>C. CH.CH<sub>2</sub> CH<sub>2</sub> CH<sub>4</sub> C

## TEXTILE PRINTING

able process employed in Egypt for the colouring of tissues After pressing the material, which is white at first, they saturate it, not with colours, but with mordants that are calculated to absorb colour." When this was finished the cloth was "plunged into a cauldron of boiling dye" and "removed the next moment fully coloured." "It is a singular fact, too, that although the dye in the pan is of one uniform colour, the material when taken out of it is of various colours according to the nature of the mordants that have been respectively applied to it." Egypto-Roman bits of printed stufts from Akhim exhibit the use, some 300 years later than the time of Pliny, of boldly cut blocks for stamping figuresubjects and patterns on to textiles. Almost concurrent with their discovery was that of a fragment of printed cotton at Arles in the grave of St Caesarius, who was bishop there about AD. 542 Equal in archaeological value are similar fragments found in an ancient tomb at Quedlinburg These, however, are of com-paratively simple patterns. Other later specimens establish the fact that more important pattern-printing on textiles had become a developed industry in parts of Europe towards the end of the 12th and the beginning of the 13th century

The Rhenish Monks .- According to Forrer (Die Kunst des Zeugdruck (, 1898) mediaeval Rhenish monasteries were the cradles of the artistic craft of ornamental stamp or block cutting. In tare menastic mss earlier in date than the 13th century, initial letters (especially those that recurred frequently) were sometimes stamped from hand-cut blocks; and German deeds of the 14th century hear names of block cutters and textile stampers as those of witnesses. Between the 11th and 14th centuries there was apparently in Germany no such weaving of rich ornamental stuffs as that carried on in Spain and Italy, but her competitive and commercial instincts led her to adapt her art of stamping to the decoration of coarse textiles, and thus to produce rather rough imitations of patterns woven in the Saracenic, Byzantine and Italian silks and brocades. Amongst the more ancient relics of Rhenish printed textiles are some of thin silken stuff, impressed with rude and simplified versions of such patterns in gold and silver foil. Of these, and of a considerable number of later variously lived stout linens with patterns printed in dark tones or in black, specimens have been collected from reliquaries, tombs and old churches. From these several bits of evidence Dr Forrer propornds an opinion that the printing of patterns on textiles as carried on in several Rhenish towns preceded that of printing on paper. He proceeds to show that from after the 14th century increasing luxury and prosperity promoted a freer use of woven and embroidered stuffs, in consequence of which textile printing fell into neglect, and only-three centuries later it revived

Augsburg, famous in the 17th century for its printing on linens. etc., supplied Alsace and Switzerland with many craftsmen in

as to be irremovable by washing Plmy describes "a very remark- this process After the revocation of the edict of Nantes, French refugees took part in starting manufactories of both painted and printed cloths in Holland, England and Switzerland, some few of the refugees were allowed back into France to do the same in Normandy, manufactories were also set up in Paris, Marseille, Nantes and Angers; but there was still greater activity at Geneva, Neuchâtel, Zurich, St. Gall and Basle. The first textile-printing works in Great Britain are said to have been begun towards the end of the 17th century by a Frenchman on the banks of the Thames near Richmond, and soon afterwards a more considerable factory was established at Bromley Hall in Essex, many others were opened in Surrey early in the 18th century At Mulhouse the enterprise of Koechlin, Schmatzer and Dollfus in 1746, as well as that of Oberkampf at Jouy, led to a still wider spread of the industry in Alsace In almost every place in Europe where it was taken up and followed, it was met by local and national prohibitions or trade protective regulations and acts, which, however, were gradually overcome

Invention of Roller Printing,-Towards the end of the 18th century a revolution in the British manufacture of printed tex tiles was brought about through the invention of cylinder or roller printing from metal plates This is usually credited to Oberkampf of Touy, but it seems to have occurred also to a Scotsman named Bell, and was successfully applied in a large way about 1785 at Monsey near Preston From this and the calico-printing works at Manchester in 1763, and in Scotland in 1768, the present huge proportions of the industry in Great Britain have been developed.

It is hardly necessary to give in this brief account illustrations of the different types of patterns used in the various European countries. Typical specimens of East Indian painted and printed calicoes for coverlets and other draperies are shown in the Indian division of the Victoria and Albert Museum These are sus generis. and therefore differ from the bulk of Western prints on chintz. cretonne, etc, which together with a less quantity of printing on satın, silk, velvet, crêpe and the like are principally from adaptations of weaving patterns An interesting series of over 2,500 patterns, chiefly of this character, was made by M. Corimand between 1846 and 1860, and is preserved in the National Art. Library at South Kensington For many years of the latter part of the 19th century, William Morris designed and produced attractively ingenious floral and bird patterns, admirable in contrasts of bright colours, frequently basing his arrangement of cusply defined forms in them upon that of Persian

ment of Crispy Genner Cont.

surface ornament, Person, L'Impression des Tissus (Paris, 1846, see vol 1, preface); E. A. Parnell, Dyesng and Calico Pranting (London, 1849); W. Crookes, F.R.S. Dyesing and Calico Printing (London, 1846, see introduction); Dr. R. Forrer, Die Knisst des Zaugfraches (Clarabourg, 1869).

(A. S. C.)

